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RETRAN-3D — A Program for Transient Thermal-Hydraulic Analysis of Complex Fluid Flow Systems

Volume 3: User's Manual

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REVISION 10 CHANGE PAGES FOR EPRI NP-7450 VOLUME 3
RETRAN-3D USER'S MANUAL

The pages listed below are the replacement pages that comprise Revision 10 of the RETRAN-3D User's Manual, Volume 3. These pages are either replacements pages for those with the same page number in Revision 9 of the User's Manual, or additional pages for those with new page numbers. Those pages which have changes are indicated by "Revision 10" in the lower, outside corner of the page, and the change is indicated by a vertical bar adjacent to the change, along the outside margin of the page.

Section	Pages	Description of Changes
	Title Page	Changed revision number and date
	vii, xv, xi-xvi	Updated Contents, Illustrations, and Tables
I	I-4	Changed supported platforms.
IV	IV-15, IV-16, IV-18-IV-42 IV-97, IV-98, IV-191-IV-238	Fixed typographical errors. Modified description of ADDM term. Added descriptions for backwards compatible accumulator and pressurizer model and input cards.
VII	VII-1 through VII-222	Update sample problem output.
VIII	VIII-1 through VIII-22	Update sample problem output.
IX	IX-1 through IX-18	Update sample problem output.
C	C-35 through C-174	Updated diagnostic messages

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ABSTRACT

RETRAN-02 has proven to be a versatile and reliable computer program for use in best-estimate transient thermal-hydraulic analysis of light water reactor systems. The RETRAN-3D computer program is an extension of the RETRAN-02 program designed to provide analysis capabilities for (1) BWR and PWR transients, (2) small break loss-of-coolant accidents, (3) anticipated transient without scram, (4) long-term transients, (5) transients with thermodynamic nonequilibrium phenomena, (6) mid-loop operation with noncondensable gas present, (7) transients where 3-D dimensional power shapes and reactivity feedback effects are important, and (8) BWR stability events. RETRAN-3D also maintains the complete analysis capabilities of RETRAN-02.

This report (the third of a four-volume computer code manual) describes the required input, the code output, and shows a number of sample problems run with RETRAN-3D. The three companion volumes describe the theory and numerical algorithms, the programming details, and the verification and qualification performed with RETRAN-3D.

Abstract

ACKNOWLEDGMENT

The RETRAN-3D Programmer's Manual is based to a large extent on previous descriptions of the programming conventions and practices used for the RETRAN code and documented in "RETRAN-02 - A Program for One-Dimensional Transient Thermal-Hydraulic Analysis of Complex Fluid Flow Systems, Volume 2: Programmer's Manual", EPRI NP-1850, Revision 6, 1996.

The vision, guidance, and encouragement offered by Lance Agee, the EPRI RETRAN project manager during the initial development of RETRAN-3D, and other members of the EPRI staff are gratefully appreciated. The cooperation of the RETRAN Code Maintenance Group has been most helpful in continuing development and maintenance of the RETRAN-3D code.

The preparation of a document like the RETRAN-3D Computer Code Manual requires the assistance of many individuals. We are grateful to Pam Richardson for editing and typing this report. Our final acknowledgment is given to all of the CSA staff for their support and interest in the RETRAN project.

Acknowledgment

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I

INTRODUCTION

The RETRAN Code Package is a semi-modular system of program modules used to analyze thermal-hydraulic transients. The package is actually a compendium of four program modules utilizing a common pool of data processing, I/0 handling, resource allocation, and computational subroutines.

The four program modules available in the RETRAN Code Package include: (1) RETRAN, a best-estimate thermal-hydraulic transient analysis program; (2) RESTRT, the program used to continue (restart) RETRAN problems; and (3) REEDIT, the program used to obtain printed edits of RETRAN problem solutions archived on data tapes. Each of the four program modules features full dynamic dimensioning and resource allocation. Execution of a particular program module is facilitated by simply supplying the appropriate data deck.

The RETRAN computer program is a result of an extensive code development effort sponsored by EPRI since 1975. The objective of this development effort is to provide a versatile and reliable thermal-hydraulic code which could be used for best-estimate analysis of light water reactor systems.

The RETRAN-01 code[I-1] was released in December 1978. The main features of RETRAN-01 are:

- a one-dimensional, homogeneous equilibrium mixture thermal-hydraulic model for the reactor cooling system,
- a point neutron kinetics model for the reactor core,
- special auxiliary or component models (nonequilibrium pressurizer, temperature transport delay),
- control system models, and
- a consistent steady-state initialization technique.

The analysis capability of RETRAN-01 can be characterized as generally applicable for one-dimensional PWR transients with a somewhat limited application for BWR transients. These limitations were primarily associated with the two-phase flow models and neutron kinetics options in the code.

RETRAN-02 was developed to extend the spectrum of transients that could be analyzed with RETRAN-01 to include:

- additional BWR transients,
- small break loss-of-coolant accidents,
- balance-of-plant modeling, and
- anticipated transients without scram (ATWS).

RETRAN-02 was developed from RETRAN-01 and was first released in May 1981. Some models in RETRAN-01 were revised and/or extended and a series of new models were developed where necessary.

The primary new models developed for RETRAN-02 included:

- an equation of state for water valid between 0.1 psia and 6000 psia,
- a dynamic slip equation and an algebraic slip equation,
- a one-dimensional neutron kinetics model,
- an iterative technique for the solution of the field equations,
- a local conditions heat transfer model,
- a vector representation for the momentum of the fluid,
- an auxiliary model (profile fit) to compute a void fraction for void reactivity feedback,
- thermophysical properties and a forced convection heat transfer correlation for supercritical water, and
- a model for steam separators based on separator efficiency curves.

In addition to these major modifications, a number of minor changes (primarily associated with user-oriented features of the code) were made which resulted from suggestions offered by the code users.

Subsequent to the initial release of RETRAN-02, the Nuclear Regulatory Commission conducted a review of RETRAN at the request of the Utility Group for Regulatory Application,[I-2] EPRI sponsored a design review of RETRAN-02 MOD002,[I-3, I-4] and the MOD002,[I-5] MOD003,[I-6] MOD004,[I-7] and MOD005.0,[I.8] updates were completed.

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From both theoretical considerations and a code user viewpoint, RETRAN-02 has limitations relative to performing some reactor transient analyses. The major theoretical limitations are:

- the requirement (excluding the auxiliary neutron void model) that the phase temperatures are equal for two-phase conditions,
- the numerical solution method in RETRAN-02 is limited to time-step sizes that are smaller than the Courant transport time,
- the limited nature of the vector momentum model relative to multidimensional flow problems, and
- the effect of noncondensable gases on the fluid behavior cannot be accounted.

Practical limitations are the ones most often encountered by code users. These practical limitations are not absolute and RETRAN-02 can be used to perform many calculations in spite of the limitations. However, the labor and computing cost required to accomplish this may sometimes be prohibitive. If the analysis is possible from a cost viewpoint, a deficient model may provide results which make some of the analysis unusable. Thus, practical limitations often prohibit RETRAN-02 from adequately performing a specific analysis.

Some of the major practical limitations of RETRAN-02 include:

- calculations of countercurrent flow behavior,
- the explicit nature of the numerical solution method,
- the discontinuous nature of some heat transfer and friction models which reduces the reliability of the code, and
- steady-state initialization of once-through steam generators and the two-phase region of some BWR models.

Other practical limitations of RETRAN are identified in the U. S. Nuclear Regulatory Commission's Safety Evaluation Report[I-2] and the Summary Report of the EPRI Design Review.[I-4] These limitations can be characterized as:

- insufficient qualification for some model applications (e.g., subcooled void model, dynamic slip, pressurizer, and bubble rise);
- improving existing models such as fluid properties for low pressure (<100 psia) and temperature (<100°F); and
- updating a model to reflect current practices such as using the 1979 ANS decay heat model.

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The RETRAN-3D development program[I-9] was designed to ease many of these limitations. This version of RETRAN-3D includes:

- an implicit numerical solution method used for the solution of the steady-state equations and the transient equations,
- a generalized algebraic slip option applicable for cocurrent and countercurrent flow conditions,
- improved constitutive relations for terms in the dynamic slip equations,
- the 1979 ANS standard for decay heat,
- a generalized transport model to transport impurities (e.g., boron) with the fluid in the system,
- significant modifications to some RETRAN-02 models including the countercurrent flow logic and the one-dimensional neutron kinetics solution algorithms,
- an option to model nonequilibrium phenomena (five-equation model),
- an option to include noncondensable gases as part of the vapor mixture,
- an option to analyze multidimensional neutron kinetics, and
- an improved model to calculate steady-state initial conditions for low power situations.

The code is also written in FORTRAN 77 and the environmental libraries have been extensively changed to minimize computer system dependencies in the coding.

This volume presents the input requirements required to execute RETRAN. Chapter II provides a cursory description of four program modules available in the RETRAN Code Package. Chapter III contains illustrations of typical shell scripts or command line procedures for executing RETRAN-3D on Linux workstations and IBM compatible PCs. Input data summaries for each of the four program modules, RETRAN, RESTRT, and REEDIT, are described in Chapters IV, V, VI, and VII, respectively. Chapter VII contains 16 sample problems for the RETRAN module. Nine of these problems are the same as used for RETRAN-02, with the exception of the options used. Seven additional sample problems demonstrate new model features. The input decks and sample output files for these problems are presented in this manual. The actual sample problem input files are included on magnetic media as part of the code transmittal package for each specific code version. Typical sample problems for RESTRT and REEDIT (Chapters IX, VIII, and, respectively) are also included.

Appendix A contains a brief description of the output quantities written on major edits, and Appendix B provides a description of the time-step control summary edit for the transient equation solution. A description of the numerical solution errors that can be encountered during

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a transient simulation are given in Appendix C. Corrective action to avoid the error conditions is also presented when possible.

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II

PROGRAM SUMMARY DESCRIPTION

A general overview of each of the four program modules available in the RETRAN Code Package is given in the following sections. The primary module, RETRAN, is used to perform thermal-hydraulic transient analyses. The program module, RESTRT, is used to continue previous RETRAN calculations and module REEDIT is a support software utility used to aid in the interpretation of analytical results. All program modules will provide printer plots of specified parameters at execution time if requested by the code user. The printer plots allow a cursory examination of the analysis immediately upon job completion.

1.0 RETRAN

The RETRAN-3D program module is used to analyze thermal-hydraulic transients and requires numerical input data that completely describe the components and geometry of the system being analyzed. The input data include fluid volume sizes, initial flow, pump features, power generation, heat exchanger properties, and material compositions. A minimal amount of information is required to describe the initial pressure and temperature distribution within the system when the steady-state initialization option is used. This option allows the user to input the best known pressures and/or loss coefficients, and the code computes the remaining unknowns (provided the system is not underspecified), such that a steady-state condition may be maintained in the transient portion of the code. The steady-state option computes volume enthalpies from a steady-state energy balance, with the restriction that generally only one enthalpy may be supplied per flow system, e.g., one enthalpy in the primary-system side and one in the secondary-system side of a steam generator. The option is also available to completely specify the system pressure and enthalpy distribution. However, it is extremely difficult to compute a consistent set of initial conditions for the field equations, constitutive models, and component models by hand. Consequently, this option generally prevents a true steady-state condition from being maintained in the transient portion of the code.

From the initial conditions, transients can be initiated by the control actions input to the program which describe breaks in fluid piping, valve actions, pump changes, and power variations. The program computes values for fluid conditions such as flow, pressure, mass inventory, and steam-water fractions (quality) each time advancement as well as fluid-solid interface conditions such as heat flux and surface temperature.

The degree of detail to which the system is described is completely specified by the program user. Nodalization of fluid flow paths within the piping and vessels is specified by the program

user as is the temperature nodalization of solids such as reactor core fuel rods, pipe walls, and heat exchanger walls. Both reactor primary and secondary flow systems can be described.

These systems are coupled by heat transfer through the walls of the heat exchangers. The modeling detail permitted is limited only by the user input.

The definition of the thermal-hydraulic system is also completely specified by the user. A portion of a system, for example a single reactor channel with a single fuel rod, can be analyzed by supplying appropriate time-dependent boundary conditions, such as pressures and enthalpies in the lower and upper fluid plenums. These boundary conditions can be defined by the user, if known, or they can be obtained from a previous RETRAN-3D analysis. For example, an analysis of a reactor blowdown transient may be performed using a RETRAN-3D model that describes the entire primary flow loop, the upper and lower plenums, and a simple nodalization of the total reactor core. A second RETRAN-3D calculation, using the previously calculated fluid condition in the upper and lower plenums, can then be performed to analyze component effects such as a single core channel. The benefit derived by this approach is that the detailed core calculation can be separated from the overall system analysis. Although both calculations can be combined into a single RETRAN-3D calculation, the separate approach is usually less expensive and more efficient for parameter studies.

2.0 RESTRT

The RESTRT program module is used to continue (restart) a RETRAN-3D analysis. Input data supplied at restart time and information obtained from the original problem input data archived on a RETRAN-3D data file are used to continue an analysis. All time-dependent information required to continue the problem, such as fluid thermodynamic conditions, conductor temperature distributions, and power level, are retrieved from the RETRAN-3D data file for the original solution time at which the problem is to be continued.

The RESTRT program module provides for two types of problem continuation. In the simple restart mode, optional input data may be supplied to modify time-step selection features, edit frequencies, minor edit parameters, and trip-control-system descriptions. Printer plots may also be requested at restart time. In the generalized restart mode, a second set of input is supplied in addition to that for the simple restart. In the second set of input, data are supplied which replace and/or augment the original problem input data. The generalized restart option allows for great flexibility to modify the original problem at restart time. However, caution is required since the modification of some problem parameters at restart may result in anomalous problem results.

3.0 REEDIT

REEDIT is the program module used to obtain printed edits and/or printer plots of RETRAN-3D problem solutions archived on data files. User input requirements are minimal and amount to specifying the RETRAN-3D data file, major and minor edit frequencies, and an optional list of minor edit parameters. REEDIT allows all consecutive data records to be edited at any

frequency and permits editing to begin at any problem solution time specified. REEDIT also has an option to write any available minor-edit variable to an auxiliary file in a user-specified format. This option permits the user to automatically use output from RETRAN-3D as input for an analysis by another code.

III

INPUT DATA REQUIREMENTS

The input data requirements of the RETRAN-3D Code Package consist of both computer-dependent shell scripts or command procedures and associated input data files which are not computer dependent. Shell scripts or procedures required to execute the RETRAN, RESTRT, and REEDIT modules of the RETRAN-3D Code Package and the input data file organization are discussed in this section. Detailed input data requirements for each module are discussed in Sections IV through VII.

1.0 JOB CONTROL STATEMENTS

Shell scripts or procedure files are required to run the RETRAN-3D program on a given computing platform. These scripts provide the necessary association between the actual input and output file names and the standard file names, listed in Table III.1-1, used internally by RETRAN-3D. They also execute the RETRAN-3D executable program and specify any necessary parameters.

The following sections provide example procedure files for executing RETRAN-3D on Linux platforms and IBM compatible Personal Computers.

1.1 Linux Workstations

RETRAN-3D is operational on Linux workstations manufactured by a large number of different vendors. While each vendor and/or installation may have site specific requirements and preferences that will be implemented in complex shell scripts, a sample procedure can be used to illustrate the requirements for executing the code. Table III.1-2 illustrates the command statements that are used to execute jobs for the RETRAN, RESTRT, and REEDIT program modules. As shown in the examples, files can be accessed for input or output through the use of copy and move commands.

The sample Linux script file makes use of the Bourne shell. It has been used on the supported platforms (those for which a complete transmittal is available) and has also been used on a number of unsupported platforms where RETRAN-3D has been installed.

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Table III.1-1

Description of RETRAN File Use

Unit No.	File Name	Description
1	TAPE1	Temporary file
2	TAPE2	Temporary file
3	TAPE3	Temporary file
5	INPUT	RETRAN input is supplied on this file
6	OUTPUT	RETRAN output is written to this file
8	REMARKS	Remark summary log
9	VBCFIL	VIPRE-01 boundary condition file (optional)
11	TAPE11	RETRAN data file that is input to the PLOTER module. TAPE12 through TAPE15 can also provide input to PLOTER.
12	TAPE12	RETRAN data file from which boundary condition data are obtained (optional). This file has to be a RETRAN-3D generated data file.
13	TAPE13	The RETRAN data file that is used by; (a) the RESTRT module to provide initial data to restart a problem, or (b) the REEDIT module to obtain printed edits. This file has to be a RETRAN-3D generated data file.
14	TAPE14	The RETRAN data (restart file) is written to this file. This file may be written by both the RETRAN and RESTRT modules.
17	ERR_LOG	Error log file created when RETRAN encounters solution errors. See Appendix C for a description of the errors and possible corrective action.
40	TAPE40	One-dimensional kinetics input file. This file contains cross-section data (required if NODEL = 2 on 01000Y data).
50	TAPE50	Output to plotter, written from the PLOTER module.
60	TAPE60	User-specified output file of minor edit variable data that can be requested by the user in the RETRAN, RESTRT, and REEDIT modules.
68	TAPE68	Cross-section file for the three-dimensional kinetics option (required if NODEL = 3 on 01000Y data).
78	TAPE78	CDI file for the three-dimensional kinetics option (required if NODEL = 3 on 01000Y data).

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Table III.1-2

Sample Linux Execution Script: run

```
#! /bin/sh
#
# HP
# dbgr=gdb
#
# SUN, IBM
# dbgr=dbx
#
dbgr=
rdeck=
tape12=
tp12ed=
tape13=
tp13ed=
xsecin=
xseced=
inpext=
debug=
opts=
nsm=
RTAPE=
XTAPE=
dattim=
xstat=
rm -f _headr
#
exec=retran3d.x
#
if [ -x "r3m004p2x" ]
 then
      exec="r3m004p2x"
fi
#
#
if [ $# = 0 ]
 then
  echo "                                                    "
  echo " **** ERROR ****  no arguments specified"
  echo "                                                  "
  echo "            -x  name  = executable name"
  echo "            -r  name  = retran input"
  echo "            -X  name  = 1D X-section file (TAPE40)"
  echo "            -3  name  = 3D X-section file (TAPE68)"
  echo "            -B  name  = old RETRAN data file (TAPE12)"
  echo "            -R  name  = old RETRAN restart file (TAPE13)"
  echo "            -C  name  = old CDI file (TAPE78)"
```


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Table III.1-2 (Cont'd)

```
  echo "            -m  mem    = size of FTB memory allocation"
  echo "                         (2000000=2000k=2m -- m & k either case"
  echo "            -ns        = no screen messages"
  echo "            -d         = run debugger"
  echo "                                                    "
  exit 1
#
elif [ $# = 1 ]
    then
     rdeck=$1
else
#
set -- `getopt x:r:B:C:R:3:X:m:n:d $*`
#  if [ $? != 0 ]
   then
      exit 99
  fi
#
    while [ "Q$1" != "Q--" ]
    do
       case $1 in
        -x)
          exec=$2
          shift; shift
          ;;
        -r)
          rdeck=$2
          shift; shift
          ;;
        -B)
          tape12=$2
          tp12ed="with TAPE12: "$2
          shift; shift
          ;;
        -R)
          tape13=$2
          tp13ed="with TAPE13: "$2
          RTAPE="TAPE13"
          shift; shift
          ;;
        -X)
          xsecin=$2
          xseced="with TAPE40: "$2
          XTAPE="TAPE40"
          shift; shift
          ;;
        -3)
          xsecin=$2
```

Table III.1-2 (Cont'd)

```
          xseced="with TAPE68: "$2
          XTAPE="TAPE68"
          shift; shift
          ;;
        -C)
          cdiin=$2
          cdied="with CDI file : "$2
          CTAPE="TAPE78"
          shift; shift
          ;;
        -m)
          mem=`echo $2|sed -e "s/[kK]/000/" -e "s/[mM]/000000/" `
          opts=$opts" -m "$mem
          shift; shift
          ;;
        -n)
          opts=$opts" -ns"
          nsm="no"
          shift; shift
          ;;
        -d)
          debug="yes"
          shift
          ;;
         *)
          echo " Bad Option on Command Line"
          exit 99
          ;;
      esac
    done
shift
fi
#
#  RUN EXECUTABLE
#
#
execc=`type $exec|awk '{print $3}'`
if [ -x "$execc" ]
 then
    if [ -n "$xsecin" ]
     then
       if [ -s "$xsecin" ]
        then
          rm -f $XTAPE
          ln -s $xsecin $XTAPE
       else
          echo " **** ERROR **** Specified "$XTAPE" does not exist :"$xsecin
          exit 40
```

Table III.1-2 (Cont'd)

```
   fi
fi
if [ -n "$cdiin" ]
 then
   if [ -s "$cdiin" ]
    then
      rm -f $CTAPE
      ln -s $cdiin $CTAPE
   else
      echo " **** ERROR **** Specified "$CTAPE" does not exist :"$cdiin
      exit 41
   fi
fi
if [ -n "$tcsin" ]
 then
   if [ -s "$tcsin" ]
    then
      rm -f $HTAPE
      ln -s $tcsin $HTAPE
   else
      echo " **** ERROR **** Specified "$HTAPE" does not exist :"$tcsin
      exit 42
   fi
fi
if [ -n "$tape12" ]
 then
   if [ -s "$tape12" ]
    then
      rm -f TAPE12
      ln -s $tape12 TAPE12
   else
      echo " **** ERROR **** Specified TAPE12 does not exist :"$xsecin
      exit 12
   fi
fi
if [ -n "$tape13" ]
 then
   if [ -s "$tape13" ]
    then
      rm -f $RTAPE
      ln -s $tape13 $RTAPE
   else
      echo " **** ERROR **** Specified "$RTAPE" does not exist :"$tape13
      exit 13
   fi
fi
if [ -n "$rdeck" -a -s "$rdeck" ]
   then
```

Table III.1-2 (Cont'd)

```
          rm -f INPUT
          cp $rdeck INPUT
          outfil=OUTPUT
    else
       echo " **** ERROR **** Specified input deck does not exist :"$rdeck
       exit 11
    fi
#
# header information
#
    echo " OS:            "`uname`    > _headr 2>/dev/null
    echo " User Name:     "`whoami`  >> _headr 2>/dev/null
    dattim=`date "+%m/%d/%y %H:%M %p"`
    echo " Start time:   "$dattim >> _headr 2>/dev/null
#
    echo "" >> _headr  2>/dev/null
    echo " Input File Information:"  >> _headr 2>/dev/null
    echo "       Input File: "$rdeck >> _headr 2>/dev/null
    if [ ! -z "$xseced" ];then echo "       "$xseced >> _headr 2>/dev/null ;fi
    if [ ! -z "$cdied"  ];then echo "       "$cdied >> _headr 2>/dev/null  ;fi
    if [ ! -z "$tcsed"  ];then echo "       "$tcsed >> _headr 2>/dev/null  ;fi
    if [ ! -z "$tp13ed" ];then echo "       "$tp13ed >> _headr 2>/dev/null ;fi
    if [ ! -z "$tp12ed" ];then echo "       "$tp12ed >> _headr 2>/dev/null ;fi
    echo "" >> _headr  2>/dev/null
    echo " Command:  "$execc" "$opts >> _headr  2>/dev/null
    echo "" >> _headr  2>/dev/null
    echo " Program Name:      "`basename $execc`"   ("`dirname $execc`")"   >>
_headr 2>/dev/null
    echo " Program Stats:    "`ls -l $execc`   >> _headr 2>/dev/null

#
#
#
    if [ -z "$nsm" ]
     then
       echo " Running  "$execc" "$opts"  with INPUT: "$rdeck
       if [ ! -z "$xseced" ];then echo "                   "$xseced ;fi
       if [ ! -z "$cdied"  ];then echo "                   "$cdied  ;fi
       if [ ! -z "$tcsed"  ];then echo "                   "$tcsed  ;fi
       if [ ! -z "$tp13ed" ];then echo "                   "$tp13ed ;fi
       if [ ! -z "$tp12ed" ];then echo "                   "$tp12ed ;fi
       echo "                    "
    fi
#
       rm -f ftn* fort* ERR_LOG
       if [ ! -z "$debug" ]
        then
          $dbgr $exec $opts
```

Table III.1-2 (Cont'd)

```
          xstat=$?
        else
          $exec $opts
          xstat=$?
       fi

#
#    continue header information
#
    dattim=`date "+%m/%d/%y %H:%M %p"`
    echo "" >> _headr  2>/dev/null
    echo " Execution ended:  "$dattim >> _headr 2>/dev/null
    echo "" >> _headr  2>/dev/null
    echo " Exit status:  "$xstat >> _headr  2>/dev/null
    echo "" >> _headr  2>/dev/null
    echo " Output File Information:" >> _headr 2>/dev/null
       rm -f INPUT TAPE2 TAPE3 TAPE20
       bdeck=`basename $rdeck`
       if [ -s "$outfil" ]
        then
         echo "        Output File: "$bdeck.out >> _headr  2>/dev/null
       fi
       if [ -s "ERR_LOG" ]
        then
           mv  ERR_LOG  $bdeck.ERR_LOG
           echo "          Error Log: "$bdeck.ERR_LOG >> _headr  2>/dev/null
       fi
       if [ -s "TAPE14" ]
        then
         mv TAPE14  $bdeck.tape14
         echo "       Restart File: "$bdeck.tape14 >> _headr  2>/dev/null
       fi
       if [ -s "TAPE60" ]
        then
         mv TAPE60  $bdeck.tape60
         echo "        TAPE60 File: "$bdeck.tape60 >> _headr  2>/dev/null
       fi
       if [ -s "VBCFIL" ]
        then
         mv VBCFIL  $bdeck.vbc
         echo "           VBC File: "$bdeck.vbc >> _headr  2>/dev/null
       fi
       if [ -s "TAPE41" ]
        then
         mv TAPE41  $bdeck.tape41
       fi
       if [ -s "TAPE42" ]
        then
```

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Table III.1-2 (Cont'd)

```
          mv TAPE42  $bdeck.tape42
        fi
        if [ -s "TAPE43" ]
         then
          mv TAPE43  $bdeck.tape43
        fi

#
#    finish header information
#
     echo "" >> _headr  2>/dev/null
     cat _headr $outfil REMARKS > $bdeck.out 2>/dev/null
     rm -f _headr $outfil REMARKS
#

else
    echo " **** ERROR **** Specified exec file not found :"$exec
    exit 20
fi
#
exit 0
```


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1.2 Windows Personal Computers

RETRAN-3D has been installed and used on a variety of personal computers using the Windows operating system. Table III.1-3 gives the control statements necessary to run RETRAN, RESTRT, or REEDIT in the form of a batch procedure file, run.bat.

1.3 INPUT Data File

The INPUT data file contains the input necessary to select the program module that is to be executed, RETRAN, RESTRT, or REEDIT and the module specific input data. The input requirements for each module is given is Sections IV, V, and VI, respectively.

1.4 RESTRT Data File

The restart data file contains the information necessary to continue the problem calculation, reedit the problem data and/or plot the data. This data file is used by the RETRAN problem modules RESTRT, REEDIT, and the time-dependent volume boundary condition calculation in RETRAN. Each data file consists of a header record identifying the data file, a record describing the data record content, a series of data records containing problem solution results, and a trailer (terminal) record. These files can be written on standard labeled magnetic data tapes or on disks. Additional information on this file is given in Volume 2: Programmer's Manual.[III.I-1]

1.5 One-Dimensional Kinetics Data File

An additional input data file is required if the one-dimensional kinetics option is used in RETRAN-3D (NODEL = 2 on Input Card 01000Y). The control rod model used for this option is referred to as the multi-state model. The data file for this model is described in this section. The space-time kinetics data file is specified as Unit 40 for RETRAN and must be identified as such in the JCL. The data file must be in character mode with each record written with a FORTRAN-formatted WRITE or equivalent. Thus, a record contains the information transmitted with each such WRITE command. The expected formats and a description of the file structure is presented in the Programmer's Manual.[III.1-1]

The multiple control state control rod model file contains four types of information: (1) the nuclear parameter data for the one-dimensional kinetics option, (2) the control rod fraction for the control rod model, (3) the one-dimensional neutron flux and power values corresponding to the nuclear parameter data, and (4) optional upper and lower limit values for the nuclear parameter data.

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Table III.1-3

Sample Windows Execution Procedure: run.bat

```
@echo off
rem
rem  RETRAN-3D run procedure (Command line version)
rem
rem
rem  Calling sequence
rem
rem    run -x exec -r rdeck -X xsecin -3 xsecin -B tape12 -R tape13 -C tape78
rem
rem   where all parameters are optional except -r (and rdeck).
rem   Note that parameters are case sensitive.
rem
rem
rem ================================================================
if "%1" == "/?" goto help
if "%1" == "-h" goto help
if "%1" == "--help" goto help

rem
rem
rem  Set environment variables
rem
    set exec=
    set exepth=
    set exenam=
    set exetim=
    set exesiz=
    set bdeck=
    set rdeck=
    set tape12=
    set tp12ed=
    set tape13=
    set tp13ed=
    set xsecin=
    set xseced=
    set tape78=
    set tp78ed=
    set CTAPE=
    set XTAPE=
    set opts=
    set nsm=
rem
    if not %1*==* goto parse
rem
```


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Table III.1-3 (Cont'd)

```
rem ================================================================
rem
rem  Error processing
rem
:error
rem
    echo  **
    echo  **** ERROR ****  argument errors detected
:help
    echo  *
    echo  * calling sequence
    echo  *
    echo  *      run -x exec -r rdeck -X xsecin -3 xsecin
    echo  *          -B tape12 -R tape13 -C tape78
    echo  *
    echo  *  where all paramters are optional except -r (and rdeck)
    echo  *
    echo  *  (parameters are order independent but are case sensitive)
    echo  *
    echo  *     -x  exec    = executable name
    echo  *     -r  rdeck   = retran input
    echo  *     -X  xsecin  = 1D X-section file (TAPE40)
    echo  *     -3  xsecin  = 3D X-section file (TAPE68)
    echo  *     -B  tape12  = old RETRAN data file (TAPE12)
    echo  *     -R  tape13  = old RETRAN restart file (TAPE13)
    echo  *     -C  tape78  = CDI file (TAPE78)
    echo  *     -m  memsize = pool memory argument
    echo  *     -ns         = no screen argument
    echo  *     -N  runnum  = run number argument
    echo  **
    exit /b
rem
rem  exec file does not exist
rem
:err_exec
    echo  *
    echo  *  Error **** RETRAN-3D executable file %exec% does not exist
    echo  *
    goto exit
rem
rem  RETRAN-3D input file does not exist
rem
:err_rdeck
    echo  *
    echo  *  Error **** RETRAN-3D input file %rdeck% does not exist
    echo  *
```

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Table III.1-3 (Cont'd)

```
      goto exit
rem
rem  Cross section file does not exist
rem
:err_xsec
    echo  *
    echo  *  Error **** %XTAPE% cross section file %xsecin% does not exist
    echo  *
    goto exit
rem
rem  Input data file does not exist
rem
:err_tape12
    echo  *
    echo  *  Error **** TAPE12 data file %tape12% does not exist
    echo  *
    goto exit
rem
rem  Restart data file does not exist
rem
:err_tape13
    echo  *
    echo  *  Error **** TAPE13 data file %tape13% does not exist
    echo  *
    goto exit
rem
rem  CDI file does not exist
rem
:err_tape78
    echo  *
    echo  *  Error **** TAPE78 data file %tape78% does not exist
    echo  *
    goto exit
rem
rem  Invalid parameter
rem
:err_opt
    echo  *
    echo  *  Error **** invalid parameter, %1 not valid option
    echo  *
    goto exit
rem
rem ================================================================
rem
:parse
```


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Table III.1-3 (Cont'd)

```
    if %1*==* goto process
    if %1==-x goto x
    if %1==-r goto r
    if %1==-X goto ux
    if %1==-3 goto 3
    if %1==-B goto ub
    if %1==-R goto ur
    if %1==-C goto uc
    if %1==-m goto um
    if %1==-ns goto uns
    if %1==-N goto un
    if not %1*==* goto err_opt

rem
rem  Set executable file name
rem
:x
    if %2*==* goto error
    del /q _tmp789 2>nul
    set fff=%2
    set fff=%fff:.exe=%
    set exec=%fff%.exe
    if exist %exec% goto xx
    echo %fff%.exe >_tmp789 2>nul
    for /F "usebackq" %%a in (_tmp789) do set exec=%%~$PATH:a
    del /q _tmp789 2>nul
    if %exec%*==*  goto err_exec
:xx
    echo %exec% >_tmp789 2>nul
    for /F "usebackq" %%a in (_tmp789) do set exepth=%%~dpa
    for /F "usebackq" %%a in (_tmp789) do set exenam=%%~nxa
    for /F "usebackq" %%a in (_tmp789) do set exesiz=%%~za
    for /F "usebackq" %%a in (_tmp789) do set exetim=%%~ta
    del /q _tmp789 2>nul

    shift
    shift
    goto parse
rem
rem  Set RETRAN-3D input deck
rem
:r
    if %2*==* goto error
    set bdeck=%~nx2
    set rdeck=%2
    set inpext=
```

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Table III.1-3 (Cont'd)

```
    if exist %rdeck%%inpext%  goto r2
    set inpext=.inp
    if exist %rdeck%%inpext%  goto r2
    goto err_rdeck
rem
:r2
    shift
    shift
    if %rdeck% == INPUT goto parse
    if exist input   del input   > nul
    if exist output  del output  > nul
    if exist remarks del remarks > nul
    if exist TAPE2   del TAPE2   > nul
    if exist tape3   del TAPE3   > nul
    if exist tape14  del tape14  > nul
    if exist tape41  del tape41  > nul
    if exist tape42  del tape42  > nul
    if exist tape60  del tape60  > nul
    if exist ERR_LOG del ERR_LOG > nul
    if exist VBCFIL  del VBCFIL  > nul
    copy %rdeck%%inpext% INPUT > nul
    goto parse
rem
rem  Set 1D cross section file
rem
:ux
    if %2*==* goto error
    set xsecin=%2
    set xseced=with TAPE40:
    set XTAPE=TAPE40
    if not exist %xsecin% goto err_xsec
    if not %xsecin%==TAPE40 copy %xsecin% TAPE40 > nul
    shift
    shift
    goto parse
rem
rem  Set 3D cross section file
rem
:3
    if %2*==* goto error
    set xsecin=%2
    set xseced=with TAPE68:
    set XTAPE=TAPE68
    if not exist %xsecin% goto err_xsec
    if not %xsecin%==TAPE68 copy %xsecin% TAPE68 > nul
    shift
```


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Table III.1-3 (Cont'd)

```
    shift
    goto parse
rem
rem  Set input retran data file
rem
:ub
    if %2*==* goto error
    set tape12=%2
    set tp12ed=with TAPE12:
    if not exist %tape12% goto err_tape12
    if not %tape12%==TAPE12 copy %tape12% TAPE12 > nul
    shift
    shift
    goto parse
rem
rem  Set restart data file
rem
:ur
    if %2*==* goto error
    set tape13=%2
    set tp13ed=with TAPE13:
    if not exist %tape13% goto err_tape13
    if not %tape13%==TAPE13 copy %tape13% TAPE13 > nul
    shift
    shift
    goto parse
rem
rem  Set CDI file
rem
:uc
    if %2*==* goto error
    set tape78=%2
    set tp78ed=with TAPE78:
    set CTAPE=TAPE78
    if not exist %tape78% goto err_tape78
    if not %tape78%==%CTAPE% copy %tape78% TAPE78 > nul
    shift
    shift
    goto parse
rem
:um
    if %2*==* goto error
    set mem=%2
    set mem=%mem:k=000%
    set mem=%mem:K=000%
    set mem=%mem:m=000000%
```

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Table III.1-3 (Cont'd)

```
    set mem=%mem:M=000000%
    set opts=%opts% -m %mem%
    shift
    shift
    goto parse
rem
:uns
    set opts=%opts% -ns
    set nsm=No
    shift
    goto parse
rem
:un
    if %2*==* goto error
    set opts=%2
    shift
    shift
    goto parse
rem
rem ================================================================
rem
rem  Start processing according to options supplied
rem
:process
rem
rem
    if %rdeck%*==* goto err_rdeck

rem
rem  header information
rem
    echo  OS:            PC          >HEADR 2>nul
    echo  User Name:     %USERNAME% >>HEADR 2>nul
    for /F "usebackq tokens=1,*" %%a in (`date /T`) do set dattim=%%b
    for /F "usebackq tokens=*" %%a in (`time /T`) do set dattim=%dattim% %%a
    echo  Start time:   %dattim%  >>HEADR 2>nul
    echo. >> HEADR 2>nul
    echo  Input File Information: >>HEADR 2>nul
    echo        Input File: %rdeck%%inpext% >>HEADR 2>nul
    if not %xsecin%*==*  echo       %xseced% %xsecin% >>HEADR 2>nul
    if not %tape12%*==*  echo       %tp12ed% %tape12% >>HEADR 2>nul
    if not %tape13%*==*  echo       %tp13ed% %tape13% >>HEADR 2>nul
    if not %tape78%*==*  echo       %tp78ed% %tape78% >>HEADR 2>nul
    echo. >> HEADR 2>nul
    echo  Command:  %exec% %opts% >> HEADR 2>nul
    echo. >> HEADR 2>nul
```


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Table III.1-3 (Cont'd)

```
    echo  Program Name:     %exenam%  (%exepth%) >> HEADR 2>nul
    echo  Program Size:     %exesiz%  >> HEADR 2>nul
    echo  Program Date:     %exetim%  >> HEADR 2>nul

rem
rem  Execute RETRAN-3D
rem
    if not %nsm%*==* goto go_exec
    echo .
    echo .  Running RETRAN-3D executable %exec% %opts%
    echo .          with  INPUT: %rdeck%%inpext%
    if not %xsecin%*==*  echo .          %xseced% %xsecin%
    if not %tape12%*==*  echo .          %tp12ed% %tape12%
    if not %tape13%*==*  echo .          %tp13ed% %tape13%
    if not %tape78%*==*  echo .          %tp78ed% %tape78%
    echo .

:go_exec

    %exec% %opts%
    set xstat=%errorlevel%

rem
rem  continue header information
rem
    for /F "usebackq tokens=1,*" %%a in (`date /T`) do set dattim=%%b
    for /F "usebackq tokens=*" %%a in (`time /T`) do set dattim=%dattim% %%a
    echo. >> HEADR 2>nul
    echo  Execution ended:  %dattim% >> HEADR 2>nul
    echo. >> HEADR 2>nul
    echo  Exit status:  %xstat%  >> HEADR 2>nul
    echo. >> HEADR 2>nul

rem
rem  cleanup files
rem
    if %rdeck%==INPUT goto exit
    if %rdeck%==input goto exit
rem
    if exist %bdeck%.tape14 del %bdeck%.tape14
    if exist %bdeck%.tape41 del %bdeck%.tape41
    if exist %bdeck%.tape42 del %bdeck%.tape42
    if exist %bdeck%.tape43 del %bdeck%.tape43
    if exist %bdeck%.tape60 del %bdeck%.tape60
    if exist %bdeck%.ERR_LOG del %bdeck%.ERR_LOG
    if exist %bdeck%.vbc     del %bdeck%.vbc
```

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Table III.1-3 (Cont'd)

```
rem
rem
    if exist TAPE14 move TAPE14  %bdeck%.tape14 > nul
    if exist TAPE41 move TAPE41  %bdeck%.tape41 > nul
    if exist TAPE42 move TAPE42  %bdeck%.tape42 > nul
    if exist TAPE42 move TAPE43  %bdeck%.tape43 > nul
    if exist TAPE60 move TAPE60  %bdeck%.tape60 > nul
    if exist ERR_LOG move ERR_LOG %bdeck%.ERR_LOG > nul
    if exist VBCFIL  move VBCFIL  %bdeck%.vbc     > nul
    if not %xsecin%*==%XTAPE%* del %XTAPE% > nul
    if not %tape78%*==%CTAPE%* del %CTAPE% > nul

rem
rem  finish header information
rem
    echo  Output File Information: >>HEADR 2>nul
    echo         Output File: %bdeck%.out >>HEADR 2>nul
    if exist %bdeck%.tape60  echo         TAPE60 file: %bdeck%.tape60 >> HEADR
2>nul
    if exist %bdeck%.tape14  echo        Restart file: %bdeck%.tape14 >> HEADR
2>nul
    if exist %bdeck%.ERR_LOG echo           Error Log: %bdeck%.ERR_LOG >>
HEADR 2>nul
    if exist %bdeck%.vbc     echo            VBC file: %bdeck%.vbc     >>
HEADR 2>nul
    echo. >> HEADR 2>nul

rem
rem
    copy HEADR+OUTPUT+REMARKS %bdeck%.out > nul
    del INPUT > nul
    del OUTPUT > nul
    del REMARKS > nul
    del HEADR > nul

rem
rem  Exit path
rem
:exit
    if exist TAPE2  del TAPE2 >nul
    if exist TAPE3  del TAPE3 >nul
    if exist TAPE20 del TAPE20 >nul

rem
rem  UnSet environment variables
rem
```


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Table III.1-3 (Cont'd)

```
set exec=
set exepth=
set exenam=
set exetim=
set exesiz=
set bdeck=
set rdeck=
set tape12=
set tp12ed=
set tape13=
set tp13ed=
set xsecin=
set xseced=
set tape78=
set tp78ed=
set CTAPE=
set XTAPE=
set opts=
set nsm=
set xstat=
set dattim=
set fff=
```

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The nuclear parameter data file must contain the initial values and coefficients needed to calculate the following variables as a function of the feedback quantities and control rod position,

β	=	delayed neutron fraction
Σ_a	=	absorption cross section
B^2	=	buckling
D	=	diffusion coefficient
Σ_s	=	downscatter or removal cross section
$\kappa\Sigma_f$	=	kappa*fission cross section
$\nu\Sigma_f$	=	nu*fission cross section
V	=	neutron speed

The control fraction data following the nuclear parameter data records are a one-dimensional representation of the rod distribution used to generate the cross-section set normalized as a fraction between minimum (0.0) and maximum (1.0) control.

The nuclear parameter and control fraction data must be included on the space-time kinetics data file. The third set of data consisting of point values for the group fluxes and one-dimensional averaged data from a multidimensional nodal code may be replaced with blank records. The fourth set of data is present on the file only if requested on the Space-Time Kinetics Data Card 30000Y.

1.6 Three-Dimensional Space-Time Kinetics Data Files

The multidimensional kinetics option requires two auxiliary files to support the model. These two files are described in this section.

The ability to design and implement multidimensional kinetics models is highly dependent upon the coupling of complex computer codes that process neutronics cross sections and core geometric data. The amount of information is extensive and a manual or non-automated method of processing the input lends itself to transcription errors or modeling inconsistencies.

A fundamental problem when constructing a new model for multidimensional kinetics is the source of data for neutronics and geometric information. How does one obtain cross sections and other group constants for the reactor core at the state point of interest, and how can one construct the core model in a relatively efficient manner that uses as much "up-stream" information as possible?

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A primary developmental activity since the early versions of RETRAN-3D were released has been the tighter coupling with upstream physics codes to provide easier, less redundant input methods and reduce sources for input error. The result of this work is the channel model which is described in Section 28.1 of the User's Manual. The data file to support the channel model is described here.

1.6.1 The CDI File

A key feature of the channel model is an ASCII data file that links the neutronic and thermal-hydraulic specifications from the CORETRAN model to the channel model input routines in RETRAN-3D. The current version of RETRAN-3D assumes that the user has access to a CORETRAN version (or an alternative method for producing the file) that can write the CORETRAN Data Interface (CDI) file. Figure III.1-1 shows the data flow for the channel model.

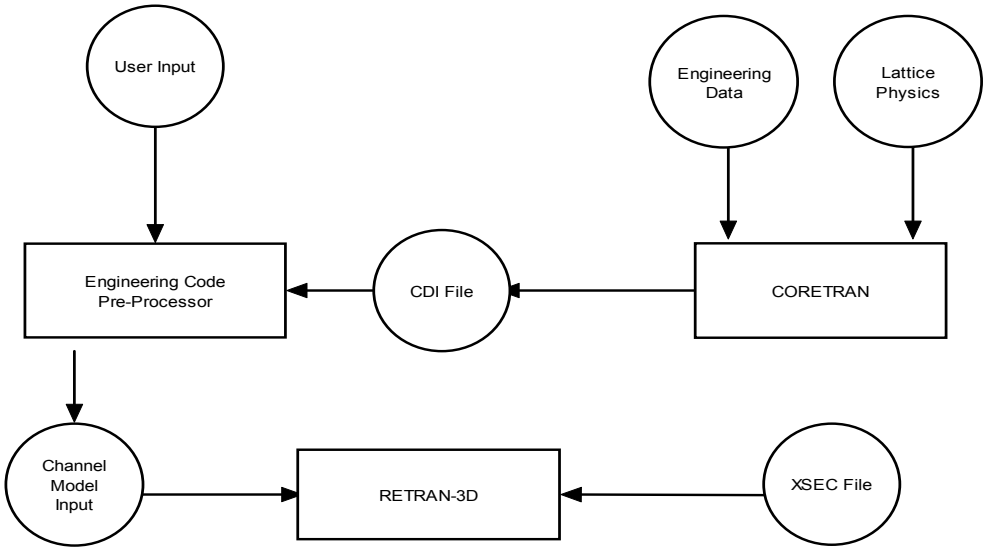


Figure III.1-1. RETRAN-3D Channel Model Data Flow

The CDI file (FORTRAN Unit 78) is written by CORETRAN to augment the RETRAN-3D channel model. The CDI file is an ASCII file containing character, integer, and floating point data that characterize the core model in terms of geometry, boundary conditions, and thermal-hydraulic definition. The two aspects of the CDI file are the physics data and the thermal-hydraulic data. The CDI file contains all of the assembly layout and geometric information required to allow RETRAN-3D to internally generate volume, junction, and conductor input for the core region in a specified layout. The CDI file contains heated lengths, flow areas, wetted perimeters, conductor volumes, and loss coefficients. By making assumptions about channel connections to the upper and lower plenums, the number of axial nodes, and user-defined core wide options such as enthalpy transport and two-phase flow model as examples, the new routine GEOM3D will generate volume and junction data internal to the code for use.

1.6.2 The Three-Dimensional Kinetics Cross-Section File

The primary source for RETRAN-3D cross sections is the CORETRAN code. Recent versions of CORETRAN have implemented a new cross-section formalism in order to address reaction types and spectrum issues of interest to fuel management groups. In general, the lattice information (from CPM-3 or CASMO calculations) is processed by CORETRAN and at given state points (i.e., point in the burn cycle) a RETRAN-3D cross-section file is written that contains instantaneous cross dependancies. No intermediate processing codes are needed.

The RETRAN-3D cross-section file (FORTRAN Unit 68) is written at the end of a CORTRAN "burn" calculation. The RETRAN-3D model is identical in format and in functionality but the historical dependancies have been removed. That is, the RETRAN-3D model only contains the "instantaneous" dependancies, such as fuel temperature, moderator density, control fraction, or boron concentration. This reduces the size of the file as well as the cross-section calculation time for the transient analysis cases.

The expected format and a description of the file is presented in the Programmer's Manual. [III.1-3]

2.0 INPUT DATA FILE ORGANIZATION

Input data files for the RETRAN Code Package are processed by use of the INP input data processing package. The INP package offers: free form input; card numbers to identify the cards, automatic removal of cards containing duplicate card numbers, arbitrary ordering of input cards except for duplicate cards, arbitrary use of comment cards and comments on data cards, and a listing of the card data.

The data deck organization contains input for one problem set. A list containing a card sequence number and the card image of each card is printed at the beginning of the printed output for each problem set. The first line of the list contains "LISTING OF INPUT DATA" and is followed by the sequence number and associated card image.

2.1 Title Card

A title card is designated by an equal sign (=) as the first nonblank character on a card. The remainder of the card can have any alphanumeric characters. The information on the title card and the current date are printed at the beginning of every edit. If more than one title card is entered for a case, the contents of the last title card are used. If no title card is furnished, an error flag is set and the case is terminated upon completion of the input processing.

2.2 Comment Cards

An asterisk (*) or a dollar sign ($) appearing as the first nonblank character identifies the card as a comment card. Any information may be entered on the remainder of the card. Blank cards are

treated as comment cards. Comment cards are not processed other than listing them in the card list. Comment cards may be placed anywhere in the input file.

2.3 Data Cards

All cards other than title cards, comment cards, and slash and period cards (Section III.2.4) are considered data cards. The data cards can contain a varying number of fields which may be decimal integer, decimal floating point, or alphanumeric.

2.3.1 Card Numbering

There is an identifying card number associated with each data card. A unique number or series of numbers are assigned to data cards for each feature or option in RETRAN. As an example, the Volume Data Cards have numbers 05XXXY where 05 indicates the card is a Volume Data Card, XXX is an arbitrary volume number assigned by the user ranging from 001 to 999, and Y is a card sequence number. The volume number XXX can be referenced by other data cards such as the Junction Data Cards when additional features of volume XXX are described, e.g., flow paths and heat sources. Card numbers, in addition to identifying a card, can be used to replace or remove cards.

The first field on a data card is treated as a card number which must be a positive decimal integer number. If the first field has an error or is not a positive decimal integer, the card number is replaced by the current card sequence number, an error statement is printed, and the error flag is set. Data on any card containing an error is not used and will be identified by the card sequence number in the list of unused data cards edited once all required cards have been read.

Continuation cards (Section III.2.3.5) do not have card numbers since they are considered an extension of the first card. After each card number and the accompanying data are converted, the card number is compared to previously entered card numbers. If a matching card number is found, the data entered on the previous card are replaced by the data of the current card. If the card being processed contains only a card number, the card number and the data entered on the previous card are deleted. If a card causes replacement or deletion of data, a statement is printed indicating that the card is a replacement card.

2.3.2 Decimal Field

Blanks preceding and following fields are ignored. A decimal field is started by either a digit (0 through 9), a sign (+ or -), or a decimal point (.). A comma or a blank (with one exception noted below) terminates the decimal field. The decimal field has a number part and an optional exponent part. A decimal field without a decimal point or an exponent is a decimal integer field; a field with either a decimal point or an exponent or both is a decimal floating point field. A decimal floating point field without a decimal point is assumed to have a decimal point immediately in front of the first digit. The exponent denotes the power of ten to be applied to the number part of the field. The exponent part is (1) a sign, (2) an E or D, or (3) an E or D and a sign followed by a number giving the power of ten. Rules for decimal floating point numbers

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are identical to those for entering data in FORTRAN E or F formatted fields except that no blanks (one exception) are allowed between characters. Floating point data punched by FORTRAN programs can be read; to permit this, a blank following an E or D denoting an exponent is treated as a plus sign. Acceptable ways of entering floating point numbers are illustrated by the following seven fields all containing the quantity 12.45,

```
 12.45
+12.45
1245+2
1.245+1
1.245E1
1.245E+1
1.245E 1
```

When entering a decimal zero for either an integer or floating point quantity, the zero can be written in either form. Thus, a floating point zero can be entered simply as 0 without a decimal point.

2.3.3 Alphanumeric Field

A field starting with a nonblank character other than a digit, sign, comma, asterisk, dollar sign or slash is considered a default alphanumeric field. The field is terminated by a comma or the end of the card. All characters except commas can be imbedded in the field. Imbedded blanks are considered part of the alphanumeric field and do not terminate the field. An alphanumeric field can also be delimited by enclosing the field within apostrophes (') or quotes ("). Either is acceptable but they must be used in pairs. A blank or comma must follow the terminating delimiter.

2.3.4 Comment Fields

Comment information may follow the data fields on any data card, including cards that are continued by preceding the comments with an asterisk or dollar sign. A default alphanumeric field preceding a comment must be terminated by a comma or the comment information will be considered part of the alphanumeric field.

2.3.5 Continuation Cards

Data on a card may be continued on a continuation card(s) by entering a plus sign as the first - nonblank character on the continuation card(s). A field starting on a card must be completed on that card and may not continue to the next card. The plus sign, indicating the continuation card, is not considered part of the first data field on the continuation card and may be placed alone or adjacent to the first data field. In subsequent processing, data on continuation cards are treated as if the data were all entered on one card. There is no limit to the number of continuation cards that can be used.

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2.3.6 Card Format Errors

When card format errors are detected, lines containing a dollar sign ($) located under the character causing the error and a comment giving the card column containing the error are printed. A field containing an error is converted as an alphanumeric field of $$$$$$$$. An error flag is set and input processing continues, but the job will be aborted at the end of input processing. Usually another error is produced by a routine attempting to process the erroneous data.

2.4 Terminator Cards

Each problem set is terminated with a period (.) terminator card. A period card or a slash (/) card can be used as the separator between problem sets such as between the base restart input data and the generalized restart data. A slash card has a (/) as the first nonblank character on a card; a period card has a (.) as the first nonblank character. Comments may follow the slash and period on slash and period cards.

3.0 ERROR MESSAGES DUE TO INPUT

RETRAN-3D input data are checked by the free form input processing package and the problem-specific input and initialization subroutines in an attempt to ensure consistency and correctness of user-supplied data. Any input or consistency errors detected during the input and initialization steps of a problem result in an error flag being set. For all detected input errors, an informative message is written and the input processing is continued unless the error is significant enough to encumber further input processing, in which case the problem is terminated. The error messages are written to the output file and to the error log file, errlog. all errors are assigned to a category and given a unique error number. They are listed in Appendix C. Each error also has a corrective action to aid new and infrequent users in resolving the error.

Often, a given input error will propagate additional errors as the input processing continues and in some cases may cause an abnormal termination. If the problem terminates abnormally during input processing or input errors are found that do not seem valid, it is probable that these problems are caused by a previous input error. The pages following the first detected error will have the message "ERROR JOB BEING ABORTED" written in the upper right-hand corner. The error flag is tested following the input and initialization steps and, if set, the problem is terminated so as to prevent execution of costly problems containing detected input errors. The three basic types of input errors are discussed in the following sections.

3.1 Free Form Input Processing Errors

The free form input data processing package checks user-supplied data decks to ensure that all data are in the appropriate format and that the correct number of data items were provided. Any errors detected are accompanied by one of the 2XX error messages listed in Appendix C. The error message is written to both the output and errlog files.

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An example of an error message that can be written from the free form input processing package is shown below.

```
****** ERROR NUMBER       208 FOR FREE FORM INPUT   IN SUBROUTINE INP
        INPUT CARD NO =       0

        A data format error was encountered as indicated above (output file only).
        Processing will be terminated.
```

The error message description for the error can be found in Appendix C. It is shown below along with the associated corrective action.

208 The input data card contains a data format error, the data type cannot be determined. In the output file only (not the **errlog)**, the error will be indicated in the card content listed above the error message.

User Recommendations

Review the data card and make any changes necessary to correct the data field. The error can be caused by including alphanumeric, punctuation or other special characters in the field that should contain an integer or floating point number.

3.2 Data Consistency Errors

Data consistency checks are performed by the problem-specific input processing and initialization subroutines within the RETRAN-3D code during input processing are categorized by input model, volume, junction, heat conductor, etc. They are also given a unique identification number that is associated with a description of the error and the recommended corrective action. An example of an error message that can be written from the control volume input processing subroutine is shown below.

```
****** ERROR NUMBER  5014 FOR VOLUME       151 IN SUBROUTINE INVOL
        INPUT CARD NO =   51151

        THE TIME DEPENDENT VOLUME TABLE NUMBER IREAD IS  12
        BUT ONLY  10 TDV TABLES WERE SUPPLIED.
```

The error message description for the error can be found in Appendix C. It is shown below along with the associated corrective action.

5014 The value of the time dependent volume table supplied via IREAD does not match any of the time dependent tables supplied.

User Recommendation
Either add the specified time dependent volume description using the 07XXYY data cards or revise the value of IREAD to match that of a described time dependent volume. If a time dependent volume description is added, the value of XX must match that of IREAD.

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3.3 Dynamic Memory Allocation Errors

Essentially all memory used by RETRAN-3D is allocated at execution time using Fortran 95 language features. The size of arrays or blocks that are allocated is determined dynamically at execution time using problem dimension and size information contained in the input model. If a memory allocation error occurs during execution, it can be due to

- an input error,
- a coding error, or
- a system configuration error.

Error messages are written for memory allocation errors. They include the type of memory block being allocated, e.g., r_vol for real blocks associated with control volumes, r2_vol for two-dimensional real blocks associated with volumes, etc. The particular component is also identified, along with the name of the subroutine that is attempting to allocate memory.

The error message also includes the size of the memory block that was being allocated as well as a status flag returned from the failed allocation. The size of the block must be > 0. The value of the status flag indicates the reason for the failure. It is operating system dependent, which may require assistance from your computer support group.

Allocation errors may result from input errors related to the size of the problem. They should be detected prior to allocating memory so review the output file to see if such an error is cascading through the input processing and causing the allocation error.

Memory allocation errors should be infrequent. One common cause during development is code errors where the size of the allocated block is negative, zero, or excessively large. The block size and status flag are useful in determining the cause and may require assistance from the code maintenance support contractor or your computer support staff.

The amount of memory available for use by an application program is defined by system configuration parameters. For very large three-dimensional kinetics problems, these parameters may need to be revised to allow the required space to be allocated. This will generally require assistance from you local computer support staff.

IV

RETRAN INPUT DATA SUMMARY

The input description for a RETRAN-3D model is comprised of information defining the geometric configuration, model parameters, and flags to activate models. Much of this information is provided as an input file in card image format. While punched cards are no longer used, the technology remains. What is referred to as a card, is actually a record in the input file.

In the following description of the RETRAN input data cards, the card number is given along with a descriptive title of the data contained on the card. The description includes an explanation of any variable data such as the volume or junction number, which is included in the card number. The order of the data (W1, W2, . . .), the format (I, R, or A), the variable name, and the input data requirements are given where applicable. The format of the data field, integer, real floating point, or alphanumeric is indicated by I, R, or A, respectively.

In addition to the RETRAN-3D data deck, other files may be required to complete the model. These files may include cross-sections and kinetics data, or thermal-hydraulic boundary conditions. Section III provides a summary description of these files. A more detailed discussion of the file formats is given in the Programmer's Manual, Volume 2.

The input files are specified by use of command language (job control) procedures or shell scripts. Examples of procedures used to execute RETRAN-3D are given in Section III.

1.0 TITLE CARD

The title card entered for each case begins with an = sign in column 1 and must have at least one nonblank character in columns 2 through 72.

1.1 Output Listing Control (SMALLR) 000040

The SMALLR option is intended to reduce the amount of printed output. If this option is used, the output file is closed then reopened and the information already written to the output file is deleted. The problem dimension information is always included on the output file. If this card is not supplied, a complete output file listing is generated.

W1-I RFLAG = A flag indicating where the output file will be rewound. This information will be deleted from the output file.
= -1, rewind input deck listing.
= -2, rewind input deck listing and the input edits.
= -3, rewind input deck listing, the input edits and the steady-state edit.

2.0 PROBLEM CONTROL AND DESCRIPTION DATA CARDS 01000Y

The RETRAN problem control and description data are used to specify some output file control flags and other flags that activate many of the model options available in RETRAN-3D. Two different formats are supported for the 01000Y data, one is the classic or long form where the problem dimensions are also included. The other is a short form that only includes the output file control and the model option flags. For the short form, 1 to 12 values may be supplied. From 17 to 42 values may be supplied for the long form.

For either the long or short form of the problem control and description data cards, Y is a sequence number ranging from 1 to 4 and need not be consecutive.

The information supplied on the short form of the problem control and description data cards follows. If the word is not input, along with all those following it, the variables will default to the values indicated. The variables that are included on the long form, but which have been omitted from the short form input, are determined automatically by the code which examines the input card file.

W1-I LDMP = Data file creation flag (used for restarting, re-editing and plotting).
= 0, No data file will be generated.
= -1, A data file will be written to FORTRAN Unit 14 (TAPE14).

W2-I NPRPLT = Flag used to turn printer plot option on (default = 0).
≤ 0, No minor edits will be generated.
= 1, A printer plot of parameter versus time will be generated for each minor edit parameter specified on the 0200XX cards.

W3-I NODEL = Power calculation flag (default = 0). (NOD
EL = 0 if NCOR = 0)
= -1, Retrieve normalized power from a data file from a previous RETRAN run.
= -2, Retrieve normalized power and core Q fractions from previously saved restart file supplied as TAPE12.

= -3 Retrieve Q fractions from TAPE12 but normalized power from power vs. time input records, 141XYY. (Data file supplied through FORTRAN Unit 12. No additional input required.)
= 0, If a nonzero power is specified on Card 010005, retrieve normalized power from power versus time table (141XYY data card). Otherwise, there is no power addition.
= 1, Point kinetics. One prompt neutron group, six delayed neutron groups. The decay heat model is specified on the Decay Heat Option Description Card, Section IV.16.
= 2, One-dimensional kinetics using QX1. This model requires cross-section data from FORTRAN Unit 40. The decay heat model is specified on the Decay Heat Option Description Card, Section IV.16.
= 3, Multidimensional kinetics. Additional input is required to execute this option and is discussed in Section IV.28.

W4-I JSST = Steady-state initialization flag (default = 0).
= 0, Use implicit steady-state option. (Related data cards are 230000 and 230XXY.)
= 1, Steady-state initialization is not used.
= 2, Use implicit steam generator initialization method. (Related data cards are 230000, 230XXY and 2350XY)
< -2, Use implicit steady-state solution and turn on steady-state debugs at iteration |JSST|. (Related data cards are 230000 and 230XXY.)
> 2, Use implicit steam generator initialization method and turn on debugs at iteration |JSST|. (Related data cards are 230000, 2350XY, and 230XXY.)

W5-I IVOID = Neutron void reactivity option flag (default = 0).
= 0, Use void from equation of state.
= 1, Use void from profile fit equation.
(This option is neglected if NEWEQS = 1.)

W6-I IGNTR = Flag to activate the general transport option (default = 0).
= 0, General transport option not used.
= 1, General transport option used with vapor transport medium (4520XX, 4530XX, and 454001 data cards).
= -1, General transport option used with liquid transport medium (4520XX, 4530XX, and 454001 data cards).

W7-I IHTMAP = Heat transfer map option flag (default = 0).
(No additional data cards required.)
= 0, Forced convection heat transfer correlation set.
= 1, Combination forced convection and free convection heat transfer correlation set with condensation. (IHTMAP must equal 1 if NEQS > 0.)
= 2, Forced convection heat transfer correlation with provisions to account for condensation.

W8-I ISFLAG = Slip option flag (default = 0).
= 0, No slip calculation.
= 1, Dynamic slip equation.
= 2, Algebraic slip equation in RETRAN-02 (Zolotar-Lellouche).
= 3, Algebraic slip equation based on drift flux model of Chexal-Lellouche (recommended option).
= 4, Dynamic slip with interphase friction based on drift flux parameters from Zolotar-Lellouche.
= 5, Dynamic slip with interphase friction based on drift flux parameters from Chexal-Lellouche.
= 6, Dynamic slip using dynamic flow regime model (developmental and not recommended for general use).

NOTE: Default coefficients for options = 2 and 4 may be changed on the 061011 data card.

W9-I NEWEQS = Flag to activate balance equations for thermodynamic nonequilibrium (default = 0).
= 0, Use thermodynamic equilibrium.
= 1, Use the five-equation constrained nonequilibrium model.

W10-I NCFLOW = Flag to activate the noncondensable gas flow model (default = 0).
= 0, No noncondensable gas flow.
> 0, Noncondensable gas will flow.

W11-I NUMRCS = Multi-field flags.
= XY Multi-field flags.
X = Iterative time-step algorithm debug edit flag.
= 0, (or blank), no edits
= 1, debug edits will be written.
Y = Flag to select the thermal-hydraulics matrix solver option.
= 2, Use the three- and four-equation solver.
= 3, Use the five-equation option. Required for NEWEQS > 0, NCFLOW = 1, and the

implicit solution for nonequilibrium pressurizer (see Section IV.25).

W12-I ITHSLV = Flag to activate the Purdue iterative thermal-hydraulics matrix solver (default = 0).
≠ 2, Use the standard block elimination solution scheme.
= 2, The iterative solution scheme will be used.

Classic or Long Form Input

The information supplied on the long form of the problem control and description data cards follows. From 17 to 42 integer words may be supplied. If a word is not input, along with all those following it, the variables will default to the values indicated.

A new output edit is provided for input decks using the long form of the problem constant and description data (Cards 01000Y). This edit will be found following the long form output edit for the 01000Y data. It contains the replacement cards required to convert the input deck to use the short form for the 01000Y data. The edit also includes instructions for use of the replacement cards.

W1-I LDMP = Data file creation flag (used for restarting, re-editing and plotting).
= 0, No data file will be generated.
= -1, A data file will be written to FORTRAN Unit 14 (TAPE14).

W2-I NEDI = Number of minor edit variables requested (0200YY data cards).
= 0, No minor edits will be generated.
> 0, Minor edits will be generated.
< 0, Minor edits will be generated and printer plots of parameter versus time will be generated for each minor edit parameter.

W3-I NTC = Number of time-step data sets supplied (03XXX0 data cards).
(NTC $\geq$ 1)

W4-I NTRP = Number of trip control cards supplied (04XXX0 data cards).
(NTRP $\geq$ 1)

W5-I NVOL = Number of control volumes described (05XXXY data cards).
(NVOL $\geq$ 1)

W6-I	NBUB	=	Number of bubble parameter data sets supplied (060XXY data cards). (NBUB $\geq$ 0)
W7-I	NTDV	=	Number of time-dependent volume boundary conditions specified on cards (07XXYY data cards). (NTDV $\geq$ 0)
W8-I	NJUN	=	Number of flow paths or junctions described (08XXXY data cards). (NJUN $\geq$ 1)
W9-I	NPMPC	=	Number of centrifugal pump descriptions supplied (090XXY data cards). (NPMPC $\geq$ 0)
W10-I	NCKV	=	Number of valves described (11XXXO data cards). A given valve description may be used at several junction locations. (NCKV $\geq$ 0)
W11-I	NLK	=	Number of general data tables supplied (12XXYY data cards). A given table may be used any number of times. (NLK $\geq$ 0)
W12-I	NFLL	=	Number of fill system curves supplied (13XXYY data cards). A given fill may be used any number of times. (NFLL $\geq$ 0)
W13-I	NSLB	=	Number of heat conductors described (15XXXY data cards). (NSLB $\geq$ 0)
W14-I	NGOM	=	Number of heat conductor geometries described (17XXYY data cards). (NGOM = 0 if NSLB = 0) (NGOM $\geq$ 1 if NSLB > 0)
W15-I	NMAT	=	Number of heat conductor materials described (18XXYY, 19XXYY and 20XXYY data cards). (NMAT = 0 if NSLB = 0) (NMAT $\geq$ 1 if NSLB > 0)
W16-I	NCOR	=	Number of powered heat conductors or core sections described (16XXX0 data cards). (NCOR = 0 if NSLB = 0) (NCOR $\geq$ 1 if NSLB > 0)

W17-I	NHTX	=	Number of nonconducting heat exchangers described (21XXYY data cards). (NHTX $\geq$ 0)
W18-I	NTMM	=	No longer used (enter as 0).
W19-I	NODEL	=	Power calculation flag (default = 0). (NODEL = 0 if NCOR = 0) = -1, Retrieve normalized power from a data file from a previous RETRAN run. = -2, Retrieve normalized power and core Q fractions from previously saved restart file supplied as TAPE12. = -3 Retrieve Q fractions from TAPE12 but normalized power from power versus time input records, 141XYY. (Data file supplied through FORTRAN Unit 12. No additional input required.) = 0, Retrieve normalized power from power versus time table (141XYY data card). = 1, Point kinetics. One prompt neutron group, six delayed neutron groups. The decay heat model is specified on the Decay Heat Option Description Card, Section IV.16. = 2, One-dimensional kinetics using QX1. This model requires cross-section data from FORTRAN Unit 40. The decay heat model is specified on the Decay Heat Option Description Card, Section IV.16. = 3, Multidimensional kinetics. Additional input is required to execute this option and is discussed in Section IV.28.
W20-I	MWREAC	=	No longer used (enter 0).
W21-I	NCFLOW	=	Flag to activate the noncondensable gas flow model (default = 0). = 0, No noncondensable gas flow. > 0, Noncondensable gas will flow.
W22-I	MTDV	=	Number of time-dependent volume boundary conditions to be retrieved from a RETRAN data file supplied by FORTRAN Unit 12 (default = 0). (MTDV $\geq$ 0)
W23-I	ISFLAG	=	Slip option flag (default = 0). = 0, No slip calculation. = 1, Dynamic slip equation.

= 2, Algebraic slip equation in RETRAN-02 (Zolotar-Lellouche).
= 3, Algebraic slip equation based on drift flux model of Chexal-Lellouche (recommended option).
= 4, Dynamic slip with interphase friction based on drift flux parameters from Zolotar-Lellouche.
= 5, Dynamic slip with interphase friction based on drift flux parameters from Chexal-Lellouche.
= 6, Dynamic slip using dynamic flow regime model (developmental and not recommended for general use).

NOTE: Default coefficients for options = 2 and 4 may be changed on the 061011 data card.

W24-I NCHT = Number of user-specified heat transfer coefficient descriptions supplied (015XXX data cards) (default = 0). (NCHT $\geq$ 0)

W25-I JSST = Steady-state initialization flag (default = 0).
= 0, Use implicit steady-state option. (Related data cards are 230000 and 230XXY.)
= 1, Steady-state initialization is not used.
= 2, Use implicit steam generator initialization method. (Related data cards are 230000, 230XXY and 2350XY.)
< -2, Use implicit steady-state solution and turn on steady-state debugs at iteration |JSST|. (Related data cards are 230000 and 230XXY.)
> 2, Use implicit steam generator initialization method and turn on debugs at iteration |JSST|. (Related data cards are 230000, 2350XY, and 230XXY.)

W26-I IPRZR = Flag to activate the two-region nonequilibrium volume option (610XXX data cards) (default = 0).
= 0, Option not used.
= 1, Two-region nonequilibrium option will be used.

W27-I ITRNS = Flag to activate the temperature transport delay option flag (default = 0). (Additional input required on 05XXXY data cards.)
= 0, No temperature transport delay volumes.
> 0, Transport delay option will be used.

W28-I IDNBC = Flag to activate the auxiliary DNB option flag (default = 0).
= 0, No auxiliary DNB calculations.

> 0, Auxiliary DNB calculations will be used (8001XX, 8002XX, 8003XX, 8004XX and8005XX data cards).

W29-I ICF = Flag to activate the control system option flag (default = 0).
= 0, Control systems option not used.
= 1, Control system option used (701000, 702XXX and 703XXX data cards).

W30-I IHTMAP = Heat transfer map option flag (default = 0).
(No additional data cards required.)
= 0, Forced convection heat transfer correlation set.
= 1, Combination forced convection and free convection heat transfer correlation set with condensation. (IHTMAP must equal 1 if NEQS > 0.)
= 2, Forced convection heat transfer correlation with provisions to account for condensation.

W31-I NACC = Flag to activate the accumulator model option flag (default = 0).
= 0, Model not used.
> 0, Number of accumulator volumes (620XXX data cards).

W32-I NGAP = Flag to activate the dynamic gap conductance solution flag (default = 0).
= 0, Model not used.
> 0, Number of dynamic gap data cards (225XXY) supplied. (If NODEL = 3, the number of gap data cards is determined from the channel data cards 672XXX and NGAP is ignored. If NODEL ≠ 3, NGAP > 0 requires NSTK > 0 and NSTK 2200XY cards are required.)

W33-I NUMRCS = Multi-field flags.
= XY Multi-field flags.
X = Iterative time-step algorithm debug edit flag. The debug edits are used as a diagnostic aid to identify which time-step control algorithm is controlling the time-step selection process. It also identifies the component (volume, junction, etc.) that is limiting the selection and includes additional information pertinent to the selection process.
= 0, (or blank), no edits
= 1, debug edits will be written.
Y = Flag to select the thermal-hydraulics matrix solver option.
= 2, Use the three- and four-equation solver.
= 3, Use the five-equation option. Required for NEWEQS > 0, NCFLOW = 1, and the

			implicit solution for nonequilibrium pressurizer (see Section IV.25).
W34-I	NSTK	=	Number of conductor stacks; required for the local conditions and dynamic gap conductance models (default = 0). = 0, No conductor stacks supplied. > 0, Number of conductor stack data cards (2200XY) supplied. NOTE: The local conditions and gap conductance models may be used together or separately. Use of the dynamic gap model with multidimensional kinetics (NODEL = 3) does not require conductor stacks.
W35-I	NTSH	=	Number of turbine shafts (default = 0). (500XXY, 5010XY, and 51XYYZ data cards).
W36-I	IVOID	=	Flag to activate the neutron void reactivity option (default = 0). = 0, Use void from equation of state. = 1, Use void from profile fit equation. (This option is neglected if NEWEQS = 1).
W37-I	NFIT	=	Number of void profile coefficient data sets (061XX1 data cards) (default = 0). = 0, Use default coefficients for slip and neutron void options and five-equation heat transfer models. > 0, User specifies coefficients on Card 061XX1.
W38-I	JFLAG	=	No longer used (enter as 0).
W39-I	NEWEQS	=	Flag to activate balance equations for thermodynamic nonequilibrium (default = 0). = 0, Use thermodynamic equilibrium. = 1, Use the five-equation constrained nonequilibrium model.
W40-I	NSEPR	=	Number of steam separators modeled with the nonequilibrium steam separator model (60XXXY data cards) (default = 0). = 0, Nonequilibrium steam separator not used. > 0, Steam separator model will be used.
W41-I	IGNTR	=	Flag to activate the general transport option flag (default = 0). = 0, General transport option not used.

= 1, General transport option used with vapor transport medium (4520XX, 4530XX, and 454001 data cards).
= -1, General transport option used with liquid transport medium (4520XX, 4530XX, and 454001 data cards).

W42-I ITHSLV = Flag to activate the Purdue iterative thermal-hydraulics matrix solver (default = 0).
≠ 2, Use the standard block elimination solution scheme.
= 2, The iterative solution scheme will be used.

2.1 Problem Control and Description Input User Guidelines

Much of the data supplied with the long form of the problem control and description input is a count for the number of specific components or is a modeling feature where there is a clear choice for selecting the input. There are some modeling choices that may not be straightforward and this section provides guidance on those option choices. The order of the input variable is shown for both the short (shown on the first line) and the long form (shown on the second line) input options.

W3-I NODEL
W19-I

This parameter defines how the core power is computed. There are several options to define power as a boundary condition. These are Options -1, -2 , -3, and 0. These options should be used when a known power response is to be imposed on a system or hot-channel analysis.

Options 1, 2, and 3 choose reactor kinetics models to define the total power and in the case of Options 2 and 3, the power distribution. There is additional input required for each of these options.

Option 1 (point kinetics) is adequate for transient analysis where very little shift in the power distribution is expected to occur during the simulation. This is the case for most PWR transients. For transients where an axial shift in power is expected, Option 2 (one-dimensional kinetics) is the proper choice. Option 2 is the recommended modeling choice for BWR transient analysis. For transients where a significant shift in both axial and radial power distribution is expected, Option 3 (multidimensional kinetics) is the proper choice for best-estimate analysis. Examples of these transients are PWR main steam line break and a rod ejection accident analysis; and BWR rod ejection accident analysis. In some cases, these transients can be analyzed with other kinetics options using conservative assumptions to account for the lack of multidimensional modeling capability.

W8-I
W23-I

ISFLAG

This option chooses the model used to simulate unequal phase velocities. If zero is chosen, the model will be use where both the liquid and vapor phases are assumed to move at the same velocity and in the same direction. This is commonly called the "three-equation" or "homogeneous equilibrium" option, where the three equations solved are the mixture continuity, momentum, and energy equations. The liquid and vapor phases are assumed to exist at equal temperature and move at equal velocity. A detailed discussion of the slip velocity models and the optional junction input is in Section 8.1.

The use of a slip model will allow the phase velocities to differ in magnitude and possibly direction. This is commonly referred to as the "four-equation" model. The slip models can significantly change the mass distribution in two-phase regions when compared to using no slip models. Slip will improve a simulation if significant two-phase conditions exist in the modeled system, e.g., BWR models and PWR models with detailed steam generator secondary-side representation.

There are two general forms of slip models, dynamic and algebraic. The RETRAN-3D SER favors the use of the algebraic slip models since more validation work has been done with these than the dynamic slip models.

Algebraic Slip

The algebraic slip model is based on the drift flux approach where coefficients in the drift flux equation are obtained from fitting experimental void fraction data. The algebraic slip model is a purely empirical model that is used to define the difference between the phase velocities.

= 2, This algebraic slip model uses and empirical Zolotar-Lellouche correlation. The data used to develop this correlation are representative of upflow conditions in BWR cores. Consequently, its use may be inappropriate for other geometries and it should be limited to applications of vertical upflow. This option was available in RETRAN-02 and is unchanged here. It should be used for RETRAN-02 made analyses as noted in the SER.

= 3, This algebraic slip model uses and empirical Chexal-Lellouche correlation. The developers of this correlation utilized the Zolotar-Lellouche correlation and the void fraction data base from that

correlation as a starting point. Void fraction data were also collected from several other experiments that have more geometry types and different flow patterns. As a consequence, this correlation is applicable to a much wider range of configurations. In addition, it maintains very similar characteristics to the Zolotar-Lellouche correlation for BWR core applications. An extensive amount of validation has been done for this option; consequently, the model is recommended for general use in the SER.

Dynamic Slip

The dynamic slip equation is obtained from differencing the phasic momentum equations. Therefore, there are two momentum equations solved, a difference momentum equation (dynamic slip equation) and a mixture momentum equation. These two differential equations are solved implicitly with the other conservation equations. The dynamic slip model requires additional flow field models to select the flow regime, which is then used to define the interphase friction and wall friction.

= 1, This option chooses the dynamic slip equation with default flow field models for interphase friction and wall friction. The predicted flow regime is used to choose specific forms of the flow field models. A choice to use a vertical or horizontal flow regime map is made on the junction input (08XXXY) using the IFRJ input variable.

= 4, This option is a hybrid algebraic/dynamic slip model. The dynamic slip equation is solved (as in the ISFLAG=1 option) however; the standard flow field model for interphase friction is replaced by a model that uses the drift flux correlation to define interphase friction. For this option, the Zolotar-Lellouche drift flux correlation is used to define the interphase friction. The same limitations stated above for the Zolotar-Lellouche model apply here.

= 5, This option is a hybrid algebraic/dynamic slip model. The dynamic slip equation is solved (as in the ISFLAG=1 option) however; the standard flow field model for interphase friction is replaced by a model that uses the Chexal-Lellouche drift flux correlation to define interphase friction.

= 6, The dynamic flow regime model is used in conjunction with the dynamic slip model. It uses an additional differential equation to determine the interfacial area required for the interphase friction

		flow field model. It is a developmental model that may be used for further research. It should not be used in any licensing related applications.
W4-I W25-I	JSST	This option provides choices relative to defining initial thermal-hydraulic conditions. A value of zero is recommended for general use since this choice will minimize the input required and will provide a consistent set of initial steady-state conditions throughout the system. If the option of 1 is chosen, all nodal thermal-hydraulic conditions must be input. The final option of 2 was designed for PWR initialization at a very low power level. Specifically, low power initialization of once-through steam generators was quite difficult. This implicit initialization method proved quite helpful for that application. It is also applicable to u-tube steam generator designs, but may not be needed.
W7-I W30-I	IHTMAP	There are two sets of heat transfer coefficient correlations to simulate the boiling curve. A set of correlations that models forced convection only that was used in early versions of RETRAN and a revised set that models both forced and free convection. Under low flow conditions, the use of forced convection heat transfer coefficient correlations may not be appropriate. Option 0 uses the forced convection set only. IHTMAP=1 allows the code to choose between the forced and free convection heat transfer coefficient correlations based on flow conditions. Condensation heat transfer correlations are available with the natural convection boiling curve IHTMAP=1 and an option, IHTMAP=2, makes condensation available with the forced convection map.
W5-I W36-I	IVOID	When thermal equilibrium between the phases is assumed, as with the three- and four-equation options, subcooled boiling cannot be modeled directly from the balance equations. Subcooled boiling is important to reactivity feedback in BWR simulations. Consequently, a special purpose model is required to simulate subcooled boiling. This option activates the subcooled boiling special purpose model. Additional input may be required as described in Section 7.8. If the five-equation option is selected, this special purpose model is not needed and will be neglected if selected.

W9-I W39-I	NEWEQS	This variable is used to select the balance equations used to model the thermal-hydraulic system. Option 0 is used with the three- and four-equation options. Option 1 should be used if thermal nonequilibrium between the phases is desired. Option 1 can be used to simulate subcooled boiling in BWR core regions or to simulate injection of cold water into two-phase regions such as activation of the emergency core cooling system.
W11-I W33-I	NUMRCS	The main difference between options NUMRCS=2 and NUMRCS=3 is the matrix that is solved. For NUMRCS=3, the matrix is much larger than for NUMRCS=2. Consequently, the time spent per time step in the solver will be more for NUMRCS=3. In general, NUMRCS=2 is the proper choice unless the five-equation option is used. NUMRCS=3 should be chosen if the five-equation option is chosen or if the implicit solution for the two-region nonequilibrium volume is desired. Refer to Section 25.0 for more details on the two-region nonequilibrium volume solution methods.
W12-I W42-I	ITHSLV	The iterative solution scheme for the fluid dynamics equations was developed for problems that involve a multiple-channel thermal-hydraulic core model, generally used in conjunction with the three-dimensional kinetics model. This iterative scheme is especially efficient compared with the block elimination solution method when there are a large number of core channels or when the steady-state flow calculation option is used. It is recommended that the user choose the iterative solution scheme if the core model consists of more than 20 hydraulic channels, or the steady-state flow calculation (flow splits) is used for initialization. It is activated by setting ITHSLV=2 on the Problem Dimension Data 01000Y.

3.0 PROBLEM AND CONSTANT DATA

A number of optional constants and model parameters can be supplied as part of a RETRAN-3D input file. They include items such as the initial thermal power level and the composition of the noncondensable gas that will be used. The following sections define the input requirements for these options.

3.1 Initial Power Data Cards 010005

The initial power, POWER, is supplied in megawatts on this card. This parameter is the initial thermal power generated in powered conductors and the associated power which may, at the user's option, be deposited directly in a fluid volume associated with a powered conductor by use of the direct moderator heating option. This card must be supplied if NCOR on Card 01000Y is greater than 0 or if a nonconducting heat exchanger (Cards 21XXYY) uses an ITYPE = 3 or 6.

W1-R	POWER	=	Initial power (megawatts).

3.2 Noncondensable Gas Composition Data Card 010010

The noncondensable gas used in RETRAN-3D defaults to air. The composition of the noncondensable gas can be specified by use of the optional Noncondensable Gas Composition Data Card 010010. It is used to define the mass fraction of each constituent gas. An error message is written and the problem terminated if the mass fractions do not sum to unity.

W1-R	Argon	=	mass fraction
W2-R	Carbon Dioxide	=	mass fraction
W3-R	Carbon Monoxide	=	mass fraction
W4-R	Helium	=	mass fraction
W5-R	Hydrogen	=	mass fraction
W6-R	Nitrogen	=	mass fraction
W7-R	Oxygen	=	mass fraction

4.0 MINOR EDIT VARIABLE DATA CARDS 0200YY

RETRAN allows both major and minor edits of printed output during problem execution, with the edit frequency for the edits specified by the use of TMAJ and TMIN, respectively (Cards 03XXX0). The minor edit allows the user to select a frequent edit of NEDI (Card 01000Y) variables from a large pool of calculated parameters. Minor edits consist of up to eight (nine including elapsed time which is automatically edited) minor edit variables across a page and values for fifty time steps down a page. If more than eight minor edit variables are edited, the first eight will be edited on one page, the next eight (or fewer), on the next page and so on until all NEDI parameters have been edited. The variables for which minor edits can be obtained are listed in Tables IV.4-1 through IV.4-22.

Table IV.4-1

Volume Parameters Available for Minor Edits

Region number is the desired volume number.

Symbol	Variable	Units	
PRES	Average Pressure	psia	kpa
TEMP	Average Temperature	deg F	deg K
SATP	Saturation Pressure	psia	kpa
SATT	Saturation Temperature	deg F	deg K
STVF	Saturated Liquid Specific Volume	ft^3/lb	m^3/kg
STVG	Saturated Gas Specific Volume	ft^3/lb	m^3/kg
STHF	Saturated Liquid Specific Enthalpy	btu/lb	kj/kg
STHG	Saturated Gas Specific Enthalpy	btu/lb	kj/kg
HW**	Specific Enthalpy	btu/lb	kj/kg
AVEX	Average Quality	( )	( )
FMAS	Total Fluid Mass	lb	kg
GASM	Vapor Mass	lb	kg
AVED	Average Density	lb/ft^3	kg/m^3
UTOT	Total Internal Energy	btu	kj
WVBR	Volume Average Flow	lb/sec	kg/sec
WQ**	Power Into Coolant	btu/hr	watts
QSPL	Energy Added to Volume	btu/sec	kw
NVOI	Void Fraction for Neutronics Reactivity	( )	( )
VOIV	Void Fraction	( )	( )
WGV*	Vapor-Phase Flow	lb/sec	kg/sec
WLV*	Liquid-Phase Flow	lb/sec	kg/sec
VSLV	Slip Velocity	ft/sec	m/sec
VGV*	Vapor-Phase Velocity	ft/sec	m/sec
LIQL	Liquid Level	feet	meters
LIQM	Liquid Mass	lb	kg
LIQV	Liquid Volume	ft^3	m^3

Table IV.4-1 (Cont'd)

Symbol	Variable	Units	
VL**	Liquid Specific Volume	ft^3/lb	m^3/kg
VS**	Vapor Specific Volume	ft^3/lb	m^3/kg
GASH	Vapor Enthalpy	btu/lb	kj/kg
LIQH	Liquid Enthalpy	btu/lb	kj/kg

Five-equation minor edit parameters.

Symbol	Variable	Units	
MDOT	Mass Transfer Rate	lb/sec	kg/sec
QLIQ	Liquid Heating Rate	btu/s	kw
TEML	Liquid Temperature	deg F	deg K
TEMV	Vapor Temperature	deg F	deg K
MDDT	Mass Transfer Due to Temperature Difference	lb/sec	kg/sec
HTC*	Interfacial Heat Transfer Coefficient	b/f^2-F	w/m^2-K
AREA	Interfacial Area Density	1/ft	1/m
IFRV	Volume Flow Regime	( )	( )

Water-noncondensable minor edit parameters.

Symbol	Variable	Units	
AIRH	Noncondensable enthalpy	btu/lb	kj/kg
AIRM	Noncondensable mass	lb	kg
HUM*	Relative humidity	( )	( )
PNC*	Noncondensable partial pressure	psia	kpa
VAPH	Water vapor enthalpy	btu/lb	kj/kg
VAPV	Specific volume of water vapor	ft^3/lb	m^3/kg
VNON	Specific volume of noncondensable	ft^3/lb	m^3/kg
VS**	Specific volume of gaseous mixture	ft^3/lb	m^3/kg
XNC*	Noncondensable mass fraction of gaseous mixture	( )	( )
XVAP	Vapor mass fraction of water mass	( )	( )

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Table IV.4-1 (Cont'd)

The flow regimes and corresponding IFRV values are:

Vertical Flow	IFRV	Horizontal Flow	IFRV
Single-Phase Liquid	1	Single-Phase Liquid	11
Bubble	2	Bubble	12
Slug	3	Slug	13
Transition	4	Transition	14
Annular-Mist	5	Annular-Mist	15
Single-Phase Vapor	6	Single-Phase Vapor	16
Dispersed Droplet	7	Dispersed Droplet	17
		Stratified	19

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Table IV.4-2

Junction Parameters Available for Minor Edits

Region number is the desired junction number.

Symbol	Variable	Units	
WP**	Mass Flow Rate	lb/sec	kg/sec
GPM*	Volumetric Flow Rate	gal/m	m^3/sec
ICHK	Choking Mode 1. = No choking, inertial flow solution 2. = Moody 3. = Extended Henry 4. = Isoenthalpic-Expansion	( )	( )
DELA	Pressure Differential Due to Acceleration	psia	kpa
DELE	Pressure Differential Due to Elevation	psia	kpa
DELF	Pressure Differential Due to Friction	psia	kpa
XP**	Quality	( )	( )
HP**	Enthalpy	btu/lb	kj/kg
AVDJ	Density	lb/ft^3	kg/m^3
PMPP	Pressure Differential Due To Pump	psia	kpa
DELP	Pressure Differential Due To Dynamic Head	psia	kpa
SPVJ	Specific Volume	ft^3/lb	m^3/kg
AJNT	Time-Dependent Area	ft^2	m^2
HFLO	Flowing Enthalpy	btu/lb	kj/kg
HPL*	Enthalpy of Liquid Phase	btu/lb	kj/kg
HPG*	Enthalpy of Vapor Phase	btu/lb	kj/kg
SPJL	Specific Volume of Liquid Phase	ft^3/lb	m^3/kg
SPJG	Specific Volume of Vapor Phase	ft^3/lb	m^3/kg
VOIJ	Void Fraction	( )	( )
VSLJ	Slip Velocity	ft/sec	m/sec
WLJ*	Liquid-Phase Mass Flow Rate	lb/sec	kg/sec

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Table IV.4-2 (Cont'd)

Symbol	Variable	Units	
WGJ*	Vapor-Phase Mass Flow Rate	lb/sec	kg/sec
VGJ*	Vapor-Phase Velocity	ft/sec	m/sec
VLJ*	Liquid-Phase Velocity	ft/sec	m/sec
SCNV	Slip Energy Convection Rate	btu/seckw	

Symbol	Variable	Units	
IFRL	Flow Regime	( )	( )
PJUN	Junction Pressure	psia	kpa
SLPR	Slip Ratio	( )	( )
TEMJ	Temperature	deg F	deg K
XPNC	Air mass fraction of gaseous mixture	( )	( )

The flow regimes and corresponding IFRL values are:

Vertical Flow	IFRL	Horizontal Flow	IFRL
Single-Phase Liquid	1	Single-Phase Liquid	11
Bubble	2	Bubble	12
Slug	3	Annular	15
Froth	4	Single-Phase Vapor	16
Annular	5	Dispersed Droplet	17
Single-Phase Vapor	6	Stratified	19
Dispersed Droplet	7		

Special Conditions	IFRL
$v^{\ell} = 0, v^{g} \neq 0$	-6
$v^{\ell} \neq 0, v^{g} = 0$	-1

Note: The flow regime is determined only if ISFLAG = 1 (Card 01000Y).

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Table IV.4-3

System Parameters Available for Minor Edits

Region number must be 0.

Symbol	Variable	Units	
AE**	Energy Added	btu	kj
AMAS	Mass Added	lb	kg
BMSW	Mass Water	lb	kg
BMSA	Mass Air	lb	kg
EB**	Energy Balance	btu	kj
FE**	Fuel Energy	btu	kj
HE**	Energy Removed	btu	kj
PNRM	Normalized Power	( )	( )
QLOS	Heat Removal Rate	btu/hr	watts
CPUS	CPU Time	sec	sec
TIMX	Elapsed Time	sec	sec
POWR	Core Power	mw	mw
PTHR	Total Thermal Power	btu/hr	watts
PPOW	Fission Power Normalized to Total Power	( )	( )
DPOW	Decay Heat Power Normalized to Total Power	( )	( )
DCAY	Decay Heat (Obsolete, use DPOW)	( )	( )
PRPT	Prompt Power (Obsolete, use PPOW)	( )	( )

Table IV.4-4

Pump Parameters Available for Minor Edits

Region number is the desired pump number.

Symbol	Variable	Units	
SPED	Speed	rpm	rpm
TORQ	Normalized Pump Torque	( )	( )
PMTQ	Normalized Motor Torque	( )	( )
PFTQ	Normalized Frictional Torque	( )	( )
PMPW	Pump Power (Irrecoverable Loss)	btu/hr	watts

All torque values are normalized to rated conditions.

Table IV.4-5

Bubble Rise Parameters Available for Minor Edits

Region number is the desired volume number.

Symbol	Variable	Units	
ALPH	Bubble Gradient	( )	( )
VBUB	Bubble Rise Velocity	ft/sec	m/sec
MIXL	Mixture Level	feet	meters
BUBM	Vapor Mass Below the Mixture Level	lb	kg
MIXV	Mixture Volume	ft^3	m^3
MIXQ	Mixture Quality	( )	( )

Table IV.4-6

Conductor Parameters Available for Minor Edits

Region number is the desired conductor number.

Symbol	Variable	Units	
SE**	Stored Energy	btu	kj
FCHL	Left Surface Critical Heat Flux	b/hr-f^2	watts/m^2
FCHR	Right Surface Critical Heat Flux	b/hr-f^2	watts/m^2
HTCL	Left Surface Heat Transfer Coefficient	b/hf^2-F	w/m^2-K
HTCR	Right Surface Heat Transfer Coefficient	b/hf^2-F	w/m^2-K
PHIL	Left Surface Heat Flux	b/hr-f^2	watts/m^2
PHIR	Right Surface Heat Flux	b/hr-f^2	watts/m^2
WQCL	Left Surface Power to Coolant	btu/hr	watts
WQCR	Right Surface Power to Coolant	btu/hr	watts
IHTL	Left Surface Heat Transfer Mode	( )	( )
IHTR	Right Surface Heat Transfer Mode	( )	( )
TL**	Left Surface Temperature	deg F	deg K
TR**	Right Surface Temperature	deg F	deg K
GL**	Left Surface Mass Flux	lb/hr-f^2	kg/hr-m^2
GR**	Right Surface Mass Flux	lb/hr-f^2	kg/hr-m^2
Txxx	Conductor Node Temperature (xxx must be a valid node number and all three characters must be supplied, e.g., xxx = 001 for the first node.)	deg F	deg K

The following are defined only if the local conditions heat transfer option is used:

XLOL	Left Volume Local Quality	( )	( )
XLOR	Right Volume Local Quality	( )	( )

Table IV.4-7

Core Conductor Parameters Available for Minor Edits

Region number is the desired core section number. When the channel model is used with three-dimensional kinetics, the core section region number is:

Region = (C-1)*P+N

where

C = channel number,
N = axial node number in the channel, and
P = maximum number of nodes in each channel.

Symbol	Variable	Units	
CORQ	Conductor Heating Rate	btu/hr	watts
TAVG	Average Metal Temperature	deg F	deg K
MODQ	Direct Moderator Heating Rate	btu/hr	watts
QFRA	Normalized Power Fraction	( )	( )
	The following are defined only if fuel density tables are entered.		
FENT	Fuel Enthalpy	cal/gr	cal/gr
DFEN	Delta Fuel Enthalpy	cal/gr	cal/gr
	The following are defined only if the metal-water reaction model is used.		
CTR*	Depth of Metal-Water Reaction (Outside)	feet	meters
QMWR	Heat Generation Rate from Metal-Water Reaction	btu/hr	watts
CTRI	Depth of Metal-Water Reaction (Inside)	feet	meters

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Table IV.4-8

Point Reactor Kinetics Parameters Available for Minor Edits

Region number must be 0.

Symbol	Variable	Units	
PERD	Reactor Period	sec	sec
REAC	Total Reactivity	$	$
W1**	Inverse Period	1/sec	1/sec
RKDT	RKEN Time-Step Size	sec	sec
RC**	Control Reactivity	$	$
RW**	Reactivity from Water Temperature Coefficient	$	$
RV**	Reactivity from Density Reactivity Tables	$	$
RF**	Reactivity from Fuel Temperature Coefficient	$	$
RD**	Reactivity from Doppler Reactivity Tables	$	$
RWIN	Coolant Reactivity at t=0	$	$
RVIN	Void Reactivity at t=0	$	$
RFIN	Fuel Reactivity at t=0	$	$
RDIN	Doppler Reactivity at t=0	$	$

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Table IV.4-9

Decay Heat Precursor Parameters Available for Minor Edits

Since the number of decay heat precursors has been made optional, the editing of individual precursors requires specification of a group number. If the user asks for a group number that does not exist (such as Group 22 when the 1973 decay heat option is employed) an error message will be written.

Region number is 0.

Symbol	Variable
CNXX	XX is the Group Number

Table IV.4-10

Time-Step Parameters Available for Minor Edits

Region number must be 0.

Symbol	Variable	Units	
NSTP	Current Time-Step Number	( )	( )
NTTS	Actual Time-Step Number	( )	( )
DTOL	Old Time-Step Size	sec	sec
DTAV	Average Time-Step Size Between Minor Edits	sec	sec

Table IV.4-11

Heat Exchanger Parameters Available for Minor Edits

Region number is the desired nonconducting heat exchanger number.

Symbol	Variable	Units	
THQ*	Primary-Side Temperature	deg F	deg K
HTQ*	Heat Removal Rate	btu/hr	watts
TSEC	Secondary-Side Temperature	deg F	deg K
HTXC	Overall Heat Transfer Coefficient	b/hf^2-F	w/m^2-K

Table IV.4-12

Two-Region Nonequilibrium Volume Parameters Available for Minor Edits

The region number is the desired volume number.

Symbol	Variable	Units	
NELM	Liquid Region Mass	lb	kg
NELE	Liquid Region Energy	btu	kj
NELH	Liquid Region Enthalpy	btu/lb	kj/kg
NLVO	Liquid Region Volume	ft^3	m^3
NELT	Liquid Region Temperature	deg F	deg K
NELV	Liquid Region Specific Volume	ft^3/lb	m^3/kg
NELX	Liquid Region Quality	( )	( )
NEVM	Vapor Region Mass	lb	kg
NEVE	Vapor Region Energy	btu	kj
NEVH	Vapor Region Enthalpy	btu/lb	kj/kg
NEVT	Vapor Region Temperature	deg F	deg K
NEVX	Vapor Region Quality	( )	( )
NEVV	Vapor Region Specific Volume	ft^3/lb	m^3/kg
VHTC	Inter-Region Heat Transfer Coefficient	btu/ft^2-hr-F	w/m^2-K
QVHT	Inter-Region Heat Transfer Rate	btu/sec	kw
CLQL	Cumulative liquid level for collapsed pressurizer	ft	m
CMXL	Cumulative mixture level for collapsed pressurizer	ft	m

Table IV.4-13

Separator Model Parameters Available for Minor Edits

The region number is the desired separator volume number. Separator volumes are numbered sequentially (beginning at 1) as they are encountered while processing the control volume input data.

Symbol	Variable
COVD	Carryover Fraction
CUND	Carryunder Fraction

Table IV.4-14

Transport Volume Parameters Available for Minor Edits

Region number is the desired volume number.

Symbol	Variable
Hxxx	Mesh Point Enthalpy, where xxx is the Mesh Point Number.

Table IV.4-15

Control System and Trip Quantities Available for Minor Edits

Region number is control block ID.

Symbol	Variable	Units	
COUT	Control Block Output	( )	( )

Region number is the trip ID (must be positive).

Symbol	Variable	Units	
TRPT	Trip Point Time	sec	sec
TRIP	Trip Activation Flag = 0, Not Activated = 1, Activated	( )	( )

Table IV.4-16

DNB Parameters Available for Minor Edits

Region number must be 0.

Symbol	Variable	Units	
HGRC	Average LHGR in Core	kw/ft	kw/m
DNBC	Average DNBR in Core	( )	( )
HGRM	Linear Heat Generation Rate at Minimum Height	kw/ft	kw/m
DNBM	DNBR at Minimum Height	( )	( )
HGRH	Linear Heat Generation Rate at the Hot Spot	kw/ft	kw/m
DNBH	DNBR at the Hot Spot	( )	( )
ZDNB	Elevation where Minimum DNBR occurs	feet	meters
HGRZ	Linear Heat Generation Rate at Minimum DNBR Location	kw/ft	kw/m
DNBZ	Minimum DNBR in Core	( )	( )

Region number is axial node.

Symbol	Variable		
DNBR	Axial Node DNBR	( )	( )

Table IV.4-17

Turbine Model Parameters Available for Minor Edits

Region number is the turbine shaft number.

Symbol	Variable	Units	
POWO	Total Output Power from the Shaft	btu/hr	watts
SRPM	Shaft Speed	rpm	rpm

Table IV.4-18

One-Dimensional Kinetics Quantities Available for Minor Edits

Overall kinetics parameters. Region number is 0.

Symbol	Variable	Units	
ALPA	Inverse Period	1/sec	1/sec
RO**	Total Reactivity - ΔK/K	( )	( )
RPOS	Rod Bank Travel Relative To Initial Position	feet	meters
PROL	Prompt Neutron Generation Time	sec	sec
RDRE	Control Rod Worth - ΔK/K	( )	( )
DPRE	Doppler Reactivity - ΔK/K	( )	( )
VDRE	Density Reactivity - ΔK/K	( )	( )
RSRE	Residual Reactivity - ΔK/K	( )	( )

Neutronic region parameters. Region number is the assigned neutronic region number.

Symbol	Variable	Units	
PFQR	Region Power Fraction	( )	( )
RGRO	Region Reactivity (includes initial reactivity which is biased out in the actual reactivity contribution) - ΔK/K	( )	( )
DELV	Change In Moderator Density	( )	( )
DLTF	Change In Square Root Of Fuel Temperature	( )	( )
DLTM	Change In Moderator Temperature	deg F	deg K
REAI	Initial Region Reactivity (biasing reactivity)	( )	( )
BETA	Region Beta	( )	( )
DENS	Moderator Density	lbm/ft^3	kg/m^3
A1**	Group 1 Absorption Cross Section	1/cm	1/cm

Table IV.4-18 (Cont'd)

Symbol	Variable	Units	
A2**	Group 2 Absorption Cross Section	1/cm	1/cm
D1**	Group 1 Diffusion Coefficient	cm	cm
D2**	Group 2 Diffusion Coefficient	cm	cm
S1**	Downscatter Cross Section	1/cm	1/cm
FK1*	Group 1 Kappa*Fission Cross Section	Mev/fis-cm	Mev/fis-cm
FK2*	Group 2 Kappa*Fission Cross Section	Mev/fis-cm	Mev/fis-cm
FN1*	Group 1 Nu*Fission Cross Section	1/cm	1/cm
FN2*	Group 2 Nu*Fission Cross Section	1/cm	1/cm
V1**	Group 1 Neutron Velocity	cm/sec	cm/sec
V2**	Group 2 Neutron Velocity	cm/sec	cm/sec
R1**	Group 1 Removal Cross Section	1/cm	1/cm
R2**	Group 2 Removal Cross Section	1/cm	1/cm

Mesh point quantities.

Region number is the mesh point number.

Symbol	Variable	Units	
PHI1	Group 1 Neutron Flux	n/cm^2-s	n/cm^2-s
PHI2	Group 2 Neutron Flux	n/cm^2-s	n/cm^2-s

Table IV.4-19

Accumulator Parameters Available for Minor Edit

Region number is the desired accumulator model number.

Symbol	Variable	Units	
TAIR	Air Temperature	deg F	deg K
EXPC	Expansion Coefficient	( )	( )
WLEV	Fluid Level	ft	m
HWAL	Wall Heat Transfer Coefficient	b/hf^2-F	w/m^2-K
HSRF	Liquid Surface Heat Transfer Coefficient	b/hf^2-F	w/m^2-K
QGAS	Gas Heating Rate	Btu/s	kw
TLIQ	Liquid Region Temperature	deg F	deg K
TWAL	Wall Temperature	deg F	deg K

Table IV.4-20

Dynamic Gap Conductance Model Parameters Available for Minor Edits

For each gap model, three minor edits are available. Region number is corresponding gap model number.

Symbol	Variable	Units	
PGAS	Fill Gas Pressure	psia	kpa
CAEX	Clad Axial Expansion	ft	m
FAEX	Fuel Axial Expansion	ft	m

Region number is the conductor number.

Symbol	Variable	Units	
CDEX	Clad Diameteral Expansion	ft	m
FDEX	Fuel Diameteral Expansion	ft	m
GPTH	Gap Width	ft	m
PINT	Fuel-Clad Contact Pressure	ft	m
GPCN	Gap Conductance	b/hr-ft^2-F	w/m^2-K

Table IV.4-21

General Material Transport Model Parameters Available for Minor Edits

Region number is the desired volume number.

Symbol	Variable	Units	
CONV	Volume Impurity Concentration	ppm	ppm
WEIT	Volume Impurity Mass	lb	kg
ADDM	Running Sum of Impurity Mass Added and Subtracted to the Volume to Prevent Numerical Problems Resulting from the Solution Technique. (Used to prevent negative impurity concentrations and mass impurities in a volume that does not contain the transport medium.)	lb	kg

Table IV.4-22

Three-Dimensional Kinetics Edit Parameters

Region Number 0 for all averaged or core wide parameter.

Symbol	Variable	Units	
RHOA	Adjoint weighted total reactivity - ΔK/K	( )	( )
CTRA	Adjoint weighted control reactivity - ΔK/K	( )	( )
DOPA	Adjoint weighted Doppler reactivity - ΔK/K	( )	( )
MODA	Adjoint weighted moderator temperature reactivity - ΔK/K	( )	( )
DENA	Adjoint weighted moderator density reactivity - ΔK/K	( )	( )
BORA	Adjoint weighted soluble boron reactivity - ΔK/K	( )	( )
XISA	Adjoint weighted XISP reactivity - ΔK/K	( )	( )
RESA	Adjoint weighted residual reactivity - ΔK/K	( )	( )

Minor Edit Variable Data Card(s) are required if the absolute value of NEDI (Card 01000Y) is greater than 0. These data cards specify the variables to be edited in minor edits, as well as the parameters to be included on printer plots if requested. |NEDI| specifications must be entered. Y is a sequence number ranging from 0 to 99. Y need not start at 0 and need not be consecutive.

The format for the card is as follows:

W1-A = Variable symbol
W2-I = Region number
.
.
.
W(2*K-1)-A = Variable symbol
W(2*K)-I = Region number

where K=|NEDI|

4.1 Optional Data Files

Options exist in RETRAN-3D to allow solution results to be written to data files, which can be created during a RETRAN-3D run. These files can be used by other applications to create X-Y plots or other graphical representations of problem solutions. Users have the option of writing data to an auxiliary file (TAPE60) and/or a RETRAN-3D plot file (R3D_PLOT). These files can be either ASCII or binary format. ASCII files have the advantage that they can be examined with a text editor, while binary files are approximately one-third the size of the corresponding ASCII file.

An auxiliary data file will contain records of minor edit variable results at times during the transient that correspond to the minor edit intervals given on the time-step control data cards 0300XX described in Section IV.5.0. It can contain a header that describes the content of the file, or it can be written without a header. These options are described in the following sections. The content and format of the file are specified by the user.

RETRAN-3D plot files can either be formatted or binary. They always contain a header that describes the content of the file. The content and format of the file are specified by the user as described in the following sections

4.1.1 Auxiliary and Plot File Description Data 025000

An auxiliary data file is created when the Auxiliary and Plot Data File Format Description Data 02500Y is used to define the auxiliary file format as discussed in Section 4.1.2. It is written to file TAPE60. An optional header contains information describing the content of the auxiliary file. If an auxiliary file with a header is desired, the 025000 data must be supplied with I60HDR = 1. If the 025000 data is absent or if the first item is zero, no header will be written.

By default, a RETRAN-3D plot file is not created; one is requested by use of R3DPLT (Word 2). The plot file is named **R3D_PLOT** and it can be either an ASCII or binary file as specified on Word 2. The user has an option to specify the list of variables to include in the plot file or use the built in list of minor edits by specifying R3D Plot list option (PLTLST) Word 3. Plot file variable data cards (027XXX) can be used to specify variables for the plot file.

There are two optional built-in lists of minor edit variables that can be included in a plot file, a short list and a full or long list. They consist of a fixed block of minor edits that are identified in Table IV.4-23. The condensed list consists of important minor edit variables for all valid regions for the current problem, e.g., volumes, junctions, etc. The full list includes additional volume junction heat conductor, system, and time step related data. When using one of the built in lists, the plot file variable data card (027XXX) can also be used to supplement the built in list.

Table IV.4-23

Built-in Minor Edit Lists Available for Plot File

Built-in List	Minor Edits
Short (1)	TIMX, PNRM, POWR, PRES, TEMP, HW**, AVEX, VOIV, LIQL, WP**, GPM*, HP**, HFLO, SLPR, SPED, MIXL, PHIL, PHIR, WQCL, WQCR, IHTL, IHTR, TAVG, PERD, REAC, RC**, RW**, RV**, RF**, RD**, PPOW, DPOW, RO**, RDRE, DPRE, VDRE, RHOA, CTRA, DOPA, MODA, DENA, BORA, XISA, RESA, NELT, NELX, NEVT, NEVX, COUT, TRIP
Long (2)	TIMX, TIMM, TIMH, PNRM, POWR, DCAY, PRPT, DTAV, NSTP, NTTS, CPUS, QLOS, PTHR, DTOL, PRES, TEMP, SATT, HW**, AVEX, FMAS, AVED, WQ**, VOIV, GASH, LIQH, STVF, STVG, STHF, STHG, WVBR, NVOI, LIQV, VL**, VS**, LIQL, CONV, MDOT, TEML, MDDT, WP**, GPM*, XP**, HP**, AVDJ, HFLO, VOIJ, WLJ*, VGJ*, VLJ*, SLPR, DELF, SPVJ, PJUN, AJNT, VLSJ, SPED, PMPW, VBUB, MIXL, BUBM, MIXQ, SE**, PHIL, PHIR, WQCL, WQCR, IHTL, IHTR, TL**, TR**, FCHL, FCHR, HTCL, HTCR, GR**, CORQ, TAVG, MODQ, QFRA, FENT, PERD, REAC, RC**, RW**, RV**, RF**, RD**, PPOW, DPOW, RO**, RDRE, DPRE, VDRE, A1**, A2**, RHOA, CTRA, DOPA, MODA, DENA, BORA, XISA, RESA, NELH, NELT, NELX, NEVH, NEVT, NEVX, COUT, TRIP

These default plot variables are supplemented by minor edit pairs requested on the 0200YY data. Only the unique minor edits will be included in the plot file, i.e., if a requested minor edit is in the default plot variable list, it is not duplicated in the plot file.

W1-I	I60HDR	=	Flag used to determine if a header is to be included on the auxiliary file (default = 0) = 1, Write a header = 0, No header will be written
W2-I	R3DPLT	=	R3D_PLOT creation flag = 0, No R3D_PLOT file will be generated = 1, Write ASCII R3D_PLOT file = 2, Write Binary R3D_PLOT file
W3-I	PLTLST	=	Option for using built-in plot lists = 0, Only minor edits will be included = 1, Short list will be used = 2, Long list will be used

4.1.2 Auxiliary Data File Format Description Data 02500Y

The Auxiliary Data File Format Description Data are optional and should be supplied only when the creation of an auxiliary data file is desired. These cards are used to specify the format that is to be used when writing the minor edit variable list specified on the 0200YY cards to FORTRAN Unit 60. The information supplied is treated as alphanumeric data and must be a legitimate FORTRAN format specification. Data will be written at each minor edit boundary in the order of the minor edit variable requests given on Card 0200YY. Y is a sequence number ranging from 1 to 9.

Word	Description		
W1-A	FORMAT(1)	=	FORTRAN format for variables to be written to Unit 60. The format should be enclosed with Hollerith delimiters (' or ") as illustrated below '(6(2x,E15.7))'. If a binary file is desired, supply the Hollerith string. 'BINARY'.
W(N)-A	FORMAT(N)	=	

The auxiliary file header contains the following information.

Record	Description	Format
1	Problem title (10 8-character words)	(10A8)
2	TIME, DATE and code version documentation (four words) as 8-character words, and a units flag and the number of minor edit parameters as integers.	(6A8,2I8)
	Each of the following records contains one word for each minor edit parameter.	
3	Minor edit flag and region merged into 8-character words (1 for each minor edit request)	(15A8)
4	Parameter label field 1 (minor edit label)	(15A8)
5	Parameter label field 2	(15A8)
6	Parameter label field 3	(15A8)
7	Units label field	(15A8)

The content and length of records one and two is fixed. The content of records three through seven is fixed, but the record length is determined by the variable minor edit list. If a binary file is written, the header is also binary, but otherwise with the same structure as described above for a formatted file.

The units flag is set to 0 for English units (default) and 1 for SI units. The parameter and units label fields contain the heading information that appears at the top of minor edit lists for each minor edit parameter.

4.1.3 Plot File Supplemental Variable List Data 027XXX

These data cards are required when a RETRAN-3D plot file is requested (R3DPLT > 0 on Card 25000) and user supplemental plot variables are included in the RETRAN-3D plot file (PLTLST = 0 on Card 25000). These cards are optional when either built-in list of plot variables is specified (PLTLST > 0). The value of XXX need not start at 001 and need not be consecutive. The number of variables specified through this card is only limited by card numbers; total of 999 cards can be specified. Any available minor edit variable can be specified as plot file variable. Only the variable name, not region number, is specified. If a requested variable is in the default list of minor edits, it will not be duplicated in the plot file.

The format for the card is as follows:

W1-A	=	Variable symbol
W2-A	=	Variable symbol
……..		Until all supplemental minor edit variables have been added.

4.2 Units Selection Card 030000

The information contained in output files written during RETRAN runs has historically been in British (or engineering) units. An option is available which allows output to be written in SI units. When the SI output option is selected, SI units are used for the major and minor edits and printer plots in the standard output file. The data written to the auxiliary data file (FORTRAN Unit 60 and R3D_PLOT) will also be in SI units. Card 030000 is used to select the SI output option as described below. Its use is optional and if it is not present, the output will default to British units.

W1-I	=	1 for British units 2 for SI units

4.3 VIPRE-01 Boundary Conditions (VBC) File 02600Y

An option is available in RETRAN-3D that allows a VIPRE-01 boundary conditions file to be created during a RETRAN calculation. This file is written to file VBCFIL and can be used to provide transient boundary conditions input to the VIPRE-01 code. The VBC file will contain the RETRAN-3D version and creation date, the problem title, and the time and date of the run. Calculation time, normalized power, and core direct moderator heating fraction are automatically included. Core-section elevations, power fractions, and heat flux are also written for use in defining axial power profiles in VIPRE-01.

Card 02600Y defines the user-specified data to be written to the VBC file. The user has the option of including junction and control block data. At least one volume must be specified if 02600Y cards are supplied. Pressure and enthalpy is written for each volume, flow and flowing enthalpy for each junction, and control block output for each control block specified. Inclusion of this card, activates the VBC file generation option. The frequency at which records are written is determined by TVBC on Card 03XXX0.

VIPRE-01 VBC code option allows specification of the core normalized power fraction, core outlet pressure (reference pressure), inlet flow, inlet enthalpy, and optionally the core pressure drop. The core pressure drop option requires the core inlet pressure. Control block output can be used for all of these parameters. RETRAN-3D users should evaluate the future VIPRE-01 use when defining the content of the VBC file.

Y is the card sequence number ranging from 0 to 9, and does not need to be consecutive.

W1-I	NVOLBC	=	Number of volumes for which pressure and enthalpy will be written to the VBC file.
W2-I	NJUNBC	=	Number of junctions for which flow and enthalpy will be written to the VBC file.

W3-I	NOUTBC	=	Number of control blocks for which the output will be written to the VBC file.
W5-I	IDXBC(1)	=	List of NVOLBC volume numbers.
.	.		
.	.		List of NJUNBC junction numbers.
.	.		
.	.		List of NOUTBC control block identifiers.
.	.		

W(N)-IIDXBC(N)

where; N = NVOLBC + NJUNBC + NOUTBC

5.0 TIME-STEP DATA CARDS 03XXX0

The time-step card count, NTC (Card 01000Y), allows the user to supply multiple sets of time-step data. The edit frequency, maximum time-step size and fixed time-step control option are specified on these cards. Coefficients for the time-step selection algorithms are input on separate cards (03XXX1) (see Section IV.5.5).

There are five different edit types controlled by the time-step data cards: VIPRE-01 boundary conditions (VBC) file records, minor edits, restart file records, major edits and timing edits. The user specifies the time interval (in seconds) for each of the five edit types. The minor edit frequency must be greater than or equal to the maximum time-step size. All other specified frequencies must be larger than or equal to the minor edit frequency. Also, all specified frequencies must be integer multiples of the maximum time-step size. If this is not the case, the code will adjust the interval and print a warning message.

The VBC file will be written only if 02600Y cards are supplied to define the file content. For multiple time-step data sets, the first supplied interval will control. If the first set flags that no VBC file is to be written, later sets with an interval greater than 0 will be ignored. If the VBC file is to be written, data sets with an interval supplied as 0 will be adjusted (VBC = TMIN). Integer constant NCHK is used to select the method of time-step control, that is either the time-step control algorithms or a fixed time-step size of DELTM.

The input parameter NSHAPE is used for the one-dimensional kinetics option only. The NSHAPE parameter deals with the principle that the neutron shape function calculation is less important than the amplitude function calculation for most transients (see Section V; Volume 1: Theory and Numerics). A problem using one-dimensional kinetics can be restarted only at a time when a neutron shape function calculation is done. Consequently, a neutron shape function calculation is forced every NSHAPE actual time steps plus (a) every minor edit time if NSHAPE > 0 or (b) every major edit time if NSHAPE < 0. If NSHAPE < 0, the run can be restarted only at data records written at major edits. NSHAPE is specified only if NODEL = 2 on Card 01000Y.

NTC (Card 01000Y) cards must be entered with XXX = 001, 002, ..., NTC. Word 9, NSHAPE, is used only for the one-dimensional kinetics option.

W1-R	TVBC	=	Time interval between VBC file records (sec). Must be greater than or equal to TMIN (W7) or equal to zero. = 0, If no VBC file is written. If a VBC is requested (02600Y cards) and TVBC = 0, TVBC will be set to TMIN and a warning issued if a VBC file is requested.
W2-R	TMIN	=	Time interval between minor edits (sec). Must be greater than or equal to DELTM (W7).
W3-R	TRST	=	Time interval between RESTART file records. Must be greater than or equal to TMIN (W2). (0 defaults to TRST = TMIN)
W4-R	TMAJ	=	Time interval between major edits (sec). Must be greater than or equal to TMIN (W2). (0 defaults to TMAJ = 50 x TMIN)
W5-R	TDMP	=	Time interval between TIMING edits (sec). Must be greater than or equal to TMIN (W2). (0 defaults to TDMP = 50 x TMIN)
W6-I	NCHK	=	Option for time-step control selection. = 0, use iterative solution method with time-step control algorithms described in Section IV.5.1. = 1, use fixed time-step size of DELTM
W7-R	DELTM	=	Maximum time-step size (sec). (0.0 < DELTM)
W8-R	TLAST	=	Time for end of current time-step data (sec).
W9-I	NSHAPE	=	One-dimensional kinetics option neutron shape function update frequency for this interval. Default is 1 or a shape function every actual time step.

5.1 Time-Step Input User Guidelines

Several different sets of time-step data can be supplied to reduce or increase allowable time-step size or change the frequency of the edits during periods of the transient. For severe periods of the transient, generally the maximum time-step size (DELTM) should be reduced. Or the maximum time-step size may be reduced for periods of the transient where more editing detail is required. Many of the input parameters control editing frequency and are self-explanatory. Parameters that may require some guidance are discussed here.

W6	NCHK	Option 0 is recommended for general use. This option provides automatic time step control based on several internal time-step algorithms. Many of these algorithms have user definable coefficients. However, the default coefficients are recommended for typical analyses.
W7	DELTM	This parameter defines the maximum time-step size the code can take. The time-step algorithms in the code may reduce the time step below this value. As a general guideline, a more efficient calculation will be obtained if the maximum time-step size is taken 20% to 40% of the time. The algorithms controlling the time-step size can be monitored by reviewing the Time-Step Summary in the output file.
W9	NSHAPE	This parameter controls how often the flux distribution is updated in the one-dimensional kinetics model. NSHAPE > 1 reduces computation time, but sensitivity studies may need to be done to evaluate the effect. A value of 1 is recommended to eliminate any question as to effect of not updating the flux shape each time step.

5.2 Time-Step Control Algorithms

RETRAN time-step control consists of time-step control algorithms and the ability to "reset" or redo a time-step integration that has failed. The time-step control algorithms are basically predictive algorithms. When these predictive algorithms fail to compute the appropriate time-step size because of nonlinearities in material properties or control actions, inaccuracies are introduced into the numerical solution. Failed solutions are often the result of using an inappropriately large time step. The iterative solution method allows the results of the time advancement to be evaluated before the solution is accepted. If a converged solution is not achieved in a given number of iterations, the time advancement can be reevaluated with a smaller time step.

The iterative solution method utilizes several predictive and accuracy control algorithms to select the appropriate time-step size. The minimum time-step value computed by these control algorithms is used, but it must be within the range of 1.0×10^{-6} sec to DELTM (Card 03XXX0) or the nearest limit is used. The coefficients for these time-step control algorithms are input on the 03XXX1 data cards.

In addition to the time-step control algorithms discussed in the following sections, there are also instances where the time-step size is halved and the time advancement reevaluated due to anomalous behavior of the initial solution. The situations leading to halving of the previous time-step size and reevaluation of the current time advancement are presented in this section.

5.2.1 Minimum Effort

One time-step control method used with the iterative advancement scheme is aimed at minimizing the total amount of computational effort while achieving an acceptable degree of accuracy. This is accomplished by approximating the functional relationship between time-step size and corresponding residual error in volume pressure convergence, ε_i, for the previous ten time steps. The largest time step expected to give convergence in one iteration is then calculated from this function.

The error in the pressure calculation is computed for each volume as

$$\Delta P_{error} = \left[P^n + \left(\frac{\partial P}{\partial M}\right)^n \Delta M^{n+1} + \left(\frac{\partial P}{\partial U}\right)^n \Delta U^{n+1} + \left(\frac{\partial P}{\partial M_v}\right)^n \Delta M_v^{n+1} + \left(\frac{\partial P}{\partial M_{nc}}\right)^n \Delta M_{nc}^{n+1} - P^{n+1} \right] \Big/ MAX\left[P^{n+1}, 100\right] \qquad \text{(IV.5-1)}$$

where

P = volume pressure,

$\frac{\partial P}{\partial M}$ = pressure change with respect to volume total mass,

$\frac{\partial P}{\partial U}$ = pressure change with respect to volume internal energy,

$\frac{\partial P}{\partial M_v}$ = pressure change with respect to volume vapor-phase mass,

$\frac{\partial P}{\partial M_{nc}}$ = pressure change with respect to volume noncondensable mass,

ΔM = change in volume mass,

ΔU = change in volume internal energy,

ΔM_v = change in volume vapor-phase mass, and

ΔM_{nc} = change in volume noncondensable mass.

and the subscripts n and n+1 refer to the old time-step and new time-step values, respectively.

The residual error ε_i for a time step is the maximum value of ΔP_{error} for all volumes, where the subscript i refers to one of the previous ten time values of ε_i. A linear least square fit of the logarithms of the residual errors is used for the iterative solution minimum effort time-step control algorithm, given by

$$\Delta t_1 = \left(\log\ (0.75 C_1)\ A\ \right) / B \qquad \text{(IV.5-2)}$$

where

C_1 = constant supplied as Word 1 on Card 03XXX1 (default = 0.005),

$$B = \frac{\sum_{i=1}^{N} \Delta t_i \log(\varepsilon_i) - \frac{1}{N} \sum_{i=1}^{N} \Delta t_i \sum_{i=1}^{N} \log(\varepsilon_i)}{\sum_{i=1}^{N} (\Delta t_i)^2 - \frac{1}{N} \left(\sum_{i=1}^{N} \Delta t_i \right)^2} \qquad \text{(IV.5-3)}$$

and

$$A = \frac{1}{N} \sum_{i=1}^{N} \left(\ \log(\varepsilon_i) - B \Delta t_i \right). \qquad \text{(IV.5-4)}$$

The value of N is set equal to 10 in RETRAN-3D.

When mass exchange is occurring for some five-equation applications, the pressure convergence criteria (EPSI on Card 03XXX1) may not be adequate. EPMDOT (Word 5 on Card 03XXX1) can be used to modify this convergence criteria for those control volumes with mass exchange.

The EPMDOT multiplier is applied to the linearized pressure error computed by Eq. IV.5-1 for these volumes. If EPMDOT is greater than 1.0, the apparent error in the linearized pressure will be increased, and the pressure convergence necessary to pass the test will be more stringent. The default value of EPMDOT is 1.0, which means the computed values of ΔP_{error} are not changed and the pressure convergence test is not modified.

The minimum effort algorithm also accounts for the situation where the slope B becomes less than 0.5. This can result in an artificially large time-step size by virtue of the small regression line slope. As B approaches zero, the relative error ε_i is not a function of the time-step size and Eq. IV.5-2 is no longer valid. When B is less than 0.5, the time-step size is computed using

$$\Delta t_i = 2^{0.25} \Delta t_n \qquad \text{(IV.5-5)}$$

5.2.2 Courant Limit

The Courant time-step algorithm limits the volume mass transport with respect to the total mass. In effect, the time step must be smaller than the time interval required for fluid to traverse any control volume. The iterative numerics Courant time step for a given junction is

$$\Delta t_{2_j} = C_2 \frac{M_j}{|W_j|} \qquad \text{(IV.5-6)}$$

where

C_2 = constant supplied as Word 2 on Card 03XXX1 (default = 5.0),

W_j = junction mass flow rate, and

M_j = the minimum value of the fluid mass in the upstream and downstream volumes.

Eq. IV.5-6 is evaluated for all junctions and the minimum value is used for the Courant time-step size.

*5.2.3 Constant * DT*

The constant * DT algorithm prevents the time step from increasing dramatically from one time step to the next. This time step is computed as

$$\Delta t_4 = C_4 \, \Delta t^n \qquad \text{(IV.5-7)}$$

where

C_4 = constant supplied as Word 4 on Card 03XXX1 (default = 1.1892).

This algorithm is not used to select the next time-step value if the previous time step has been reduced to match an edit boundary or to initiate a trip.

5.2.4 Edit Boundary

In addition to the algorithms described above, the times selected by the user for major and minor edit boundaries are also part of the time-step selection process. Computational efficiency can be degraded by frequent edit requests. A review of the time-step edit summary (see Appendix B) will reveal if edits are controlling the time step an unreasonable amount.

5.2.5 Time-Step Selection for Trip Actuation

The status of trips must be considered when selecting time-step values. The requirement is to select a time step to provide trip actuation when the signal setpoint is reached rather than after it has been exceeded. For trips that monitor time, the setpoint can be matched exactly. For trips that monitor volume pressure or junction flow, first order derivatives along with current pressure or flow are used to project the remaining time until the setpoint is reached. For all other signals that can be monitored by a trip, a backward difference approximation of the first derivative and the current signal value is used to project the remaining time until the setpoint is reached. Any time delay between reaching the setpoint and actuation time can be matched.

There are two points that need to be considered in the time-step control algorithms for trips. The first is the time when the setpoint is reached and the second is when the delay time is satisfied. The first time-step control algorithm for trips is

$$\Delta t_{5_i} = \frac{(S_i - f_i)}{df_i / dt} \qquad \text{(IV.5-8)}$$

where

S_i = the setpoint,

f_i = the current value of the monitored parameter, and

df_i/dt = the time rate of change of the monitored parameter.

Eq. IV.5-8 is evaluated for all trips whose setpoints have not been reached, excluding time trips which are discussed below. Negative time-step values are ignored.

The algorithm used for time trips and for a trip where the setpoint has been reached but the delay time is not satisfied is given by

$$\Delta t_{6_i} = t_d - \Delta t_{set} \qquad \text{(IV.5-9)}$$

where

t_d = the delay time or setpoint plus delay time for time trips and

Δt_{set} = the elapsed time since satisfying the setpoint or the current time for time trips.

5.2.6 Normalized Power Change

For one-dimensional and three-dimensional kinetics, normalized power change is also taken into account to select time-step values. Change in normalized power value is calculated from

previous iteration to current iteration. Time-step value for next iteration is predicted based on change in normalized power.

This time step is computed as

$$\Delta P_N = \frac{\left(P_N^n - P_N^{n-1}\right)}{P_N^{n-1}} , \qquad \text{(IV.5-10)}$$

$$\Delta t_7 = \frac{\Delta t^n}{\left(P_N^n - P_N^{n-1}\right)} C_7 P_N^{n-1} , \qquad \text{(IV.5-11)}$$

and

$$\Delta t_7 = \frac{\Delta t^n}{\Delta P_N} C_7 \qquad \text{(IV.5-12)}$$

where

P_N^n = normalized power at current time step,

P_N^{n-1} = normalized power at previous time step, and

C_7 = constant supplied as Word 7 on Card 03XXX1 (default 0.01 for one-dimensional and three-dimensional kinetics).

A large change in Δt can give erroneous results for three-dimensional kinetics. Therefore, time-step value Δt_7 predicted by this method is compared with Δt^n. If change in time-step value is more than 30%, the increase or decrease in time-step value is limited.

$$\Delta t_C = \left| \frac{\Delta t_7 - \Delta t^n}{\Delta t^n} \right| \qquad \text{(IV.5-13)}$$

where

Δt_C = change in time-step value.

Logarithmic averaging is used to limit time-step value if Δt_7 is greater than Δt^n. Otherwise, exponential averaging scheme is used.

If $\Delta t_C > 0.3$ and $\Delta t_7 > \Delta t^n$ then

$$\Delta t_7 = e\left(\frac{\ell n\left(\Delta t_7\right) + \ell n\left(\Delta t^n\right)}{2}\right) \qquad \text{(IV.5-14)}$$

or if $\Delta t_7 < \Delta t^n$ then

$$\Delta t_7 = \ell n\left(\frac{e^{(\Delta t_7)} + e^{(\Delta t^n)}}{2}\right). \qquad \text{(IV.5-15)}$$

5.3 Time-Step Reduction

The time-step selection algorithms given in Section IV.5.2 are designed to determine the appropriate time-step to be used for the next time advancement. There are situations that require the current time advancement to be reevaluated with a smaller time step than that initially used. These limiting situations are discussed below. Reevaluating a time advancement with a smaller time step is similar to restarting a job with smaller time steps but has the advantage of being automatic.

For a given time step and iteration, numerical difficulties may be encountered in the course of establishing the next iterate values. These problems manifest themselves in one or more of the following ways.

- Volume pressure convergence not acceptable. Uses Eq. IV.5-1 to compute the error and compares it to EPSI on Card 03XXX1.
- The "pressure search algorithm" used to determine the thermodynamic pressure within a control volume fails to obtain a converged solution for one of the control volumes.
- The pressure and specific enthalpy calculated for some volume either do not represent a valid thermodynamic state or they represent one which is not within the thermodynamic state modeling bounds of RETRAN.
- The pressure and specific enthalpy calculated for a junction transmitted by one of the choking models is not within the modeling bounds for that critical flow model.
- A flow reversal occurs.
- The pressure change calculated for some volume from previous iteration is more than specified limit.
- Normalized power change calculated for point kinetics is more than specified limit.
- Water packing occurs.

In the event that any of the first four items is encountered, the original time-step size is halved and the numerical integration is reinitiated from the previous time. The time-step algorithm for the flow reversal, pressure rate change, and normalized power change are discussed in the following section.

5.3.1 Flow Reversal

The flow reversal time-step control is designed to provide the correct energy equation convection terms when a flow reversal occurs at a junction. The convection terms are initially estimated based on the "from-to" convention and the sign of the junction flow. If the flow at a particular junction changes sign from one time step to the next, the donor volume at the end of the advancement will be different from the one at the start and thus the energy part of the convection terms in the energy equation may be in error. The flow reversal time-step control is used to minimize this error.

If a flow reversal occurs during a time-step advancement, a second junction enthalpy value is calculated based on the new donor volume values. The error in the energy equation convection term is calculated as

$$\varepsilon_u = \frac{1}{2} W_j W_j \left[h_j^n - h_j^{n+1} \right] \Delta t_{old} / \Delta W_j \qquad \text{(IV.5-16)}$$

where h_j^n is the junction enthalpy at the beginning of the time-step advancement and h_j^{n+1} is the value at the end (based on the new donor volume).

If the error is less than the user supplied limit (C_3, supplied as Word 3 on Card 03XXX1) the solution is accepted and checked for general convergence. If the error is greater than this limit, a new time-step size is computed from

$$\Delta t_3 = 0.8 \frac{C_3}{\varepsilon_u} \Delta t_{old} \quad . \qquad \text{(IV.5-17)}$$

If the time-step size calculated by the flow reversal algorithm is less than the minimum allowable time-step size, the average of the minimum time-step size and the current time-step size is used. The time-step advancement is then repeated with the new time-step size, Δt_3.

5.3.2 Pressure Rate Change

The pressure rate change time-step control is designed to provide control over change in pressure for any volume from one iteration to the next. If change in pressure is more than the limit specified, the time-step value is predicted to give the pressure change within the prescribed limits and the time-step advancement is then repeated with the new time-step size as

$$\Delta p_K^n = \frac{p_K^n - p_K^{n-1}}{p_K^{n-1}} \qquad \text{(IV.5-18)}$$

and

$$\Delta t^{n+1} = \frac{\Delta t^n}{\Delta p_K^n} C_6 \qquad \text{(IV.5-19)}$$

where

p_k^n, p_k^{n-1} = pressure in Volume k at current and previous time-step value, respectively and

C_6 = constant specified on Word 6 on Card 03XXX1 (default = 0.015) Normalized Power Change (Point Kinetics Only)

The normalized power change time-step control algorithm is designed to limit change in normalized power for point kinetics. Change in normalized power is calculated from one time step to the next and if change is more than the prescribed value, a new time-step value is calculated. The time-step advancement is then repeated with this new time-step value as

$$\Delta P_N = \frac{\Delta P_N^n - P_N^{n-1}}{\Delta P_N^{n-1}} \qquad \text{(IV.5-20)}$$

and

$$\Delta t^{n+1} = \frac{\Delta t^n}{\Delta P_N} C_7 \qquad \text{(IV.5-21)}$$

where

C_7 = constant supplied as Word 7 on Card 03XX1 (default = 0.01999).

5.3.3 Water Packing

The water packing time-step control algorithm is designed to mitigate the pressure fluctuations that occur when a volume transforms from two-phase to single-phase. The water packing algorithm calculates the time-step size required to have just enough mass inventory for a volume to transform to single-phase. The quadratic equation for mass required is solved to calculate the new time-step size as

$$DW_t + \frac{dM_N}{dt} - \Delta M_N = 0 \qquad \text{(IV.5-22)}$$

where

$$DW_t = \sum_{j \varepsilon T_N} dW_j - \sum_{j \varepsilon I_N} dW_j \text{ and}$$

$$\Delta t^{n+1} = \text{abs}\left[\frac{\frac{-dM_N}{dt} + \sqrt{\left(\frac{dM_n}{dt}\right)^2 + 4DW_t \Delta M_N}}{2DW_t}\right].$$

The time step will be reset to the beginning of Time-step value and a new advancement taken using the new time-step value.

5.4 Detailed Edit Data Card 030002

A detailed edit data card is used to obtain minor and/or major edits every actual time step rather than as a multiple of the maximum time-step size. This option is designed for a detailed investigation of anomalous behavior that may occur during a transient analysis. Caution should be exercised when using this option since it is possible to obtain a large amount of printed output. This data card is optional and may be supplied at restart time along with at least one time-step replacement card (03XXX0). The use of this card does not change the frequency of data records.

W1-I	IEVERY(1)	= 0,	no effect on the printed output for the time-step set indicated by the subscript of IEVERY(J), where "J" refers to XXX on Cards 03XXX0.
W2-I	IEVERY(2)	= 1,	a major edit will be obtained for every actual time step for the time-step card indicated by the subscript of IEVERY(J).
		= 2,	a minor edit will be obtained for every actual time step for the time-step card indicated by the subscript of IEVERY(J).
		= 3,	both major and minor edits will be obtained for every actual time step for the time-step card indicated by the subscript of IEVERY(J).
W(NTC)-1	IEVERY(NTC)		

5.5 Iterative Time-Step Control Constants Cards 03XXX1

The iterative time-step control constants cards allow the user to input time-step coefficients for the iterative solution methods. One time-step control constants card is optional for each time-step card, with XXX1 here corresponding to XXX0 on the time-step cards.

W1-R	EPSI	=	Linearized pressure convergence criteria for iterative time-step control (constant C_1 in Eq. IV.5-2). Default value is 0.005.

W2-R	COURNT	=	Courant time-step control coefficient (constant C_2 in Eq. IV.5-6). The default is 5.0 and the maximum is 1.0E+6.
W3-R	EPSIU	=	Junction flow reversal convergence criteria for iterative time-step control (constant C_3 in Eq. IV.5-11). Default value is 0.005.
W4-R	CONDT	=	Constant used in Constant * DT time-step advancement algorithm (constant C_4 in Eq. IV.5-7). Default value is 1.1892.
W5-R	EPMDOT	=	A multiplier on the linearized pressure error (Eq. IV.5-1) that is applied when five-equation mass transfer rate is nonzero. EPMDOT is applied on a volume-by-volume basis and values larger than 1.0 imply more stringent convergence, i.e., smaller time-step size. Default value = 1.0.
W6-R	PRATE	=	Constant used in pressure rate change algorithm (Eq. IV.5-11b). Default value is 0.015. This constant can be viewed as a limit to a pressure change in percent. Default value of 0.015 described as the change in pressure in any volume is limited to 1.5%. If pressure change is equal or more than 1.5%, the pressure rate change model will be used. The user can override pressure rate change model by using a very high value, i.e., 5.0.
W7-R	FNPOW	=	Constant used in normalized power change algorithm (Eq. IV.5-9b and Eq. IV.5-11c). Default value = 0.02 for point kinetics and 0.0100 for one-dimensional and three-dimensional kinetics. For point kinetics, this constant acts as a limit on normalized power change. The default value is used as a limit on the change in normalized power, 2%. If normalized power change is more than 2%, the algorithm specified by Eq. IV.5-11c will be used. The user can override the use of this model by specifying a high value for constant C7, i.e, 10.0. For one-dimensional and three-dimensional kinetics, this constant is used for predicting the time-step value for the next iteration. The default value of 0.01 can be described as a constant which gives the time-step value for which normalized power change is 1%. The user can override use of this constant by providing a very high value, i.e., 10.0,

such that time-step value predicted by this model is much longer than other models and those values will be used.

W8-I	WPACK	=	Water packing mitigation option flag = 0, water packing mitigation is active for all volumes (default). = 1, water packing mitigation is turned off for all volumes.

6.0 TRIP CONTROLS

The control functions normally needed to simulate a reactor system may be described through the trip-control data. An arbitrary number of these control cards may be specified. Trips can be controlled directly by parameters such as elapsed time, reactor power or period, and volume pressure, temperature, mixture or liquid levels and control block output. However, since the output of a control block can be monitored by a trip, any parameter available for minor edit can be monitored in addition to mathematical combinations of these parameters. These controlling variables can be used to perform a number of actions such as reactor scram, valve actions, fill water injections, pump shut off, and simplified heat exchanger control. At least one problem termination condition must be specified as a trip. Trip control parameters are compared to specified set points and if the set point condition is satisfied, the trip action can be delayed by a specified time that represents an instrumentation or mechanical delay.

Trips based on the elapsed time parameter are interrogated by steady-state initialization and those which are activated at zero time are considered in the initialization process. Thus, fills and valves which are tripped at zero time will refer to the values from the appropriate tables such that a proper steady-state initialization is calculated. Only trips activated on elapsed time, not those activated on other system parameters, are considered in the steady-state initialization process.

A trip is identified by the value of IDTRP "trip ID" assigned to it on the trip data cards. The trip ID is referenced by other models that can have trips associated with them. By using the same value of IDTRP on several trip cards, the user can model a trip which is activated when any one of several conditions is met making the "OR" logic function available. In addition, a single trip may be referred to in multiple places in the input, thereby initiating several actions all beginning at the same time.

Coincidence trips allow modeling of trips which are activated when all of several conditions are met. Coincidence trips make the "AND" logic function available. With coincidence trips, it is possible to model "majority logic" where a trip is activated only when at least two out of three conditions are met.

Indirect trips are trips activated by another trip but with an additional delay. Indirect trips allow a trip condition to initiate several actions at different times. With indirect trips, it is possible to model a sequence of events occurring at different times, all triggered by the same trip.

Reset trips allow previously activated trips to be reset. A reset trip used this way is sometimes called a "reverse" trip or an "off" trip. Reset trips also reverse trips whose setpoint threshold has been crossed, but whose delay time has not yet expired. An indirect trip used this way is sometimes called a "blocking" trip.

6.1 Coincidence Trip

The coincidence trips, also called "AND" trips, refer to a trip which occurs only after both of two conditions have been satisfied. For example, a PWR may trip a safety injection system when there is low pressure and low level in the pressurizer. Consider the following example.

	IDTRTP	IDSIG	IX1	IX2	SETPT	DELAY	
040020	2	4	10	0	2000.0	0.0	"Hi Pressure Trip"
040030	3	-6	10	0	10.0	0.0	"Lo Water Level Trip"
040040	4	13	2	3	0.0	0.0	"Coincidence Trip"

Trip ID 2 is activated when the pressure in volume 10 exceeds 2000.0 psia. Trip ID 3 is activated when the water level in volume 10 drops below 10.0 feet. Trip ID 4 represents the safety injection system trip. Consider Card 040040. IDSIG = 13 denotes that a coincidence trip is being used. IX1 = 2 denotes that trip ID 2 is one operand trip. IX2 = 3 denotes that trip ID 3 is the other operand trip. SETPT is not used and is arbitrarily set to 0. DELAY was set to 0.0 for this example. The Card 040040 represents the logic that the safety relief system is activated with zero delay after both trip ID 2 and trip ID 3 have been activated.

In preparing trip data using coincidence trips, the user must define operand trips before a coincidence trip can refer to them. In this example, trip ID 2 and trip ID 3 are defined before the coincidence trip is defined.

6.2 Indirect Trip

An indirect trip is defined to be a trip which is activated by another trip. The indirect trip simplifies modeling of trip logic which would be very cumbersome to model with the "OR" logic function. Consider a system which trips the turbine whenever the reactor is scrammed. The reactor scram could be tripped by a number of different signals, say, six signals. The reactor scram logic could be modeled using six cards. To model the turbine trip with the "OR" logic function, the user would have to duplicate those six cards with a different value of IDTRP and a larger value for the delays. If an indirect trip is used, only one additional trip card would be required. See example below.

	IDTRTP	IDSIG	IX1	IX2	SETPT	DELAY	
040020	2	2	0	0	1.2	.5	"Scram on Hi Power"
040030	2	4	10	0	1070.0	1.0	"Scram on High Pressure"
040040	2	-6	5	0	1.0	1.0	"Scram on Lo Level"
040050	3	12	2	0	0.0	1.0	"Indirect Turbine Trip"
							*1.0 Sec Delay

The value of IDTRP corresponding to a reactor scram is 2. The reactor is scrammed if reactor power is high or if vessel pressure is high or if liquid level is low. The value of IDTRP corresponding to a turbine trip is 3. The turbine is to be tripped one second after the reactor is scrammed.

Card 040050 represents the logic that the turbine is to be tripped one second after the reactor is scrammed. IDSIG = 12 denotes that an indirect trip will be used. IX1 = 2 denotes that the trip with IDTRP = 2 will be the initiating trip. IX2 is not used and must be set to 0. SETPT is not used and is arbitrarily set to 0. DELAY is set to 1.0 second.

IX2 is not used in the above example, so it is set to 0. IX2 may denote another initiating trip. When IX1 and IX2 are used to denote different initiating trips, the interpretation is that the indirect trip is activated when either trip IX1 or IX2 is actuated.

In preparing trip data which used indirect trips, the user must observe the following rule. Initiating trips must be defined before an indirect trip can refer to them. In the example above, the scram trip is defined before the indirect trip.

6.3 Reset Trips

Consider the following example where the trip logic for a relief valve is modeled. The valve is opened when the pressure in volume 10 exceeds 2400 psia and is closed when the pressure in volume 10 drops below 2300 psia.

	IDTRTP	IDSIG	IX1	IX2	SETPT	DELAY	
040020	2	4	10	0	2400.0	0.0	"Hi Pressure Normal Trip"
040030	-2	-4	10	0	2300.0	0.0	"Lo Pressure Reset Trip"

The data on the reset trip card are analogous to the data on a normal trip card. The only difference is that the sign of IDTRP on all reset trip cards is negative. The absolute value of IDTRP on a reset trip card is equal to the value of IDTRP of the normal trip which is to be reset. In this example IDTRP = -2 for the reset trip and IDTRP = 2 for the corresponding normal trip.

All other parameters on a reset trip card may have different values from the normal trip which is to be reset. The reset trip may monitor a different signal, have a different setpoint, or have a different delay time from the normal trip.

Other points which the user should be aware of are:

- Once a trip has been activated, it will remain activated for the duration of the transient even though the monitored parameter may cross back over the setpoint. The only way to undo a trip once activation occurs is through a reset trip.

- Any number of reset trip cards may be specified for a particular value of IDTRP. If the condition on any one reset card is met, then the trip is reset.

- If a normal trip and a corresponding reset trip are activated at the same time, the reset trip dominates and the normal trip is not activated.

- Reset trips will not reset the normal trips for reactor scrams. Once a reactor scram is activated, the action can only be reversed by having a second reactivity table which is tripped to add positive reactivity.

- The setpoint of a normal trip can be reached but the trip may not be activated because of the delay time specified. If a reset trip is activated during that delay time, the normal trip is reset and it will not show on the trip summary edit because it has never activated.

- Just as it is possible to build an oscillator in practice, it is possible to set up an oscillation which is contained entirely within the trip logic. If the delays specified on reset trips are all smaller than every delay specified on corresponding normal trips, then oscillations within the trip logic are avoided.

- Operand trips must be ordered in input before they are used in indirect, reset, and indirect trips.

6.4 Trip Control Data Cards 04XXX0

NTRP (Card 01000Y) cards must be entered with XXX equal to the trip number. NTRP sets of 04XXX0 cards must be supplied but XXX need not start at 001 and need not be consecutive.

W1-I IDTRP = Action to be taken (IDTRP $\geq$ 1),
= 1, End of problem.

IDTRP = IDSIG = 1 must be the first trip card.
IDTRP corresponds to entry on pertinent card elsewhere in the input where trip action is desired. IDTRPs do not have to be in order on a set of Trip Control Data Cards. IDTRP can be any arbitrary integer less than 999 with the exception noted above.

End problem trip cards (IDTRP=IDSIG=1) can be extended by adding IX1=-99. This will cause the trip subroutine to initiate an inquire to determine if file "STOPRUN" is present in the directory where the problem is executing. If the file is present, the problem will be terminated as if the end problem trip time were set to the current time elapsed time. This results in all edits and auxiliary files being closed normally. The "STOPRUN" file (must be upper case) can be zero length and should be deleted or renamed before running another problem, otherwise the next problem will terminate at time = 0.

W2-I	IDSIG	=	Signal being compared. (1 = ≤ |IDSIG |≤ 14)	Trip Limit
			= 1, Elapsed time	NOT APPLICABLE
			= 2, Normalized reactor power	+ =HIGH, - =LOW
			= 3, Reactor period	+ =HIGH, - =LOW
			= 4, Pressure (Volume IX1)	+ =HIGH, - =LOW
			Differential pressure If IX2 ≠ 0	+ =HIGH, - =LOW
			= 5, Mixture level (Bubble Rise Volume IX1)	+ =HIGH, - =LOW
			= 6, Liquid level (Volume IX1)	+ =HIGH, - =LOW
			= 7, Water temperature (Volume IX1)	+ =HIGH, - =LOW
			Differential temperature If IX2 ≠ 0 (Volumes IX1, IX2)	+ =HIGH, - =LOW
			= 8, Average fuel temperature (Core Section IX1)	+ =HIGH, - =LOW
			= 9, Flow (Junction IX1)	+ =HIGH, - =LOW
			= 10, Conductor temperature (Conductor number IX1) (Temperature node number IX2)	+ =HIGH, - =LOW
			= 11, Not used	
			= 12, Indirect trip (Trip IX1 OR IX2)	NOT APPLICABLE
			= 13, Coincidence trip (Trip IX1 AND IX2)	NOT APPLICABLE
			= 14, Control block output (Control block IDC)	+ =HIGH, - =LOW
W3-I	IX1	=	Volume, junction, core, conductor, control block numbers, or trip ID. (IX1 = 0 for IDSIG = 1, 2, 3) (IX1 = Volume number for IDSIG = 4, 5, 6, or 7) (IX1 = Core section number for IDSIG = 8) (IX1 = Junction number for IDSIG = 9) (IX1 = Conductor number for IDSIG = 10) (IX1 = Control block IDC for IDSIG = 14) (IX1 = IDTRP of a previously defined trip for IDSIG = 12 or 13)	

W4-I	IX2	=	Volume, conductor node number, or trip ID. (IX2 = Optional volume number for IDSIG = ± 4 or ± 7 for differential pressure or differential temperature trip) (IX2 = Conductor node number for IDSIG = 10) (IX2 = 0 or IDTRP of a previously defined trip for IDSIG = 12 or 13) (Otherwise IX2 = 0)
W5-R	SETPT	=	Signal setpoint.
W6-R	DELAY	=	Delay time for initiating trip action after reaching setpoint (sec).
W7-A	IDITL	=	Trip description, 32 characters maximum. This description is used for edit purposes. The description should be enclosed with Hollerith delimiters (' or ").

7.0 RETRAN CONTROL VOLUMES

Each RETRAN volume is defined by a set of volume data cards consisting of up to nine cards per set. The data required to describe a volume include geometric information such as dimensions and elevation, initial conditions of the material in the volume, and option-control information.

When the multidimensional neutronics model is used (NODEL = 3 on Card 01000Y), core volume information is not input through the control volume data cards. See Section 28.0 for the input requirements for this option. NVOL (Word 5 on Card 01000Y) does not include the number of core volumes if multidimensional neutronics is used.

Initial conditions within the volume can be completely specified by describing the state of the fluid and indicating the presence or absence of an air head. The input variables consist of pressure, enthalpy, or temperature and relative humidity or quality.

When using the steady-state initialization option, the volume pressure can be specified and the form loss coefficients(s) of the junction(s) entering and/or leaving the volume will be calculated; or the pressure will be calculated if input as 0.0 and the form loss coefficient(s) of the junction(s) entering the volume is specified. Only one enthalpy per flow system should be supplied when the steady-state initialization option is used. The code will compute all other enthalpies from steady-state boundary conditions and the energy equation (a P-X or T-X entry specifies the enthalpy and T or P, respectively). The particular state in a volume is one of several possible states, many of which are completely specified by a subset of the four input variables. The remaining input variables, if any (which if used to convey thermodynamic information would overspecify the state), pass control information to the program defining the particular subset of input variables to be used.

The information required to specify the initial steady state conditions and thermodynamic conditions has historically been supplied on the volume data cards (05XXXY). For the three- and four-equation options, this information can still be supplied on the volume cards. For the five-equation model and noncondensable gas flow options, a new set of data cards (231XXX) are used to define the initial conditions. They can also be used with the three- and four-equation options and are the recommended method since they isolate the initial conditions specifications into a small block of input that is more convenient to use and review. These new cards will override any input for corresponding volumes supplied on the volume data cards.

The volume flow length (FLOWL) is input as Word 8 and if input as 0., the code will calculate a value based on the user values of FLOWA and V. Note however that the proper flow length will be calculated only if the proper flow area and volume values are specified. This caution also applies for the default value for the equivalent hydraulic diameter (Word 10).

Other input data on the volume data cards are required only for the temperature transport delay and the nonequilibrium (five-equation) options. The input required for the transport delay option is on the problem dimension card (Word 27 on 01000Y) and Word 13, the number of mesh intervals, on the volume data card. If the five-equation option is selected on the problem dimension card (Word 39 on 01000Y), all volumes will be treated as five-equation volumes unless they are associated with a component that precludes use of the five-equation option. These could include accumulators, bubble rise volumes, and two-region nonequilibrium volumes.

Variable IHTGL is a flag that can be used to force a given volume to be treated as a thermal equilibrium volume, i.e., the four-equation balance equations and the equilibrium equation of state will be used for the volume.

7.1 Control Volume Boundary Conditions

The option of using special boundary volumes with explicit time-dependent fluid boundary conditions is intended primarily for performing detailed calculations on part of a reactor system using results of previous RETRAN calculations as boundary conditions. For a detailed core calculation, the special boundary volumes would be the upper and lower volumes which connect to the core regions. Any volume may be chosen independently to have fluid conditions described as an explicit function of time. The fluid conditions in such boundary volumes are unaffected by the course of the detailed transient being calculated. The necessary fluid boundary data (07XXYY data) may be provided as tabular input, as the output of control blocks, or by automatic retrieval from a data tape created during a previous RETRAN calculation. Performing detailed calculations on part of a system by using special boundary volumes saves computer time as compared to modeling the complete system. A detailed calculation can be performed on any portion of the reactor system by using special boundary volumes.

The geometric detail of a time-dependent volume is required, just as for a normal volume. Fluid conditions are required as a function of time and include pressure, temperature, quality, and mixture level. The geometric detail plus these four time-dependent functions provide sufficient information to define completely the fluid conditions in a volume. For each time step, the data

supplied on either cards or tape is interpolated to obtain current fluid conditions. To perform calculations for a single core channel, a RETRAN problem would be set up with the upper and lower volumes defined as time-dependent volumes. The data can be retrieved from the volumes representing the upper and lower plenums from a RETRAN data tape created in a RETRAN calculation of the entire primary system.

7.2 Volume Thermodynamic Conditions

The particular thermodynamic state of a fluid volume can be one of several possible states. In RETRAN-3D, the vapor phase and liquid phase can be assumed to exist in equilibrium thermodynamic conditions (NEWEQS = 0 on Card 01000Y) or nonequilibrium thermodynamic conditions (NEWEQS = 1). The conditions in the fluid volume can generally be specified by a subset of the complete set of variables describing the thermodynamic conditions. The third option in RETRAN-3D involves volumes with a combination of air and water.

In addition to these basic considerations regarding the thermodynamic state of the fluid, the input requirements can vary by the selection of the steady-state option (JSST on Card 01000Y). When JSST = 0 or JSST = 2, the steady-state initialization process can compute data for a major portion of the system. This feature reduces the amount of input data the user is required to provide, and also helps to assure that the input data do not over specify the problem initial conditions. These various options are discussed in this section. If the steady-state initialization feature is used, fluid states in a few volumes need be defined instead of all the volumes.

The assumption of thermodynamic equilibrium means that the conditions within the fluid volume can be determined from two of the four variables, pressure, temperature, enthalpy, and quality. The various input combinations for these variables are summarized in Tables IV.7-1 and IV.7-2.

The initial volume fluid state can be defined in one of two places. The volume fluid state can be defined on the Volume Input (05XXXY input records) or on the Initial Condition Specification (231XXX input records). For the majority of situations, the analyst will use steady-state initialization and will define the initial volume state in only one or two volumes. In addition, typically the location that the conditions are specified are at locations that are initially single-phase liquid or vapor. However, the option is available to specify conditions in volumes that contain two-phase water, two-phase water and a noncondensable, single-phase vapor and a noncondensable or only a noncondensable. Initial condition specification for volumes containing two or more fluid components are a bit more complicated. For volumes that have only water in thermal equilibrium, only two independent thermodynamic quantities are required. For volumes that are initially two-phase and are in thermal nonequilibrium, three independent thermodynamic quantities are required to define the state. If air is also present an additional state parameter may be required. Listed below are some general guidelines as to how to use the state specification tables when the analyst wants to define the complete fluid state and which input stream sequence is required.

Table IV.7-1

Fluid Condition Specification for Volumes Using Equilibrium Equation of State - User Specifies Initial Fluid Properties

Mixture Level	Conditions Present	Quantity Specification
Volume filled with water only	Superheated Vapor	P>0.0, H>0.0, X=0.0 (flag)
	Saturated Vapor	1) P>0.0, T=0.0, X=1.0, or 2) P=0.0, T>0.0, X=1.0, or 3) P>0.0, H>0.0, X=0.0 (flag).
	Saturated Liquid	1) P>0.0, T=0.0, X=-1.0 (flag), or 2) P=0.0, T>0.0, X=-1.0 (flag), or 3) P>0.0, H>0.0, X=0.0 (flag).
	Subcooled Liquid	P>0.0, H>0.0, X=0.0 (flag)
	Two-Phase Mixture (thermal equilibrium)	1) P>0.0, T=0.0, 0.0<X<1.0, or 2) P=0.0, T>0.0, 0.0<X<1.0, or 3) P>0.0, H>0.0, X=0.0 (flag).
Separated Volume (0 < ZM < ZVOL) X_m = quality of fluid below the mixture level	Two-Phase Mixture (thermal equilibrium)	1) P>0.0, T=0.0, $0.0 \leq X_m < 1.0$, or 2) P=0.0, T>0.0, $0.0 \leq X_m < 1.0$, or 3) P>0.0, H>0.0, X=-1.0 (flag).

where,

P = pressure (Word 3 - P)
T = temperature (Word 4 - TEMP)
H = enthalpy (Word 4 - HW)
X = quality (Word 5 - X)

NOTE: The input value of X is used as a flag for logic control in many cases.

Table IV.7-2

Fluid Condition Specification for Volumes Using Equilibrium Equation of State - Steady-State Computes Initial Fluid Properties

Mixture Level	Conditions Present	Quantity Specification
Volume filled with water only	Superheated Vapor Saturated Liquid Saturated Vapor Subcooled Liquid Two-Phase Mixture	Any of the three below 1) P=0.0, H=0.0, X=0.0 (flag), or 2) P>0.0, H=0.0, X=0.0 (flag), or 3) P=0.0, H>0.0, X=0.0 (flag).
Separated volume with water only (0 < ZM < ZVOL)	Two-Phase Mixture	Any of the three below 1) P=0.0, H=0.0, X=-1.0 (flag), or 2) P>0.0, H=0.0, X=-1.0 (flag), or 3) P=0.0, H>0.0, X=-1.0 (flag).

where,

P = pressure (Word 3 - P)
H = enthalpy (Word 4 - HW)
X = utilized as a logic flag (Word 5 - X)

Single-Phase Water (subcooled liquid, saturated liquid, saturated vapor or superheated vapor)

- Use specification guide Table IV.7-1 (for 05XXXY) or Table IV.19-1 (for 231XXX).
- Input can be supplied through Word 3, 4 and 5 on 05XXXY or on 231XXX input data.

Two-Phase Water Mixture (thermal equilibrium)

- Use specification guide Table IV.7-1 (for 05XXXY) or Table IV.19-1 (for 231XXX).
- Input can be supplied through Word 3, 4 and 5 on 05XXXY or on 231XXX input data.

Two-Phase Water Mixture (thermal nonequilibrium)

- Use specification guide Table IV.19-2.
- Input can be supplied only on 231XXX input data.

Water/Noncondensable Mixture (thermal equilibrium, noncondensable confined to the volume for the transient duration)

- Use specification guide Table IV.7-3 (for 05XXXY) or Table IV.19-1 (for 231XXX).
- Input can be supplied through Word 3, 4 and 5 on 05XXXY or on 231XXX input data.
- Has the designation as "normal NCG/water" (air not allowed to flow through the system).

Table IV.7-3

Fluid Condition Specification for Volumes with Air in Which the User Specifies Initial Fluid Properties

Normal Air/Water	Conditions Present	Quantity Specification
Separated Volume (0 < ZM < ZVOL)	Saturated Air Over Saturated Liquid	P>0.0, T>0.0, h_m=1.0 (flag)
Volume filled with steam-air mixture (ZM = 0.0)	Saturated Steam - Air Mixture	P>0.0, T>0.0, h_m=1.0
	Superheated Vapor - Air Mixture	P>0.0, T>0.0, 0.0<h_m<1.0
Accumulator Component		
Separated Volume	Air Over Subcooled Liquid	P>0.0, T>0.0, h_m=0.0

NOTE: (a) Nonsaturated air over liquid not allowed

(b) Dry air (h_m=0) is not allowed and a very low nonzero relative humidity may lead to a partial pressure which is below the applicable range of the water property curve fits.

where,

P = pressure (Word 3 - P)
T = temperature (Word 4 - TEMP)
h_m = relative humidity of vapor-air mixture (Word 5 - HUM)

Water/Noncondensable Mixture (thermal equilibrium, noncondensable can flow from the volume)

- Use specification guide Table IV.19-1.
- Input can be supplied only on 231XXX input data. **Water/Noncondensable Mixture** (thermal nonequilibirum, noncondensable can flow from the volume)
- Use specification guide Table IV.19-2.
- Input can be supplied only on 231XXX input data.

For the majority of the fluid volumes in the system, the analyst will want to either not specify the volume fluid state or will want to specify only one independent state variable such as pressure or enthalpy. In ether case, steady state initialization will either compute the state or will compute the unspecified state variable. The two choices are:

No thermodynamic variables defined.

- Use specification guide Table IV.7-2.
- Input can be supplied only through Word 3, 4 and 5 on 05XXXY card.
- Steady-state initialization computes thermodynamic state.

One Thermodynamic Variable Defined.

- Use specification guide Table IV.7-2 (for 05XXXY) or Table IV.19-3 (for 231XXX).
- Input can be supplied through Word 3, 4 and 5 on 05XXXY card or on 231XXX input data.
- Used when only one quantity is known (either pressure or enthalpy).
- Steady-state initialization computes undefined thermodynamic state variable.

For the cases in which thermodymamic input can be supplied on the 05XXXY or 231XXX input data, there is nothing to prevent specification in both locations however, the input supplied on the 231XXX input data will override that supplied on that on the 05XXXY input data.

As discussed above, a different set of input data are required when the fluid volume contains air and that air does not leave the volume during the transient. These requirements are summarized in Table IV.7-3 and must be used at all times, whether the steady state is computed by the code or specified by the user. Note that the input requirements are different when the air-water volume is an accumulator. In a normal air-water volume, such as a containment, the liquid and vapor are assumed to be in thermal equilibrium and, thus, behave in an isothermal manner. In an

accumulator, the expansion of the cover gas can be at a much different temperature than the liquid region. The RETRAN accumulator model is designed to model the gas and liquid region temperatures and the vessel wall temperature.

Tables IV.7-1, and IV.7-3 and IV.19-1 should be used exclusively for all volumes when the steady-state initialization option is not used, i.e., JSST = 1 on Card 01000Y. If the user is using the equilibrium field equations (NEWEQS = 0 on Card 01000Y or NEWEQS = 1 and IHTGL $\geq$ 0 on Card 05XXXY) and allows the code to compute the steady-state conditions, input data can be prepared according to Tables IV.7-1, IV.7-2, IV.7-3, or IV.19-1.

The same type of guidelines are used for volumes with nonequilibrium thermodynamic conditions (NEWEQS = 1 on Card 01000Y and IHTGL = 0 on Card 05XXXY). The five-equation option assumes the vapor phase is saturated anytime two-phase conditions are present. In order to completely specify the conditions for a volume, the user needs to supply the pressure, enthalpy or temperature, and quality. The initial fluid state for two-phase nonequilibrium volumes must be supplied on the 231XXX input data according to the specification in Table IV.19-1.

7.3 Temperature Transport Delay Model

The timing of temperature changes in the primary system can be very important in the simulation of plant transients for both BWR(s) and PWR(s) because of the effects reactivity feedback and/or steam generator heat removal have on the system transient response. Temperature changes move through some regions (such as piping) essentially as a front; that is, the incoming fluid does not mix with the fluid within the particular region but displaces it. The standard RETRAN method for determining the junction enthalpy is to homogeneously mix incoming fluid with the contents of a particular region; thus, the outlet enthalpy begins to respond immediately to changes in the inlet. This is the type of response that best represents a plenum.

The RETRAN temperature transport delay time model is an approximate submodel designed to track the movement of temperature fronts through piping systems.

Increasing the number of control volumes will not produce results that are comparable to the temperature transport delay time model due to the numerical dispersion inherent in the finite difference equations. The number of mesh intervals needed in the transport delay model is dictated by the shape of the temperature front. A simple step function can be tracked with as few as three mesh intervals, while a sine wave may require 10 to 20 mesh intervals (fewer mesh intervals will distort the input wave form). It should be noted that the model has a Courant limit equal to the control volume Courant limit divided by the number of mesh intervals. If time steps are taken that exceed this limit, results will be unpredictable and will typically lead to junction enthalpies that are unreasonable. The affect of the number of mesh intervals upon the submodel Courant limit should be considered.

The temperature transport delay model can be used in a volume with either the equilibrium or nonequilibrium equation of state. In either case, the model will only be used while the fluid is

single-phase liquid. The standard homogeneous mixture will be used when the volume becomes two phase.

7.4 Nonequilibrium Field Equation Input Data

RETRAN-3D includes an option to analyze problems involving nonequilibrium thermodynamic conditions. This option is selected using NEWEQS (Word 39) on the problem dimension card (01000Y). Additional input data are provided on the volume data cards.

In the five-equation model, the vapor phase is assumed to be saturated and the liquid can be subcooled, saturated, or superheated for two-phase conditions. The five-equation model is activated in every volume if NEWEQS = 1 on Card 01000Y, unless it is turned off by specifying the volume as a bubble rise or two-region nonequilibrium volume. The model can also be turned off in individual volumes using IHTGL = 1 (Word 14) of the volume data card (05XXXY).

IMAP (Word 15) of the volume data card is used by the five-equation model. It is used to specify the volume orientation so the correct flow regime map is used. If a volume is horizontally oriented, IMAP must be 1 for a circular pipe or 2 for a duct with a rectangular cross section. The rectangular option must be used in order for the stratified flow interfacial area to be correctly calculated.

The mass transfer due to wall heating is always computed using the EPRI boiling model if the volume is adjacent to a conductor and the conditions for nucleate boiling are present. The profile fit data given on data card 061011, are used by the EPRI boiling model. The default values are for tubes or channels and should be revised for rod bundle geometries.

7.5 Optional Wall Friction Models - Data Cards 2331XX and 2332XX

RETRAN-3D contains correlations for modeling both turbulent and laminar wall friction. For turbulent conditions, the Colebrook correlation is used and for laminar conditions the friction factor is obtained using 64/Re. If no optional friction model input is supplied, these default correlations will be used. They are recommended for most applications; however, in some situations alternate correlations may be useful for insuring consistency with other computer codes or allow incorporation of geometry affects for laminar flow conditions. In these situations, one of the optional turbulent and/or laminar wall friction models can be specified on a volume-by-volume basis. The input necessary to define the optional models is discussed in the following sections. To request use of one of the models for a given volume, the IFRIC flag (Word 16 on the 05XXXY cards) is used.

7.5.1 Optional Turbulent Wall Friction - Data Cards 2331XX

Two different equation forms are available for use in determining the turbulent wall friction. These are the Blasius and Moody forms. When these optional models are used, input data will

be used to specify the correlation form and the accompanying coefficients. Both forms are shown below.

Blasius Form

$$f_{tur} = 4\frac{C_{t1}}{Re^{C_{t2}}}$$

where

f_{tur} = turbulent friction factor,

Re = Reynolds number,

C_{t1} = model coefficient (typically 0.0791), and

C_{t2} = Reynolds number exponent (typically 0.25).

Moody Form

$$f_{tur} = 4\,C_{t1}\left[1+\left(C_{t2}+C_{t3}/Re\right)^{C_{t4}}\right]$$

where

C_{t1} = model coefficient (typically 0.001375),

C_{t2} = model coefficient (typically 20000 ε/D_h),

C_{t3} = model coefficient (typically 10^6),

C_{t4} = Reynolds term exponent (typically 0.33333), and

ε/D_h = relative roughness.

The model selection flag and associated correlation coefficients are supplied using the 2331XX card. The value of XX represents the correlation number that will be referenced using IFRIC on the volume data card 05XXXY. Many volumes can reference a single correlation number (value of XX). Values of XX on 2331XX cards included in a deck must be sequential. Correlation set data can be supplied but not referenced on any volume card. Input fields for the 2331XX card follow.

W1-I LTURB = Friction Factor Model Selection Flag
= 1, Use the Blasius Form
= 2, Use the Moody Form

For LTURB = 1 (only 2 coefficients must be supplied)

W2-R	CTURB1	=	Friction Model Coefficient C_{t1}
W3-R	CTURB2	=	Friction Model Coefficient C_{t2}

For LTURB = 2 (four coefficients must be supplied)

W2-R	CTURB1	=	Friction Model Coefficient C_{t1}
W3-R	CTURB2	=	Friction Model Coefficient C_{t2}
W4-R	CTURB3	=	Friction Model Coefficient C_{t3}
W5-R	CTURB4	=	Friction Model Coefficient C_{t4}

7.5.2 Optional Laminar Wall Friction - Data Cards 2332XX

The default parameters for the laminar flow wall friction correlation in RETRAN-3D may not be appropriate for some natural circulation flow conditions. Comparisons with test data has shown that the laminar flow wall friction model required to match the data may vary with geometry. A generalized laminar flow correlation is available to allow use of specific models of the form.

$$f_{lam} = 4\left[\frac{C_{rey}}{Re^{x_{rey}}} + C_{const}\right]$$

where

f_{lam}	=	Laminar Friction Factor,
Re	=	Reynolds Number,
C_{rey}	=	Friction Factor Coefficient Multiplier,
X_{rey}	=	Reynolds Number Exponent, and
C_{const}	=	Friction Factor Constant.

The user can specify alternate laminar wall friction correlation parameters by using Card 2332XX. The XX represents the correlation number and must be consecutive. These correlations are associated with specific volumes by specifying the correlation number in IFRIC on the 05XXXY card.

W1-R	CREY	=	Friction Factor Coefficient Multiplier
W2-R	XREY	=	Reynolds Number Exponent
W3-R	CCONST	=	Friction Factor Constant

7.6 Volume Data Cards 05XXXY

NVOL (Card 01000Y) sets of cards must be entered, with XXX equal to the Control Volume Number. NVOL sets of 05XXXY cards must be supplied but XXX need not start at 001 and need not be consecutive. Y is a card sequence number ranging from 1 to 9 for each set, starting at 1, and must be consecutive. The input may be entered on up to nine cards.

The mixture level is input on the bubble rise Cards 06XXXY and is required only if the volume uses a bubble rise model. The parameters VRAIN and VLHTC for a two-region nonequilibrium volume are input on separate nonequilibrium volume cards, 610XXX.

W1-1	IBUB	=	Bubble data set number (06XXX1 cards). ($0 \leq$ IBUB $\leq$ NBUB) = 0, volume is treated as homogeneous. > 0, bubble rise set number (XXX on Card 06XXX1). Each nonzero value of IBUB must be unique.
W2-I	IREAD	=	Time-dependent volume data retrieval index. = 0, this volume is not a time-dependent volume. < 0, use the data pertaining to volume |IREAD|, stored on the data file for a previous run for the time-dependent volume data. This data file is supplied as FORTRAN Unit 12 (Tape 12). > 0, obtain time-dependent volume data from data cards and use set IREAD of the time-dependent volume conditions on Cards 07XXYY where IREAD = XX.
W3-R	P	=	Pressure (psia) For P = 0.0, pressure will be calculated
W4-R	TEMP	=	Temperature (F)
	or, HW	=	Thermodynamic enthalpy (Btu/lbm)
W5-R	X	=	Quality
	or, HUM	=	Humidity (Dimensionless)

NOTE: Words 3 through 5 define the thermodynamic state of the control volume. Refer to Tables IV.7-1 through IV.7-3 when preparing the volume thermodynamic input to ensure that a proper combination of variables is specified.

W6-R	V	=	Volume (ft^3) (V > 0.)
W7-R	ZVOL	=	Volume height, bottom to top (ft) (ZVOL > 0.)
W8-R	FLOWL	=	Geometrical flow length (ft). This parameter should be representative of the flow path of the fluid through the volume. If entered as 0., FLOWL will be calculated from FLOWL = V/FLOWA
W9-R	FLOWA	=	Flow area of volume (ft^2)
W10-R	DIAMV	=	Equivalent hydraulic diameter of flow channel (ft). If entered as 0., DIAMV will be reset to $2\sqrt{FLOWA/\pi}$
W11-R	ELEV	=	Elevation at the bottom of the volume (ft)
W12-R	EOVRD	=	Wall relative roughness for use in friction factor calculation (default = 0.0).
			NOTE: If the remainder of this card is left blank, it will default to the standard RETRAN calculations. See Section IV.7.3 for information on the temperature transport model and Section IV.7.4 for information on the five-equation option.
W13-I	MESH	=	Number of mesh intervals to be used in temperature transport delay calculation ($0 < MESH \leq 999$) = 0, no temperature delay time model (default)
W14-I	IHTGL	=	Balance equation selection for the five-equation model (only used when NEWEQS = 1 on Card 01000Y). = 0, use five-equation model for this volume (default) = 1, use four-equation model for this volume
W15-I	IMAP	=	Volume orientation flag for the five-equation model (only used when NEWEQS = 1 on Card 01000Y). = 0, vertical volume (default) = 1, horizontal volume = 2, horizontal volume with rectangular cross section
W16-I	IVFIT	=	Profile fit data set number used for this volume. =0, use default coefficients >0, coefficient data set XX, as specified on Card 061XX1.

W17-I IFRIC = Multi-field flag used to define optional turbulent and/or laminar wall friction model correlation number.
= 0, use the default turbulent and laminar friction models
> XXYY, multi-field flags described below.
XX = turbulent wall friction correlation number (XX on Card 2331XX)
= 0 or blank, the default turbulent model will be used.
YY = laminar wall friction correlation number (XX on Card 2332XX)
= 0, the default laminar model will be used.

7.6.1 Volume Input User Guidelines

Most of the parameters supplied for a volume are geometric or thermodynamic data, which require no additional guidance. There are some optional parameters that are discussed here.

W12-I EOVRD Relative roughness can optionally be supplied. Any nonzero value will increase the single-phase friction factor value. RETRAN-02 assumed zero roughness, so a zero value here will reproduce the model in RETRAN-02.

W13-I MESH If MESH > 0, this activates the temperature transport delay option in this volume (see discussion in Section 7.3). Three to five mesh intervals are generally adequate to track the movement of a temperature front properly. The time step the code can take is limited to the time it takes for the given flow to completely move through a mesh region(Courant limit). Consequently, small mesh intervals may limit the time-step size that can be taken.

The application of this model should be limited to piping type configurations. In plenum areas where considerable mixing might occur, the application of this model is questionable.

W14-I IHTGL This parameter is meaningful only if the five-equation option is selected on the problem dimension card (NEWEQS on 01000Y). In areas where thermal nonequilibrium is not expected or is not important to overall transient behavior, IHTGL = 1 can be used to force a four-equation solution for specific volumes.

W15-I IMAP This parameter is meaningful only if the five-equation option is selected on the problem dimension card (NEWEQS on 01000Y).

		The five-equation interphase mass and energy transfer requires a prediction of the flow regime. This parameter selects the appropriate flow regime map to be used.
W16-I	IVFIT	This parameter corresponds to the profile fit data set number (XX on Card 061XX1) that defines the coefficients for either the profile fit (three- or four-equation model) or subcooled void generation model (five-equation) applied to this volume.

7.7 Bubble Rise Model Cards 060XXY

The bubble rise model used in RETRAN is a semi-empirical fit to data for which the void distribution within the two-phase mixture is assumed to be linear with elevation. The purpose of this model is to estimate the junction enthalpy as a function of vertical elevation within the flow-source volume modified for either horizontal or vertical flow areas. A separate bubble set (XX on Card 060XX1) is required for each control volume that uses the bubble rise model.

The input constant, ALPH, which must be limited to values of zero through unity, determines the maximum vertical bubble gradient at any instant. If ALPH is chosen as zero, the mixture is homogeneous; if chosen as unity, the bubble gradient is always the maximum within the permissible physical constraints. Values outside this range give negative values for the partial bubble density and are not allowed.

The separation velocity of steam bubbles relative to the mixture interface, VBUB, is another input quantity. If the velocity is zero, no separation occurs although a bubble-density gradient may still exist. Large values of VBUB, say 10^6, provide for essentially complete separation.

If the steady-state initialization option is employed, the RETRAN code will adjust the bubble rise models to ensure a steady-state solution. Steady-state initialization is discussed in Volume 1: Theory and Numerics.

The bubble density gradient, ALPH, and bubble velocity, VBUB, can be defined by the control system (Words 5 and 6). However, the user should be careful when using this option since any adjustment of the bubble rise parameters by steady-state initialization will be replaced by the control block definitions the first time step. If the Wilson bubble rise velocity correlation is used, the correlation value is normalized to the bubble velocity computed to maintain a steady-state condition in the separated volume.

NBUB (Card 01000Y) cards must be entered with XXX = 001, 002, ..., NBUB.

W1-R	ALPH	=	Bubble-gradient parameter ($0. \leq$ ALPH ≤ 1.0)
W2-R	VBUB	=	Bubble velocity (ft/sec) (VBUB $\geq 0.$)

W3-R	ZMIX	=	Mixture level (ft) (from bottom of volume 0 ≤ ZM ≤ ZVOL from the volume data Card 05XXXY)
W4-I	IWILSN	=	Wilson bubble rise velocity correlation index. = 0, do not use Wilson model. = 1, use Wilson model.
W5-I	IDALPH	=	ID of control block defining bubble gradient (IDALPH < 0). = 0, Use constant ALPH.
W6-I	IDVBUB	=	ID of control block defining bubble velocity (IDVBUB < 0). = 0, Use constant VBUB or Wilson correlation as specified above.

Words 5 and 6 are optional. If the control model is invoked, either W5 or W6 (or both) can be entered and the corresponding constant(s) ignored. When using the Wilson bubble rise velocity correlation, the bubble gradient can be constant (IDALPH = 0) or computed by the control system.

7.8 Profile Fit Data Cards 061XX1

The profile fit data are used with the EPRI subcooled boiling and the profile fit models. For the five-equation model, the subcooled boiling model is used to compute the mass transfer at heated walls. The profile fit model is an auxiliary model that is used with the three- and four-equation models (NEWEQS = 0 on Card 01000Y) to compute a subcooled void fraction for use with the void reactivity calculations for all kinetics options. The 061XX1 data are read if NFIT > 0 on Card 01000Y. The profile fit model is based on the Zolotar-Lellouche drift flux model.[IV.7-1] The thermodynamic void fraction is used for computing the void feedback if the profile fit model is not used. The profile fit model is activated by setting IVOID=1 (Word 36) on Card 01000Y. Profit fit data cards with sequential values of XX must be supplied with XX ranging from 1 to NFIT.

The algebraic slip option (ISFLAG = 2 on Card 01000Y), the dynamic slip option (ISFLAG = 4), and the profile fit model are based on the drift flux method. These data cards allow the user to override the set of default coefficients provided for these models. Two coefficients (KAPPA1 and CGL) are used in the slip model while all four coefficients are required for the profile fit model.

The profile fit data are used with the five-equation subcooled boiling model whenever five-equations are used (NEWEQS = 1 on Card 01000Y). The profile fit model is skipped when the five-equation model is used. The same default values and suggested values apply to the profile fit and EPRI subcooled boiling models.

W1-R	KAPPA1	=	Flow channel geometry factor (default = 0.71) = 0.71 for tubes and channels = 0.80 for rod bundles
W2-R	CGL	=	Coefficient in expression for drift velocity (default = 1.41)
W3-R	CDB	=	Coefficient for Dittus-Boelter heat transfer correlation (default = 0.023) = 0.023 for tubes and channels = 0.013 + 0.033 ε for rod bundles where ε is the fraction of unit cell available for flow
W4-R	CHN	=	Coefficient for Hancox-Nicoll heat transfer correlation (default = 0.2) = 0.2 for tubes and channels = 0.1 D_{he}/D_{rod} for rod bundles where D_{he} is the heated equivalent diameter, and D_{rod} is the rod diameter.

7.9 Level Model Data 06500X

The level model is designed to accommodate a discrete liquid level movement through a vertical stack of volumes. Specifically, it is intended to model level movement within the vessel during a transient initiated from mid-loop operating conditions. The user can define a vertical stack of volumes to apply the model to. The volume stack can be initially full of liquid, initially full of vapor, or can have an initial level within the stack and the model will work for either draining or filling. The model can be applied to one or more volume stacks.

The level model is based on the bubble rise model and allows a mixture level to become established only in the volume where the level exists. An example of how the logic works is illustrated by the following examples. First, consider a volume stack that is initially full of liquid and it is expected that a level will be established and the level will move through the stack during the transient. The code will set the bubble velocity in the top volume to a non zero value and the bubble velocity to zero for all volumes below the top volume. This allows an initial mixture level to become established in the top volume when conditions permit and not in the lower volumes.

As the level drops through the top volume the bubble velocity in the volume immediately below the top will be set to a nonzero value to allow the level to move into that volume. As the level continues to drop, this process will be continued until the level has passed through all the volumes. The second example is for a volume stack that is initially full of vapor. In this situation, the bubble velocity in the bottom volume will be set to a non zero value and the upper volumes will have zero bubble velocity. This will allow the level to establish in the bottom volume and when it fills, the bubble velocity in the volume above will be set to non zero. This process will continue until the volume stack completely fills with liquid.

In reality, all volumes in the stack are bubble rise volumes, but by having zero bubble velocities, a mixture level will not develop. However, the vapor distribution gradient will apply to all the volumes regardless of whether the bubble velocity is zero or not. One of the basic assumptions is that model will be applied to transients in which little or no vapor entrainment is expected below the level. Therefore, a default bubble velocity of 1000 ft/sec is assumed that will minimize entrainment for the volume that contains the level. Currently, this bubble velocity is fixed and cannot be altered by the user.

It is recommended modeling practice that the junction connecting the bubble rise volume with other volumes not be placed at the exact bottom or top of the volume. Instead, the junction should be moved into the volume slightly and the vertical junction option used (JVERTL = 1). This implies that connected volumes should be overlapped a small amount. The reason for this discussion is that the level model works differently depending on whether or not the volumes are overlapped. If volumes in the stack are not overlapped, a non zero bubble velocity will exist in only one volume and it will not move to another volume until the mixture level becomes zero if it is draining or equal to the volume height if it is filling. If the volumes are overlapped, a non zero bubble velocity will exist in two adjoining volumes when the mixture level is in the overlap between those volumes.

If the volume stack is initially full of liquid vapor (no level), the user does not need to supply bubble rise input (060XXY data) for these volumes and the volume bubble rise flag (IBUB on 05XXXY data) does not have to be non zero. The code will automatically set up bubble rise data for any volumes for which the user has not already supplied data. As discussed above, the bubble rise velocity will be set to 1000 ft/second for the volume in which the level exists and zero for the other volumes. The bubble rise slope parameter will default to 0.8. The user can elect to supply bubble rise data for the volumes if a slope parameter other than 0.8 is desired: however, the user supplied bubble velocities will be overridden.

If an initial level exists within the volume stack, the user must supply bubble rise data for the volume with the mixture level and the bubble rise data for the remainder of the volumes will be set up automatically.

X is a sequence number that ranges from 1 to the number of volume stacks. There is no flag on the problem dimension card to activate this model. Currently, NBUB (01000Y data) must be greater than zero for the model to be active.

W1-I INITIAL = Initial condition indicator
= 1, the volume stack is initially full of liquid
= 2, the volume stack is initially full of vapor
= 3, there is an initial mixture level somewhere within the volume stack

If INITIAL is 1 or 2, the user need not supply any bubble rise information for these volumes, the bubble rise data will be set up by the code. If INITIAL = 3 the user must supply a bubble rise data set for the volume in which the mixture

			level exists initially, bubble rise data for the remaining volumes in the stack will be set up automatically.
W2-I	IVOLT	=	Volume numbers in the stack supplied in the order from top volume number to the bottom volume number
.			
.			
.			
WN-I	IVOLB	=	Bottom volume number

7.10 Time-Dependent Volume Data Cards 07XXYY

Data to specify the thermodynamic conditions for time-dependent volumes can be obtained from (1) a data file created in a separate RETRAN calculation, (2) tabular data provided by the user, or (3) the RETRAN control system. If the data are obtained from another RETRAN data file, no additional input is required here. The input in this section is used for the other two methods of specifying time-dependent volume data. The thermodynamic variables used to obtain state properties are shown in Table IV.7-4. Note that this input is converted to equivalent pressure/ enthalpy values which will be used for the property interpolation. Make sure that an adequate number of points are provided and recognize that the input quantities are not used for the interpolation. All four thermodynamic variables are not always used to obtain state properties. However, all four variables must be present for consistent interpolation between data points if the fluid changes phase and another set of thermodynamic variables is used to obtain the state properties. Thermodynamic equilibrium is assumed for all time-dependent volumes.

Quality in all time-dependent volumes is defined as average volume quality,

$$X^m = \frac{M_{gm}}{M}$$

where

M_{gm} = mass of gaseous mixture (vapor mass plus noncondensable mass).

The quality for a subcooled liquid is 0.0 and is 1.0 for a superheated vapor. Only two of the three thermodynamic quantities (pressure, temperature, and quality) are required input to define each state point in volumes containing water only. For subcooled liquid or superheated vapor, pressure and temperature must be input, and quality will be set to 0.0 or 1.0 as appropriate. When including noncondensable gases the pressure, temperature, and/or quality are required, as well as the quality of the noncondensable (or the humidity). Thermodynamic quantities not supplied should be entered as 0.0 (any parameter input as zero is interpreted as being unspecified). The missing quantities are calculated and stored in the appropriate table locations.

Table IV.7-4

Input Requirements for Time-Dependent Volumes

Volume Filled with Water Only (XNC = 0.0)

Mixture Level	Conditions Present	Thermodynamic Variables Used
Volume filled with water only (ZM = ZVOL)	Superheated Vapor	P,T
	Saturated Vapor	T,X or P,X
	Saturated Liquid	T,X or P,X
	Subcooled Liquid	P,T
	Two-Phase Mixture	T,X or P,X
Volume containing mixture (0<ZM<ZVOL) NOTE: Xm = quality of fluid below the mixture level	Two-Phase Mixture	T,Xm (Xm input in X field)

Volume Contains Noncondensable (XNC > 0.0)

Volume filled with water and noncondensable (ZM = ZVOL)	Noncondensable Only	P,T
	Vapor and Noncondensable	P,T,X = 1.0, 0.0 < XNC < 1
	Vapor, Noncondensable, and Liquid	P,T, 0.0 < X < 1.0, XNC = 1
Volume containing mixture (0<ZM<ZVOL) NOTE: Xm = quality of fluid below mixture level	Vapor, Noncondensable, and Liquid	P,T, 0.0 < Xm < 1, XNC = 1 (Xm entered in X field)
	Humid Air	P,T,X 0.0 < XNC < 1
	Humid Air - Liquid Water	P,T,X as above, and 0.0 < XNC < 1

NTDV (from Card 01000Y) sets of cards must be entered with the set number XX=01,02, . . ., NTDV. Data points may be entered on these cards ordered by YY ranging from 00 to 99. YY need not start at 00 and need not be consecutive. The first entry for a set specifies either the number of data points (IRIN) contained in the set or that the data will be taken from control blocks. A data point consists of time, pressure, temperature, mixture quality, mixture level, and quality of noncondensable. The noncondensable gas quality is not required input if a noncondensable is not present; however, a value of zero may be entered. If the noncondensable quality is nonzero for any time dependent volume, NCFLOW (or 01000Y) must be equal to one. The first data point must begin at time = zero. At time = zero the thermodynamic state of the time-dependent volume is obtained from the data on these cards and the information supplied on the volume card (05XXXY) is ignored.

W1-I	IRIN	=	Number of data points in the table (0 < IRIN < 1000) = 1000, obtain boundary condition data from the control system.

For IRIN < 1000 (tabular data):

W2-R	TIMTBL(1)	=	Time (sec)
W3-R	PTABL(1)	=	Pressure (psia)
W4-R	TTABL(1)	=	Temperature (F)
W5-R	XTABL(1)	=	Quality of Mixture
W6-R	ZTABL(1)	=	Mixture level (from bottom of volume) (ft)
W7-R	XNCTABL(1)	=	Relative humidity (required only if noncondensable is present)
W8-R,....	TIMTBL(2),PTABL(2), TTABLE(2), XTABL(2), ZTABL(2), XNCTABL(2).		
W13-R,...	...		

NOTE: Entry (1) must be data set for time = 0.0. Time must be in ascending order.

For IRIN = 1000 (values from control blocks) IDs must be input as floating point number.

W2-R	IDPRES	=	ID of control block controlling the pressure
W3-R	IDTEMP	=	ID of control block controlling the temperature
W4-R	IDQUAL	=	ID of control block controlling the quality
W5-R	IDZMIX	=	ID of control block controlling the mixture level

W6-R	IDXNC	=	ID of control block controlling relative humidity (required only if noncondensable is present)

8.0 RETRAN JUNCTIONS

A junction card is used to define a flow path between two RETRAN volumes. The "from" and "to" convention on the junction data card defines the flow direction. Flow leaving the "from" volume and entering the "to" volume is defined as positive. The full open flow area is denoted by AJUN and the junction elevation, ZJUN, is referenced to the same base as the volume elevation, ELEV.

When the multidimensional neutronics model is used (NODEL = 3 on Card 01000Y), junctions connecting core volume are not specified through the junction data cards. See Section 28.0 for the input requirements for this option. NJUN (Word 8 on Card 01000Y) does not include the number of junctions in the core if multidimensional neutronics is used.

Three types of junctions are permitted in RETRAN problems. The first of these junctions is a "normal" junction connecting two control volumes. The second junction type, a "fill" junction, is a specified flow boundary condition. Fill junctions are described by setting IW1 to zero and selecting the set of tabular data used to determine the junction flow conditions. Selection of fill data is facilitated by setting IPUMP equal to the desired fill curve XX, described on Cards 13XXYY. Fill junctions can be either positive or negative (flow is negative), although the use of a negative fill is not considered to be a proper boundary condition for RETRAN. The mass flow rate specification on Card 08XXXY for a fill junction is neglected and can be input as zero. Mass flow rates for fills are computed from the fill table data and trip status for the trips associated with fill junctions.

The third type of junction is a "spray" junction, used only with a two-region nonequilibrium control volume to model a PWR pressurizer. Modeling the pressurizer spray system as a "normal" junction into the vapor region desuperheats the vapor region. The special "spray" option, called for by specifying ISP (Word 21) equal to 1, involves the removal of mass and energy from the vapor region but does not desuperheat the region. The spray, in falling through the atmosphere, condenses vapor from that region. The spray plus condensed mass is deposited directly in the liquid region without a time delay.

Form loss coefficients for all junctions are required for a RETRAN analysis. If the steady-state initialization option is not used, all junction form loss coefficients are required input. If the steady-state initialization option is used, any or all of the normal junction form loss coefficients may be calculated depending on the number of control volume pressures that are input (i.e., if all control volume pressures are input, then all of the junction form loss coefficients can be calculated by RETRAN). In addition to using a constant value for the loss coefficient, the options allow a value to be obtained from a control block or from a correlation for sharp-edged area changes.

Three basic forms of the flow equation are provided in RETRAN. Each form contains a particular set of assumptions. The user chooses the form most appropriate for a particular junction. This choice is controlled by the input quantity MVMIX.

Specifically the three basic forms are:

- compressible single-stream flow with momentum flux,
- compressible two-stream flow with one-dimensional momentum mixing, and
- incompressible single-stream flow without momentum flux.

The choice of the flow equation form depends upon the purpose and detail of the desired calculation. The forms for compressible single-stream flow with momentum flux and for compressible two-stream flow with one-dimensional momentum mixing both include a one-dimensional momentum flux term and are applicable when the control volumes represent a one-dimensional stream tube. The form for compressible two-stream flow with momentum mixing should be used only when two streams can combine and exchange momentum in a one-dimensional sense. This form is the basis for the jet pump model and should be applied to the jet pump suction and nozzle junctions (MVMIX = 2). The basic momentum mixing equation has four forms that represent four different flow patterns of the streams. The incompressible single stream flow form without the momentum flux term provides an alternate to the compressible flow equation with the momentum flux term.

General one- or two-dimensional flow problems can be modeled using RETRAN. The user must recognize the approximation may be restrictive for highly complex two- and three-dimensional geometries.
RETRAN-3D uses a junction hydraulic diameter for the phase friction terms in the dynamic slip equation and to compute the junction quality for vertical junctions associated with a separated volume. This hydraulic diameter can be obtained in one of three ways. The first option requires the user to specify a nonzero value of DIAMJ (Word 15). With the second option, the code will use the hydraulic diameter from the donor flow volume during the time step of the calculation. The third option computes the hydraulic diameter from AJUN (Word 6) if JVERTL = 1 (Word 11). To use the second and third options, the user specifies DIAMJ = 0.0.

Two forms of the Baroczy two-phase multiplier are available in RETRAN-3D. The default form (JTPMJ = 0) uses the static quality to evaluate the Baroczy correlation, but the flowing quality will be used when JTPMJ = 3. The latter option is recommended.

There are two angles associated with the junction input (Words 21 and 22, ANGLJ1 and ANGLJ2). These angles specify junction orientation relative to the upstream and downstream volumes, respectively. These angles affect the manner in which the momentum flux is computed.

These angles are intended to correctly adjust the momentum flux terms for special cases where there is a flow split and one junction splits off at an angle relative to the main flow such as in tees, wyes, or manifolds. In most instances, there is one junction in and one junction out of a volume in which the angles should be specified as zero (the default value) to indicate the

junction flow paths are parallel. The angle information is not intended to represent turns in a single flow path such as elbows.

The basic enthalpy transport option from RETRAN-02 has been retained in RETRAN-3D. This model cannot be used if the five-equation option (NEWEQS = 1 on Card 01000Y) is activated. An option has been added that allows the user to control the use of this model under certain conditions. This option and associated input are discussed in Section IV.8.3.

8.1 Slip Velocity Options

RETRAN-3D has several models that can be selected to model the velocity difference (slip velocity) between the vapor and liquid phase in a two-phase mixture. The specific option is selected by the value of ISFLAG (Card 01000Y). This section provides a brief summary of the slip options and associated input. Additional information on the basis of each model is given in Volume I: Theory and Numerics.

Four of the slip options are based on a differential equation to represent the velocity difference. This equation includes terms for wall-to-phase friction, interphase friction and added-mass, pressure differential, and gravity effects. The models used for the last three terms are independent of flow structure and are of the same form for each of the four differential slip equations. The main difference between the models is the treatment of the friction terms. Empirical flow regime maps are used for the case of ISFLAG = 1, a model (referred to as a "taugl" model) based in part on a drift flux approach is used if ISFLAG = 4 or 5, and a dynamic flow regime model is used for the friction terms if ISFLAG = 6. The ISFLAG = 1 model is the same equation as the dynamic slip option in RETRAN-02.
Two of the slip models are algebraic equations and are based solely on drift flux modeling. The two options are the Zolotar-Lellouche[IV.8-1] model, which is also in RETRAN-02, and the Chexal-Lellouche model.[IV.8-2, IV.8-3] The Zolotar-Lellouche correlation is generally applicable to upflow in heated regions and, thus, the application of this option should be limited to these type conditions. The Chexal-Lellouche model is based on a large group of data including vertical cocurrent and countercurrent upflow and flow in horizontal geometries. This model can be applied for a variety of conditions.

The input variable, IFRJ (Word 17), is used in conjunction with the ISFLAG specification to implement a specific slip option. If the user wishes to impose an equal velocity assumption at any individual junction, this can be accomplished by setting IFRJ = -99. In addition to this input option, which applies for all values of ISFLAG, the input value of IFRJ is used to specify several other aspects for the slip models.

The flow regime maps for the dynamic slip option (ISFLAG = 1) are based on cocurrent flow data in pipes. The user may override the flow regime determined from the maps by specifying a fixed flow regime of -IFRJ in the input. This feature is used for conditions such as large plena, where the flow structure is generally homogeneous across the volume.

The Chexal-Lellouche model, as implemented in RETRAN-3D, has coefficients that are dependent on both the flow direction (i.e., cocurrent or countercurrent) and the flow geometry

(i.e., vertical or horizontal). RETRAN can determine the flow direction, but cannot readily determine if a flow path should be treated in a vertical or horizontal manner. The variable, IFRJ, is used to make this determination. To indicate a horizontal flow path, a value between 10 and 19 should be input for IFRJ. This input specification should be used for both the algebraic slip equation (ISFLAG = 3) and the taugl model (ISFLAG = 5).

A summary of the various friction terms and input requirements for the slip models is given in Table IV.8-1.

8.2 Junction Data Cards 08XXXY

NJUN (Card 01000Y) sets of cards must be entered with XXX equal to the junction number. NJUN sets of 08XXXY cards must be supplied but XXX need not start at 001 and need not be consecutive. Y is a card sequence number for each set, starting at 1, and must be consecutive. The data may be entered on up to nine cards.

When junctions use the optional FIBWR model (as opposed to the conventional inertial solution) and they are not part of the multidimensional kinetics model, only the first seven words should be supplied. The use of the "from-to" specifications, IW1 and IW2, are unchanged. The value of IPUMP is 100 plus the particular lateral leakage coefficient set (XX from Cards 6351XX). For bypass inlet junctions connecting the lower plenum with the bypass, IPUMP should be 201. The flow from the individual bypass leakage sets (defined on Cards 6352XX) will be summed to determine the total bypass inlet flow. All other input variables can be zero except W7-R, ZJUN, is the junction elevation.

Normal junctions, fill junctions, and leakage junctions may be intermixed at will in an input deck.

W1-I	IW1	=	Fluid volume number at junction inlet (IW1 $\geq$ 0). > 0, corresponds to XXX on the desired Volume Data Card 05XXXY. = 0, this is a fill junction.
W2-I	IW2	=	Fluid volume number at junction outlet (IW2 > 0); corresponds to XXX on the desired Volume Data Card 05XXXY.

Table IV .8-1

Summary of RETRAN-3D

ISFLAG	DESCRIPTION	WALL FRICTION	INTERPHASE FRICTION	IFRJ	COMMENT
1	Dynamic Slip	Flow regime map	Flow regime map	Fixes flow regime; Deactivates slip	Model from RETRAN-02
2	Algebraic Slip	NA	NA	Deactivates slip	Zolotar- Lellouche
3	Algebraic Slip	NA	NA	Selects correlation form (vertical or horizontal flow); Deactivates slip	Chexal-Lellouche
4	Dynamic Slip	Assume bubble flow regime	Based on drift flux correlation	Deactivates slip	Zolotar-Lellouche used for inter-phase friction
5	Dynamic Slip	Assume bubble flow	Based on drift flux	Selects correlation	Chexal-
Lellouche	regime	correlation	form (vertical or	used for inter-	
				horizontal flow) Deactivates slip	phase friction
6	Dynamic Slip	Uses mechanistic dynamic flow regime model	Uses mechanistic dynamic flow regime model	Deactivates slip	Jaycor model

W3-I	IPUMP	=	(a)	Pump number if IW1 > 0 and IW2 > 0. For junctions connecting to a pump volume, the suction side junction should have a negative pump number and the discharge junction should have a positive pump number. IPUMP should correspond to the appropriate pump data (Cards 090XXY) were IPUMP is equal to XX. (IPUMP $\geq$ 1 and each IPUMP is unique)
			(b)	Fill index if IW1 = 0 and IW2 > 0. For fill junctions, IPUMP should correspond to the appropriate Fill Table Data Set (Cards 13XXYY) where IPUMP is equal to XX.
			(c)	Normal junction if IW1 > 0 and IW2 > 0 and junction is not connected to a pump volume. IPUMP = 0.
			(d)	For FIBWR junctions, IPUMP = 100 + XX where XX corresponds to XX for lateral leakage Card 6351XX. IPUMP = 201 identifies a bypass inlet junction. These leakage flows across the core support plate are determined from the flow coefficient data supplied on 6352XX.
W4-I	IVALVE	=	Valve index = 0, no valve > 0, IVALVE specifies the desired valve description(Cards 11XXX0) where XXX = IVALVE.	
W5-R	WP	=	Initial flow (lbm/sec)	
W6-R	AJUN	=	Junction flow area in square feet, must be greater than zero. For a time-dependent area junction (specified through the use of a valve and a normalized area versus time curve), AJUN is the full open area.	
W7-R	ZJUN	=	Junction elevation (ft) (a) If IW1 > 0 and IW2 > 0, ZJUN must lie between the bottom and top of both volumes IW1 and IW2. (b) If IW1 = 0 and IW2 > 0, ZJUN must lie between the bottom and top of volume IW2.	
W8-R	INERTA	=	Junction effective L/A (ft^{-1}) $\geq$ 0, INERTA must be input if JCALCI (W13-I) = 0 or 1. The input value of INERTA is ignored and recalculated by the program if JCALCI = 2 or 3. The calculated value is the sum of one-half of the	

length of each adjacent volume divided by the volume flow area where volume length is FLOWL. (INERTA is not used for a fill flow solution but a dummy value must be supplied.)

< 0, Junction inertia obtained from control block. INERTA defines the control block ID. (This option overrides JCALC = 2 or 3.)

W9-R FJUNF = Forward flow "form loss coefficient". This is either zero or a dimensionless positive number dependent on geometric changes occurring within the flow control volume. It is the standard energy loss coefficient as normally used in text books. The pressure loss is

$$\frac{1}{144\,g_c}\,\frac{K}{2\rho_j A_j(t)^2}\,W_j\left|\,W_j\,\right|\,(\text{psi})$$

where FJUNF is K, ρ_j is the junction density, $A_j(t)$ is the time-dependent junction area, and W_j is the junction mass flow rate.

Four input options are available.

(a) Input the loss coefficient which is constant throughout the calculation.

(b) Let steady-state compute a loss coefficient which will be constant after time zero. The junction loss coefficient will be calculated in steady-state initialization by solving the steady-state form of the junction momentum equation if FJUNF = -1.0 (or FJUNR = -1.0 for negative flows) and the pressure values on both sides of the junction are either defined through volume input or can be determined from other specified input.

(c) If JCALCI (Word 13) is equal to 1000, FJUNF is the control input ID or control block ID whose output defines the forward loss coefficient. The initial value for FJUNF is set equal to the initial condition specification of the control input or the control block.

(d) If JCALCI (Word 13) is equal to 1 or 3, FJUNF and FJUNR is computed from a correlation for sharp-edged area changes. If JCALCI equals 1 or 3, any input value of form loss coefficient will be

overridden and replaced with that from the correlation.

NOTE: As far as steady-state initialization is concerned, options (c) and (d) are the same as specifying the form loss coefficient (option (a)).

W10-R FJUNR = Reverse flow "form-loss-coefficient".
If FJUNR is entered as 0., FJUNR is set equal to FJUNF. The same options apply for the FJUNR coefficient as described for FJUNF.

W11-I JVERTL = Vertical junction index
= 0, junction flow area is not distributed vertically and junction enthalpy is "smoothed" when the two-phase mixture interface is predicted to pass through the junction elevation during a time step
= 1, junction flow area is assumed to be a circular area centered and distributed vertically about ZJUN
= 2, junction flow area not distributed vertically and junction enthalpy is "not smoothed." This is a special option designed to model the phenomena that occurs when a mixture level passes through a horizontally oriented junction. The junction flow is redistributed assuming a constant volumetric flow for the time step when the donor volume mixture level drops below the junction elevation. The adjacent volumes must be overlapped for this option.
= 3, Automatic overlap option flag. Junction flow area is distributed vertically and enthalpy smoothed as discussed for JVERTL = 1 above. Adjacent volume heights will be adjusted automatically to overlap by 0.2 ft. The junction elevation will also be adjusted so it is centered in the overlap region. For bubble rise volumes when initial volume height and mixture level are the same, the mixture level is also adjusted accordingly.

W12-I JCHOKE = Junction choking flag
= -1, No choking
= XYZ, Multi-field flags described below
Z = choking model selection flag (unit's place digit)
= 0, Use combination model comprised of the Extended Henry (subcooled) and Moody (saturated) models
= 1, Use full-range Isentropic Expansion Homogeneous Equilibrium Model

(subcooled, two-phase, and superheated)

= 2, Use combination model comprised of the Extended Henry (subcooled) and Isentropic Expansion Homogeneous Equilibrium Model (saturated and superheated) models

Y = pressure-enthalpy model selection flag (ten's place digit)

= 0 or blank, use stagnation pressure and enthalpy (recommended option)

= 1, Use the RETRAN-02 form, where the upstream volume pressure is adjusted for hydrostatic head and junction enthalpy are used

= 2, Use the RETRAN-3D MOD003.1 form, where the upstream volume pressure is adjusted for hydrostatic head and friction loss and the junction enthalpy are used

X = option to compute choked flow for vapor enthalpy

= 0 or blank, model not used.

= 1, Use vapor only flow model.

Note: CONCO (W15-I) is used to specify a control input or control block that defines an enthalpy multiplier that is used to adjust the choking input enthalpy to transition to and/or from the normal choking model and the vapor only model. See the description of W15-R CONCO for additional details.

W13-I JCALCI = Initial condition calculation index

= 0, use input for inertia and form loss coefficients as given by user

= YYZ, multi-field flags described below

Z = inertia/loss calculation flag

= 1, RETRAN calculates form loss coefficients FJUNF and FJUNR for sharp-edge area changes. The equations for the loss coefficient are given in Section III.2.3 of Volume 1: Theory and Numerics.

= 2, RETRAN calculates junction inertia

= 3, RETRAN calculates both form loss coefficients and inertia

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YY = Grid loss model indicator. YY=XX from Card 2330XX. For YY > 0, Z = 1 or 3 are not valid selections.

= 1000, both forward and reverse loss coefficients are obtained from the control system. The ID's of the control blocks defining the loss coefficients are supplied in Words 9 and 10 (FJUNF and FJUNR). The initial values of the loss coefficients are obtained from the initial condition specification of the governing control block.

NOTE: (a) Options to calculate inertias and/or loss coefficients will override any corresponding values input in Words 8, 9, or 10.

(b) When using the steady-state initialization, a value of JCALCI equal to 1, 3, or 1000 has the same effect as supplying a value of FJUNF or FJUNR $\geq$ 0.

W14-I MVMIX = Flow equation type
= 0, compressible flow, single stream
= 1, mixed two-stream compressible flow in the volume "from volume" side
= 2, mixed two-stream compressible flow in the volume "to volume" side
= 3, momentum flux terms are omitted

W15-R DIAMJ = Junction equivalent hydraulic diameter (ft)
(see discussion in Section IV.8)

W16-R CONCO = Contraction coefficient for critical flow correlations (0. is interpreted as 1.0). This parameter is applied as a direct multiplier to the critical mass flux value obtained from the choking model (Word 12, JCHOKE).

For JCHOKE = 1YZ, the choking model calculates the flow for saturated steam (vapor only flow model) when two-phase conditions exist in the junction. The contraction coefficient is assumed to be 1.0 for this model option and the CONCO input is as follows.

<0, control block ID used as a multiplier on the enthalpy used for the choking model evaluation, h_{chok}. The output of the control block $\left(C_{mu_\ell}\right)$ must be limited to the range 0.0 to 1.0 and is used as follows

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$$h_{chok} = h_j + C_{mu_i}\left(h_{g_{sat}} - h_j\right)$$

where k_j is the normal junction enthalpy and $h_{g_{sat}}$ is the enthalpy for saturated vapor.

A control system should also be used to drive a nonconducting heat exchanger to maintain an energy balance (see Volume 1, Section V.3.7).

W17-I IFRJ = Slip flow regime/orientation flag[1]
(Ignored when ISFLAG = 0 on 01000Y Card)
≥ 0, flow regime selected from designated map
= 0 to 9, use vertical flow regime map
= 10 to 19, use horizontal flow regime map
< 0, fixed flow regime
= -1 > IFRJ > -7, vertical flow
= -11 ≥ IFRJ ≥ -19, horizontal flow

NOTE: IFRJ values between -1 and -4 inclusively are treated as bubbly flow and values of -6 and -7 are treated as dispersed flow. For IFRJ values between -11 and -14 inclusively are treated as bubbly flow, value of -16 and -17 are treated as dispersed, and -18 is treated as annular flow. No interpolation is performed in the transition regimes.

= Vertical or horizontal flow indicator for algebraic slip option (ISFLAG = 3) and dynamic slip option (ISFLAG = 5).
= 0 ≤ IFR ≤ 9 for vertical flow path.
= 10 ≤ IFR ≤ 19 for horizontal flow path.
= -99, specifies zero slip velocity for junction for all ISFLAG > 0 (see discussion in Section IV.8.1)

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1 The flow regimes and corresponding IFRJ values are:

Vertical Flow	IFRJ	Horizontal Flow	IFRJ
Single-Phase Liquid	1	Single-Phase Liquid	11
Bubble	2	Bubble	12
Slug	3	Annular	15
Froth	4	Single-Phase Vapor	16
Annular	5	Dispersed Droplet	17
Single-Phase Vapor	6	Stratified	19
Dispersed Droplet	7		

W18-I JTPMJ = Two-phase wall friction index (see discussion in Section IV.8)
= -1, no wall friction,
= 0, use Baroczy two-phase multiplier (static quality) with wall friction,
= 1, use homogeneous two-phase multiplier with wall friction,
= 2, use EPRI two-phase multiplier with wall friction,
= 3, use Baroczy two-phase multiplier (flowing quality) with wall friction.
= 4, use the Martinelli-Nelson correlation with the Jones correction with wall friction.

NOTE: Words 19 through 23 are optional and can be omitted in whole or in part. Words omitted are read as though they were entered as 0.

W19-I IHQCOR = Enthalpy transport model
= 0, donor model, no enthalpy transport for either flow direction (default).
> 0, donor model, enthalpy transport on if the "from" volume is heated, no enthalpy transport if the "from" volume is not heated.

NOTE: The user has the option to deactivate the enthalpy transport model during the transient if certain conditions occur. See Section IV.8.3 for more information and the input requirements.

W20-I ISP = Flag indicating that this is a pressurizer spray junction.
= 0, or blank, the junction is handled in the normal manner (default).
= 1, the junction flow is treated as a pressurizer spray junction.

W21-R ANGLJ1 = Angle of junction relative to the "from" Volume (IW1). Default is zero degrees. There are no limitations on the input value; however, the code will reset angles to the range 0. ANGLJ1 < 360. An angle bias of 180 degrees, when added to the actual angle, effectively reverses the "from-to" orientation for the volume average momentum calculation.

W22-R ANGLJ2 = Angle of junction relative to the "to" Volume (IW2). The same requirements as those for ANGLJ1 apply.

A value of 180 degrees may be required for negative fills to obtain the correct average volume flow and momentum flux.

W23-R SLPMUL = Junction slip velocity multiplier (only applies to the Chexal-Lellouche algebraic slip model; W23-I, ISFLAG = 3 on 01000Y). SLPMUL defaults to one.

> 0, constant multiplier on slip velocity.

< 0, the control block ID whose output defines the multiplier on the Chexal-Lellouche drift flux based slip velocity. The initial value for SLPMUL is set equal to the initial condition specification of the control block.

NOTE: ID has to be entered as a floating point number.

8.3 Junction Input User Guidelines

Many of the parameters supplied for a junction are geometric or connection data which require no additional guidance. There are some model selection parameters that are discussed here.

W3-I IPUMP In addition to its use in defining centrifugal pumps, IPUMP is also used to designate leakage path numbers for FIBWR option when the multidimensional kinetics option is not used.

For FIBWR junctions, IPUMP = 201 identifies the core bypass inlet, and IPUMP = 100 + XX identifies lateral leakage paths, where XX corresponds to XX on Card 6351XX. For example, suppose there are two lateral leakage paths between the active core channel and the bypass channel and the leakage flows across the core support plate from the lower plenum to the bypass. The flows for all three are determined from the FIBWR model. In this case there are two sets of data cards, 635101 and 635102, that are required to set the FIBWR coefficients for the lateral leakage paths. All flows defined on 6352XX data cards are summed to define the support plate leakage flow into the bypass.

The value of IPUMP for the bypass inlet junction is 201. In the case of the lateral leakage paths, the values of IPUMP would be 101 and 102.

W11-I	JVERTL	This parameter is used only for junctions connected to volume using a bubble rise model. For bubble rise volumes, a mixture level can exist that separates a liquid or two-phase mixture region from a vapor region. If the junction removes fluid from this volume and the junction elevation is above the mixture level, the junction enthalpy is consistent with that of the vapor region. If the junction removes fluid from this volume and the junction elevation is below the mixture level the junction enthalpy is consistent with that of the mixture region. During a transient, the mixture level can pass through the junction elevation and JVERTL defines the method to compute junction enthalpy for that instant. A horizontally oriented junction is considered a single vertical point. In this case, the junction is either above or below the mixture level. So as the level moves through the junction elevation, the junction enthalpy will change significantly in one time step. This instantaneous change in junction enthalpy can cause numerical problems. Option 1 is the recommended option since it will smooth the junction enthalpy as the mixture level passes through the vertically oriented junction. Option 0 smoothes the junction enthalpy transition over one time step for horizontally oriented junction. It may not eliminate all numerical oscillations associated with a mixture level passing through a junction elevation. Option 2 is a seldom used option that is also referred to as the “jet pump uncovery model”. It is applied to horizontally oriented junctions when a mixture level falls below a junction. In this situation, the junction mass flow rate is adjusted to preserve the volumetric flow when the junction density changes from a two-phase to vapor value as the level passes through the junction. For this model, the junction enthalpy is not smoothed. Option 3 will automatically adjust the height of adjacent volumes so they will overlap by 0.2 ft. The elevation of the junction is then adjusted so it is centered in the overlap region. The result is an overlapped bubble rise volume that will then use the Option 1 smoothing. For bubble rise volumes when initial volume height and mixture level are the same, the mixture level is also adjusted accordingly.

W12-I	JCHOKE	The choking model is effectively a flow boundary condition. If the flow obtained from the momentum equation solution exceeds that from the choking model, the flow from the choking model is imposed on the solution. In general, no choking option should be used for most internal junctions where critical flow will not occur. This will save a small amount of CPU time since critical flow will not be evaluated each time step for those junctions and may eliminate problems if the junction conditions get outside the range of validity for the selected choking model. The critical flow correlations are a function of pressure and enthalpy. However, the break geometry can also have a significant influence on flow magnitude. The flow through a split can be significantly different from the flow through a round guillotine type rupture with the same flow area. The contraction coefficient (W16-CONCO) is a multiplier to account for break geometry effect. Three critical flow models are available. Two of which are combinations of two correlations. The Extended Henry/ Moody model (JCHOKE=0) and the Extended Henry/ Isentropic Expansion model (JCHOKE=2) are combination choices. The Isentropic Expansion model (JCHOKE=1) is a single correlation for single and two-phase regions. The Isentropic Expansion Homogeneous Equilibrium model has a much wider range (pressure and enthalpy) of application. For this reason, this model is recommended for general use unless one of the other models is specifically desired. None of the critical flow models are applicable when noncondensable gas is present at a junction. The effect of this limitation must be evaluated by the user. The RETRAN-3D critical flow model (see Volume 1 Section IV.3.0) differs from that of RETRAN-02 in the pressure used to evaluate a given critical flow function. RETRAN-3D uses the stagnation pressure, which includes the wall friction loss between the volume center and junction and the velocity head. The critical flow models were all developed for stagnation conditions, thus the RETRAN-3D model is consistent with the theoretical basis of the models.

		There is also a difference between the current choking model implementation and earlier versions of RETRAN-3D (MOD003.1 and prior). These code versions omitted the velocity head, which can be a significant contribution to the junction pressure. It is possible to include the velocity head in RETRAN-02 and earlier versions of RETRAN-3D by setting the upstream volume flow area to a large number. Options have been added to obtain the RETRAN-02 and RETRAN-3D models for comparison with previous code versions. The default stagnation condition model is recommended.
W13-I	JCALCI	This parameter is used to select options for computing the junction inertia and/or loss coefficients based on input geometric information. If the geometry is quite simple, such as in piping volumes, this is a convenient way to let the code compute the inertia rather than having to supply it through input. It also provides for computation of loss coefficients based on a very specific sharp edge orifice correlation. It is recommended that loss coefficient be computed and supplied by the analyst rather than using this default method. JCALCI is also used to indicate where Reynolds number dependent grid losses are to be applied. YY in the YYZ multi-field flag is used to select the specific form of the grid loss model defined using 2330XX card data. When a grid loss model is specified, it will override any values supplied for FJUNF or FJUNR. If the flow reverses in a junction using a grid loss model, the reverse loss will be evaluated from the forward correlation. The calculated losses are stored in FJUNF and FJUNR.
W14-I	MVMIX	Option 0 is recommended for general use. Option 3 should be used only in special situations where the analyst wants to eliminate the momentum flux terms from the momentum equation. For general applications, this is not the case. Options 1 and 2 activate special models that are used to simulate the momentum exchange when two fluid streams with significantly different velocities mix. Option 2 should be used for BWR jet pump suction and nozzle junctions.

W17-I	IFRJ	This parameter is used only if one of the slip options is chosen (ISFLAG > 0 on 01000Y). IFRJ can be used to deactivate the slip model at a specific junction (IFRJ=-99) regardless of the specific slip model that is chosen. Table IV.8-1 lists the meaning of this parameter for all slip options. For the dynamic slip option (ISFLAG =1), this parameter should be used to select the appropriate flow regime map to use (vertical or horizontal) and can be used to fix the junction in a specific flow regime if desired. For most applications, the analyst should allow the code to select the flow regime from the appropriate flow regime map rather than fixing it to a given flow regime. For the Chexal-Lellouche algebraic slip model (ISFLAG=3), this parameter should be used to select the appropriate form (for vertical or horizontal flow) of the correlation. Algebraic slip models do not require flow regime prediction, so a flow regime map does not need to be selected.
W18-I	JTPMJ	Wall friction can increase significantly for two-phase conditions. The models in RETRAN-3D apply a multiplier to the single-phase friction coefficient to simulate the increased friction. The options available to define this multiplier are empirical correlations. Option 3, the Baroczy model using flow quality is the recommended option. Option -1 is an option that should only be selected if no wall friction is desired for both single- and two-phase conditions.
W19-I	IHQCOR	The enthalpy transport model is used to account for the effects of heating on the junction enthalpy (or difference between the volume center and junction enthalpies) and was originally developed to improve the accuracy of simulations using large node sizes in the heated region (3 to six in the core). The concept here is that the heat is uniformly applied to the volume length. Therefore, there is a difference between the volume center and exit junction enthalpy. This is an optional model that is activated by setting IHQCOR=1. With the more recent practice of using more detailed nodalization in heated regions such as using 24 nodes in BWR cores, the model becomes less important. For two-phase heated regions, the use of this model will have an

		effect on the mass inventory. A simple sensitivity study where the mass inventory in two-phase regions is compared for cases with and without enthalpy transport will give an indication of whether or not it is needed. For single-phase heated regions, the enthalpy transport model will not significantly affect the mass inventory, but it will affect the volume average temperature used for heat transfer.
W20-I	ISP	This parameter is only meaningful for pressurizer spray junctions. The option selection here determines how the pressurizer vapor condensation on the spray is computed. Option 0 will provide the maximum condensation and minimize the pressure increase by instantaneously mixing the spray flow with the vapor region. Option 1 is recommended for used in spray junctions. For this option, the spray is heated to the saturation enthalpy as it is directly deposited in the liquid region (fall time through vapor region is neglected). This model will give a higher, and more realistic pressure than Option 0.
W21-R	ANGLJ1	There are two angles associated with the junction input (ANGLJ1 and ANGLJ2). These angles specify junction orientation relative to the upstream and downstream volumes respectively. These angles affect the manner in which the momentum flux is computed. The angles are intended to correctly adjust the momentum flux terms for special cases when there is a flow split and one junction splits off at an angle relative to the main flow such as in tees, wyes or manifolds. In most instances, there is one junction in and one junction out of a volume in which the angles should be specified as zero (the default value) to indicate the junction flow paths are parallel. The angle information is <u>not</u> intended to represent turns in a single flow path such as elbows. An important application of these angles to PWR analyses would be the connection of a branch from the hot or cold leg such as the pressurizer surge line or spray line. In the example of a junction that connects the hot leg (from volume) to the surge line (to volume), the correct input should be ANGLJ1 = 90 and ANGLJ2 = 0.

W22-R	ANGLJ2	Refer to the description for ANGLJ1. When a negative fill is used to model flow exiting a volume from the end opposite that of the inlet flow, ANGLJ2 = 180 is required to obtain the correct momentum sense. If ANGLJ2 = 0, the exiting fill flow is removed from the same side of the volume that the inlet flow enters. The momentum affects for the two cases can be significantly different.
W23-R	SLPMUL	This option allows the user to modify the slip velocity calculated by the Chexal-Lellouche algebraic slip model (ISFLAG=3 on the problem dimension card). This multiplier is applied directly to the slip velocity. SLPMUL defaults to one. If SLPMUL is negative it is assumed to be the ID of a control block whose output defines the multiplier on slip velocity; if the output of control block ID goes negative during a transient, an error message is written and the code terminates. Since this option modifies the slip velocity, it should only be used for special applications where modification of the slip velocity can be justified.

8.4 Enthalpy Transport Deactivation Options

Several options are available for deactivating the enthalpy transport model during a run. The first globally deactivates the model based on one of several different conditions. The second option selectively deactivates the model. Input requirements for the two options are discussed below.

8.4.1 Enthalpy Transport Deactivation Data Card 080000

The default junction enthalpy model defines the junction enthalpy to be equal to the upstream volume enthalpy. The enthalpy transport model (IHQCOR on Cards 08XXXY) is designed to model the enthalpy increase between the volume center and the outlet junction due to energy exchange within the volume. The use of the enthalpy transport model provides a better resolution of fluid temperatures (or void distribution for two-phase conditions) for heated regions than does the default donor enthalpy model. The enthalpy distribution can influence energy exchange rates in core regions of PWR's and BWR's, and in steam generators or heat exchanges.

These are, however, situations in which the behavior in the heated regions are such that the assumptions on which the enthalpy transport model are based are no longer valid or when the model is no longer applicable. Examples of these conditions are:

- when counter-current flow exists,
- when a flow reversal occurs at the junction, or
- when the conductor-to-fluid energy exchange rate is small.

Problems with application of the enthalpy transport model under these conditions will manifest themselves with either unreasonably small time steps or a code failure. Generally, when one of these conditions occur, they usually happen together and the heat conductor/fluid energy exchange rates are small, which negates the need for an enthalpy transport model.

The RETRAN code has an option to deactivate the enthalpy transport model once any of these conditions occur. The model is deactivated on a junction by junction basis and once deactivated for a given junction, it will remain so for the duration of the transient.

The user can supply a data card to deactivate the enthalpy transport model if any of these criteria occur or a trip can be used to deactivate enthalpy transport for all junctions. The trip, like any trip, can monitor a multitude of system parameters.

This card needs to be supplied to activate this option.

W1-I	IDENTR	=	Trip ID number to deactivate the enthalpy transport model for all junctions. = 0, no trip supplied, use standard deactivation criteria only (default).
W2-I	HDELT	=	Minimum enthalpy change (Btu/lbm) between volume center and the junction after which the enthalpy transport model will be deactivated. = 0.0, the enthalpy transport model will not be deactivated for low energy exchange rates.
W3-I	IFLWRV	=	Enthalpy transport flow reversal deactivation flag. = 0, enthalpy transport will be deactivated at a junction in which the flow reverses. = 1, enthalpy transport will not be deactivated at any junction in which the flow reverses.
W4-I	ICCFLO	=	Enthalpy transport counter-current flow deactivation flag. = 0, enthalpy transport will be deactivated at a junction in which counter-current flow occurs. = 1, enthalpy transport will not be deactivated at any junction in which counter-current flow occurs.

W5-I	ISELCT	=	The number of junction groups for which enthalpy transport is to be deactivated. If this option is chosen, additional input is required on the Selective Enthalpy Transport Deactivation Data Cards 08000X
W6-I	IENTRN	=	Flag to deactivate the improved error handling for the enthalpy transport model. The improved error handling allows enthalpy transport to survive extreme variations such as counter-current flow or flow reversals without failing. This option is included to allow backward compatibility with previous analyses. = 0, use improved error handling (default) = 1, improved error handling deactivated

8.5 Two-Region Enthalpy Transport Model Data Card 008001

The default junction enthalpy model defines the junction enthalpy to be equal to the upstream volume enthalpy. The enthalpy transport model (IHQCOR on Cards 08XXXY) is designed to model the enthalpy increase between the volume center and the outlet junction due to energy exchange within the volume. The use of the enthalpy transport model provides a better resolution of fluid temperatures (or void distribution for two-phase conditions) for heated regions than does the default donor enthalpy model. The enthalpy distribution can influence energy exchange rates in core regions of PWRs and BWRs, and in steam generators or heat exchangers.

There are, however, situations when the enthalpy transport model may produce unrealistic results, i.e., when the secondary side dries out. During steam generator bundle region dry out, temperatures often exceed those of the primary side.

The two-region enthalpy transport model will compute exit junction enthalpy similar to the standard transport model. It accounts for changes in the heat transfer mode that occurs as fluid boundary conditions transition from two-phase to superheated region.

This model will be used only for a situation where junction enthalpy calculated by other models are superheated and it only considers two-phase to superheated transition.

The user can supply a data card to activate the two-region enthalpy transport model.

W1-I	SHSFLG	=	Flag to activate two-region enthalpy transport model = 1, model is turned on. = 0, model is turned off (default).

8.5.1 Selective Enthalpy Transport Deactivation Data Cards 08000X

These data card(s) are required if ISELCT > 0 on Data Card 080000, where there must be consecutive data cards ranging from 080001 to 08000X, where X is equal to ISELCT . On each data card, the following parameters must be supplied.

W1-I	IETID	=	Trip ID to deactivate enthalpy transport for the junctions defined below.
W2-I	NETJUN	=	First junction in this group
.			
.			
.			
WLASTJ-I	NETJUN	=	Last junction in this group.

8.6 Grid Loss Model Data Card 2330XX

The grid loss model is a generalized equation for defining junction form losses that can be a function of the Reynolds number. The grid loss model for single-phase conditions is

$$k = \left[A + B\,Re^{C} \right] \tag{IV.8-1}$$

and for two-phase conditions it is modified to include a two-phase multiplier and a density ratio

$$k = \left[A + B\,Re^{C} \right] \left(\frac{\rho_m}{\rho_{ls}} \right) \phi_D^2 \tag{IV.8-2}$$

where A, B, C, and D are input constants, Re is the Reynolds Number, X_g^w is the flow quality. The two-phase multiplier (last term) is user selectable. The two-phase form for the loss coefficient contains a density ratio that effectively changes the standard form loss model from using the mixture velocity to the required liquid velocity.

Local grid losses can be defined using the 2330XX cards where each value of XX is used to define a specific loss model that can be used by one or many junctions. Up to 99 separate sets of coefficients can be included in an input deck. The values of XX must begin at 01 and must also be sequential. A minimum of two data items must be supplied (LSET and COEFA) on each card. All data items not specified are treated as if they are 0. Unused coefficient sets or loss models can be included in an input deck. Local loss models are referenced on the Junction Cards 08XXXY using the JCALCI multi-field input variable (Word 13).

W1-I	LSET	=	Two-phase multiplier option
		= 0,	use mixture velocity (default)
		= 1,	$\phi_D^2 = \left(1.0 + X_g^w\right)^D$

$$= 2, \quad \phi_D^2 = 1.0 + DX_g^w \left(\frac{\rho_{\ell s}}{\rho_{gs}} - 1.0 \right) \quad \text{(HEM)}$$

$$= 3, \quad \phi_D^2 = \frac{\left(1 - X_g^w\right)^2}{(1-\alpha)} + \left(\frac{\rho_{\ell s}}{\rho_{gs}} \right) \frac{\left(X_g^w\right)^2}{\alpha} \quad \text{(Romie)}$$

W2-R	COEFA	=	Coefficient A
W3-R	COEFB	=	Coefficient B (default =0)
W4-R	COEFC	=	Coefficient C (default =0)
W5-R	COEFD	=	Coefficient D (default =0)

Note that the value of COEFD does not affect the use of the Romie model so any value can be input or it can be allowed to default.

For three-dimensional kinetics cases, the default grid loss model coefficients are obtained from the CDI file. The 2330XX cards can be used to replace (override) the coefficients obtained from the CDI file.

9.0 PUMP DESCRIPTION DATA CARDS 090XXY

A Pump Description Data Card is required for each centrifugal pump modeled with RETRAN. The RETRAN pump model describes the interaction of a centrifugal pump and the fluid within a volume using information from the pump characteristic curves. An option is available to simulate the effect of two-phase flow on pump performance.

Pumps can be initially running or idle, where the initial state is determined by the sign of ITPUMP on the pump description data card. A choice of ITPUMP in the range of ITPUMP > 2 results in a pump that is initially running until trip conditions are satisfied, shutting the pump motor off for the remainder of the transient, unless restarted via reset trip action. If the pump is to be restarted in the transient, a motor torque curve (097XXY cards) must be supplied. A choice of ITPUMP $\leq$ -2 results in a pump that is initially off until trip conditions are satisfied, starting the pump according to the motor torque characteristics. The pump remains running throughout the remainder of the transient, unless stopped again via reset trip action. If this option is used, a motor torque curve (097XXY cards) must be supplied, the speed ratio must be input as zero, and the rated motor torque must be input. Either of these pump options is controlled by generalized trip data where IDTRIP (Card 04XXX0) matches |ITPUMP|. If a value of IMT < 0 is used with either pump option, the pump can be tripped to slow down or speed up following the speed versus time curve (097XXY cards), but if the trip is reset, the pump will run for the remainder of the transient at the speed that it was running when the reset occurred. If this option is used, the pump should not be tripped again or it will return to the time zero speed value on the speed versus time curve.

NPMPC (Card 01000Y) sets of cards with XX equal to a pump number IPUMP (Cards 08XXXY) must be entered. The values of XX need not start on 01 and need not be consecutive. Y is a card sequence number for each set and can range from 1 to 9.

W1-I IPC = Pump curve set sequence number J on Card 100000

W2-I ITPUMP = Trip ID number used to start or shut pump off (|ITPUMP| ≥ 2)
- ≤ -2, a pump initially off, to be started under control of trip ID = |ITPUMP|
- ≥ 2, a pump initially running, to be shut off under control of trip ID = ITPUMP.
- = 1000, normalized pump motor torque is controlled by control system
- = -1000, pump speed (rpm) is controlled by control system

W3-I IRP = Pump reversal indicator
- = 0, no reverse allowed
- = 1, reverse allowed

W4-I IPM = Two-phase option index
- = 0, no two-phase option
- > 0, sequence number J on Card 100000 of the desired two-phase difference curve set.

W5-I IMT = Pump motor torque curve or pump speed versus time curve set index or control block ID.

If |ITPUMP| ≠ 1000, IMT represents a curve set index. See Motor Torque Curve Data Cards 097XXY.
- IMT < 0, time-dependent pump speed curve number where |IMT| is the curve number.
- IMT = 0, no motor torque curve (gives constant speed)
- IMT > 0, motor torque curve number.

If ITPUMP = 1000,
- IMT = ID of control block controlling normalized pump motor torque.

If ITPUMP = -1000,
- IMT = ID of control block controlling pump speed (rpm).

W6-R	POMGAR	=	Rated pump speed (rpm)
W7-R	PSRAT	=	Pump speed ratio of initial speed-to-rated speed
W8-R	PFLOWR	=	Rated flow (gal/min)
W9-R	PHEADR	=	Rated head (ft)
W10-R	PTORKR	=	Rated torque (lbf-ft)
W11-R	PINRTA	=	Moment of inertia (lbm-ft^2)
W12-R	VRHOI	=	Rated density (lbm/ft^3) If VRHOI = 0.0, VRHOI is set equal to the initial pump volume density.
W13-R	TORKMR	=	Rated pump motor torque (lbf-ft) If TORKMR = 0.0, it is set to the sum of the frictional torque (TORKF) and the hydraulic torque at time t = 0. The actual rated motor torque must be supplied if the pump is initially off and is then tripped on.
W14-R . . .	TORKF1 . . .	=	Coefficients of a third order polynomial for the frictional torque TORKF. The pump frictional torque is computed as
W17-R	TORKF4		$TORKF = TORKF1 + TORKF2*S + TORKF3*S^2 + TORKF4*S^3$ where S is the absolute value of the ratio of pump speed to rated speed.

9.1 Pump Head Multiplier Data Cards 091XXY

The pump head multiplier data are used for the two-phase pump model. At least one set of Pump Head Multiplier Data Cards must be supplied if any value of IPM (Cards 090XXY) is nonzero. For any nonzero values of IPM, XX corresponds to IPM. A single Pump Head Multiplier Curve can be used by more than one set of Pump Description Data Cards (090XXY).

A Pump Head Multiplier Curve must be supplied for each unique nonzero value of IPM specified on Cards 090XXY. Y is a card sequence number ranging from 0 to 9. Y need not start at 0 and need not be consecutive to facilitate additions to or deletions from the table.

W1-I	NPHM	=	Number of points on curve. ($\|NPHM\| \geq 1$) Positive value indicates no extrapolation; negative value indicates extrapolation is permitted.

W2-R	PHDM(1)	=	Void fraction
W3-R W4-R, W5-R . . .	PHDM(2) PHDM(3), PHDM(4), . . .	=	Head multiplier for difference curves in Set IPM until NPHM points are entered. Void fraction must be in ascending sequence. Normally, both void fraction and multiplier will range from 0.0 to 1.0.

9.2 Pump Torque Multiplier Data Cards 092XXY

The pump torque multiplier data are used for the two-phase pump model. The use and general requirements of the Pump Torque Multiplier Data Cards are identical to those noted for the Pump Head Multiplier Data Cards (091XXY).

W1-I	NPTM	=	Number of points on curve ($\|NPTM\| \geq 1$) Positive value indicates no extrapolation; negative value indicates extrapolation is permitted.
W2-R	PTKM(1)	=	Void fraction
W3-R W4-R, W5-R,	PTKM(2) PTKM(3), PTKM(4),	=	Torque multiplier for difference curves in Set IPM until NPTM points are entered. Void fraction must be in ascending sequence.

9.3 Pump Stop Data Cards 095XX1

This card must be present for each pump using this option, where XX is the Pump Description Number XX on Cards 090XXY. Once any of the conditions below are met, the pump speed is set to 0.

W1-R	CAVCON	=	Elapsed time (sec) ≤ 0.0, option not used > 0.0, option used
W2-R	FPUMP	=	Maximum forward speed (rpm) $= 0.0$, option not used $\neq 0.0$, option used
W3-R	SPUMP	=	Maximum reverse speed (rpm) $= 0.0$, option not used $\neq 0.0$, option used NOTE: Normally this number is negative.

9.4 Pump Motor Torque Data Cards 097XXY

Pump Motor Torque Data Cards are read if, on any 090XXY cards (Pump Description Data Cards), |ITPUMP| ≠ 1000 and IMT ≠ 1. If |ITPUMP| ≠ 1000, positive values of IMT specify that Pump Motor Torque Data Cards with XX equal to IMT must be present, while negative values of IMT specify that the Pump Motor Torque Data Card (actually Pump Speed Versus Time Data Cards) must be present and XX must equal |IMT|. Any given motor torque (or pump speed) curve may be used by more than one set of Pump Description Data Cards (090XXY). A pump motor torque (pump speed) curve must be supplied for each unique nonzero value of |IMT|. Y is a sequence number ranging from 0 to 9. Y need not start at 0 and need not be consecutive to facilitate additions to or deletions from the table.

W1-I	NTMO	=	Number of points in curve (|NTMO| ≥ 1) Positive value indicates no extrapolation; negative value indicates extrapolation is permitted.	
W2-R	PTMO(1)	=	Pump speed (rpm) Time (sec)	(IMT > 0) (IMT < 0)
W3-R	PTMO(2)	=	Motor torque, normalized pump speed (rpm)	(IMT > 0) (IMT < 0)
W4-R, W5-R,	PTMO(3), PTMO(4),		until NTMO points are entered. The independent variable (speed or time) must be in ascending sequence.	

9.5 Pump Curve Set Input Data Card 100000

Pump curve set input flags are used to control the input of pump curve sets describing the performance characteristics of centrifugal pumps. Several options are available for selecting or specifying pump curve sets. Built-in curve sets may be used or modified by the user, or a curve set may be supplied by the user. User supplied curve sets need not describe pump performance characteristics of all quadrants, but merely those describing the pump characteristics in the quadrant(s) necessary to define pump performance during the modeled transient. However, if all quadrants are not described, and characteristics are needed for a quadrant not described, the problem will be terminated. Any number of single-phase and/or single-phase minus two-phase curve sets may be supplied by the user.

This curve is entered if NPMPC (Card 01000Y) is greater than 0. At least one pair of data are required, where each pair has a unique sequence number J. The sequence number J ranges from 1 to the number of unique pump curve sets (set of head and torque curves) requested.

W1-I	NPC(J)	=	Curve set selection flag. = 0, user will supply a pump curve set. = 1, Bingham Pump NS-4200 pump curve set will be used.

= 2, Westinghouse Pump NS=5200 pump curve set will be used.
= 3, Semiscale two-phase head difference curve set will be used. The two-phase torque difference curve must be input by the user.

W2-I NC(J) = Number of curves to be supplied for curve set NPC(J).
< 0, |NC(J)| curves will be supplied and overlaid on built-in curve set NPC(J). ($1 \leq NPC(J) \leq 3$),
= 0, built-in curve set NPC(J) will be used without modification.
> 0, number of user supplied curves to be used in creating a pump curve set (NPC(J) = 0),

W3-I, NPC, Until all pump characteristic curve sets are

W4-I NC, described.

9.6 Pump Head and Torque Data Cards 10XYYZ

Pump Head and/or Torque Data Cards must be supplied for each unique value of the curve set sequence index J, if NC(J) on Card 100000 is nonzero. X corresponds to the sequence number J. If NPC(J) is 0, Head and Torque Data Cards must be supplied for the quadrants describing the pump characteristics in the region of interest (characteristics in all quadrants need not be described). Any built-in curve set can be modified without having to supply the complete curve set if $1 \leq NCP(J) \leq 3$ and $JC(J) < 0$. Head curves one through eight are input by setting YY to the desired curve number, i.e., 01, 02,...or 08. Torque curves one through eight are specified by setting YY to the desired torque curve ranging from 09 to 16. The individual curves are ordered by Z, but Z need not start at 1 and need not be consecutive.

W1-I N = Number of data points
($|N| \geq 1$)
Positive value indicates no extrapolation;
negative value indicates extrapolation is permitted.
Extrapolation is generally not recommended.

W2-R PHEAD(1) = Independent variable ($1 \leq YY \leq 8$)
(v/α for YY odd; α/v for YY even)

or PTORK(1) = Independent variable ($9 \leq YY \leq 16$)
(v/α for YY odd; α/v for YY even)

W3-R	PHEAD(2)	=	Dependent variable ($1 \leq YY \leq 8$) (h/α^2 for YY odd; h/v^2 for YY even)
or	PTORK(2)	=	Dependent variable ($9 \leq YY \leq 16$) (β/α^2 for YY odd; β/v^2 for YY even)
.			
.			
.			
W(2N+1)-R	PHEAD(2N)	=	Pairs of independent and dependent
or	PTORK(2N)	=	variables until |N| pairs have been entered.

NOTE: v, h, α, and β are ratios of performance parameters to rated parameters, where v = flow ratio, h = head ratio, α = speed ratio, and β = torque ratio (see Volume 1: Theory and Numerics).

10.0 VALVE DATA CARDS 11XXX0

A valve may be placed in any RETRAN junction by using a positive valve index (IVALVE, on Card 08XXXY) to refer to a Valve Data Card. The type of valve selected is determined by ITCV on the Valve Data Card. A choice of ITCV in the range of ITCV $\leq$ -2 results in a valve which is closed until the trip conditions are satisfied and is then opened for the remainder of the transient, unless closed via reset trip action. A choice of ITCV in the range of ITCV $\geq$ 2 results in a valve which is open until the trip conditions are satisfied and is then closed for the remainder of the transient, unless opened via reset trip action. Either of these two types of valves is controlled by generalized trip data for which the action to be taken (IDTRP on Card 04XXX0), matches |ITCV|.

Either of two types of check valves may be chosen: Type 0 without a hysteresis loop in the characteristic flow-versus-pressure curve; and Type 1 with the hysteresis loop. The characteristic curves for these two types are shown in Figure IV.10-1.

Both types of check valves are controlled by flow-dependent pressure losses of the form

$$\left(\frac{1}{144\,g_c}\right)\left(\frac{CVi}{2\rho_j A_j(t)^2}\right) W_j \left| W_j \right| (psi)$$

which is the same form used for normal junction losses. The check valve losses are in addition to those specified by FJUNF and FJUNR on the Junction Data Cards 08XXXY.

Three regions of operation are defined for each check valve:

- CV1 is used for positive flow with the valve open,
- CV2 is used for negative flow with the valve open, and

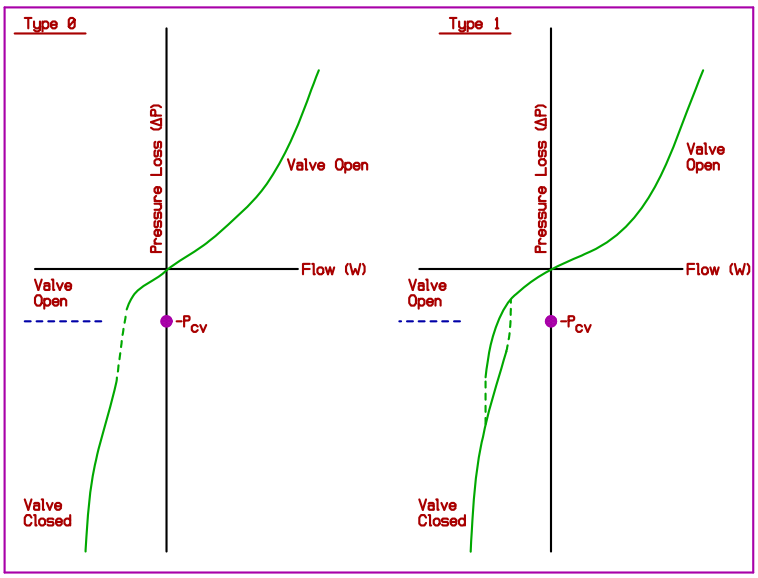


Figure IV.10-1. Check Valve Characteristic Curves

- CV3 is used for negative flow with valve almost closed.

For positive flow, the valve remains open and sustains a pressure loss proportional to CV1. For negative flow, the valve remains open if the pressure loss, which is proportional to CV2, is less than the back pressure, PCV, required to close the valve.

After the valve closes, the pressure loss is proportional to CV3 for small leakage flows. Type 0 check valves open in exactly the reverse sequence of the closing sequence. A Type 0 valve opens when negative flow has decreased to a value such that the pressure loss for the open phase is less than the loss required to keep the valve closed. A Type 1 valve reopens only when the pressure loss developed across the valve in the closed position is less than the required back pressure.

A time-dependent flow area may be associated with a valve defined by $|ITCV| \geq 2$. The normalized junction area for any time step is interpolated from input tables of area-versus-time (Cards 12XXYY). The junction area used during the time step is then given by the product of the interpolated normalized area and AJUN on Cards 08XXXY. Either one or two curves may be input for a valve. If two area-versus-time curves are supplied, one is for the normalized junction area-versus-time when the valve is opening, and the other is for the normalized junction area-versus-time when the valve is closing. If only one curve is supplied, then it is an opening curve if $ITCV \leq -2$ and a closing curve if $ITCV \geq 2$. A valve whose area is modulated by a feedback control system may be modeled by setting ITCV = 1000 and IACV equal to the IDC of the control block described on Cards 702XXX and 703XXX.

While it is not recommended, the normalized area obtained from either an area-versus-time table or a control block output signal can exceed unity. This will give a time-dependent area that exceeds that input junction area. This situation has been retained for compatibility with RETRAN-02.

Valves having inertial properties differ from check valves in that the valve gates have a significant inertia which controls the rate of opening for a given differential pressure across the valve. The valve gates are assumed to be hinged on each side and open from the center. The differential pressure across the valve acts as a torque on the gates, and the gate angle at any time is found by integrating the equation of motion. All inertial valves are assumed to be closed for steady-state initialization. A viscous damping coefficient may optionally be supplied for the equation of motion. Once the gates reach a rotation of 90° they are latched and remain fully open.

Inertial valves are defined by setting ITCV = -1 in the valve data. Each inertial valve must be associated with a table of normalized area versus angle by setting the variable IACV to the appropriate table number. These tables are combined with the area versus time tables and may be intermixed but not used for both functions.

NCKV (Card 01000Y) cards must be entered with XXX = 001, 002, ... NCKV. The data on the card are interpreted according to the type of valve being described.

W1-I ITCV = Type of valve

- -1, inertial valve
- 0, Type 0 check valve
- 1, Type 1 check valve
- $\leq$ -2, a closed valve to open under control of trip ID = |ITCV|
- $\geq$ 2, an open valve to close under control of trip ID = ITCV
- 1000, time-dependent area defined by control system
- < -1000 a special spray line valve used for pressurizer steady-state initialization. A closed valve to open under control of trip ID = |ITCV| - 1000.

W2-I IACV =

Number of the General Data Table containing area-versus-angle data if ITCV = -1

=

Number of the General Data Table containing area-versus-time data if |ITCV| $\geq$ 2 and ITCV $\neq$ 1000. IACV refers to XX on the General Data Table Cards 12XXYY.
If ITCV $\geq$ 2, then IACV is the number of the General Data Table containing the normalized junction area-versus-time when trip ID = |ITCV| closes the valve.
If ITCV $\leq$ -2, then IACV is the number of the General Data Table containing the normalized junction area-versus-time when trip ID = |ITCV| opens the valve

=

Control system IDC for normalized area from control system if ITCV = 1000

=

0 otherwise

W3-I	IACV2	=	Number of an optional General Data Table containing area-versus-time data if |ITCV| $\geq$ 2 and ITCV $\neq$ 1000. IACV refers to XX on the General Data Table Cards 12XXYY. If ITCV $\geq$ 2 and IACV2 $\neq$ 0, then IACV2 is the number of the General Data Table containing the normalized junction area-versus-time for opening the valve when trip ID = |ITCV| is reset. If ITCV $\leq$ -2, then IACV2 is the number of the General Data Table containing the normalized junction area-versus-time for closing the valve when trip ID = |ITCV| is reset.
		=	0 otherwise
W4-R	PCV	=	Back pressure for closure (psia)
		=	0. if |ITCV| $\geq$ 2
W5-R	CV1	=	Forward flow friction coefficient if ITCV = 0 or 1 (dimensionless)
		=	Area*moment arm if ITCV = -1 (ft^3)
		=	0. if |ITCV| $\geq$ 2
W6-R	CV2	=	Reverse flow friction coefficient (valve open) if ITCV = 0 or 1 (dimensionless)
		=	Moment of Inertia if ITCV = -1 ($lbm*ft^2$)
		=	0. if |ITCV| $\geq$ 2
W7-R	CV3	=	Reverse flow friction coefficient (valve closed) if ITCV = 0 or 1 (dimensionless)
		=	Damping constant if ITCV = -1
		=	0. if |ITCV| $\geq$ 2

11.0 GENERAL DATA TABLE CARDS 12XXYY

General Data Tables can be used to provide input data for several models. The General Data Table Data Cards from RETRAN-02 remain unchanged for most applications. The use of the data cards has been extended for use with the two-dimensional function generator control block (F2D).

Tabular normalized area versus time or normalized area versus angle data are used in conjunction with valve descriptions to describe transient area changes in RETRAN flow paths, with XX corresponding to IACV or IACV2 on the valve data cards. The transient flow path area is assumed to be constant over a time step and is computed as the product of the interpolated normalized area (given the independent variables time since the trip), and the full open junction area AJUN (described on Cards 08XXXY).

Tabular data for the control system function generator control blocks are input on General Data Table Cards. The tabular function generator data should be entered on General Data Table XX, where XX is the table number referenced by INC2 on the control block description cards.

Tabular data describing carryover or carryunder for the Separator model can be supplied on the General Data Table Cards. General Data Table XX is referenced by ICO1, ICO2, ICU1, or ICU2 (Words 8, 9, 10, and 11, respectively) on the Separator Description Cards 60XXXY.

NLK (Card 01000Y) sets of cards must be entered with XX = 01, 02, ..., NLK. YY is a card sequence number for each set ranging from 00 to 99. The cards are ordered by YY, but YY need not start at 00 and need not be consecutive. An arbitrary number of items may be entered on each card.

W1-I	NAREA	=	Number of data points ($\|NAREA\| \geq 1$) Positive value indicates no extrapolation; negative value permits extrapolation except for the two-dimensional function generator block.
		=	Number of table values + 1000 (NAREA > 1000 indicates table is used with a two-dimensional function generator control block. Extrapolation is not permitted for this application.)
			For XX = CGAIN, the x coordinates of the rectangular grid must be input in ascending order.
			For XX = CP1, the y coordinates of the rectangular grid must be input in ascending order.
			For XX = CP2, $F(x_j,y_k)$ must be input in the order $F(x_1,y_1)$, $F(x_2,y_1)$, ... $F(x_n,y_1)$, $F(x_1,y_2)$, $F(x_2,y_2)$, ... $F(x_n,y_2)$, ... $F(x_n,y_m)$.
W2-R	TAREA(1)	=	Time (sec) Angle (degrees) Control System Independent Variable
W3-R	TAREA(2)	=	Area normalized to full open area AJUN Control System Dependent Variable
W4-R	TAREA(3),		Until NAREA points are entered, where the
W5-R	TAREA(4),		independent values are in ascending order.

12.0 FILL TABLE DATA CARDS 13XXYY

Tabular fill data is used in conjunction with a "fill" junction to specify a flow boundary condition for a RETRAN problem. Water or a noncondensable gas may be injected into any volume through one or more "fill" junctions, and flow through any of these junctions may be initiated by use of a trip signal. Fill curves are represented by tabular input of either flow rate or mass flux versus time or pressure. Several junctions can use a single fill curve.

The thermodynamic fluid properties for positive fills (positive flow) are determined from information supplied with the fill table. Negative fill thermodynamic properties are determined by the fluid conditions within the RETRAN volume supplying the fluid being removed from the system. To obtain the correct momentum sense for negative fills, the junction angle (ANGLV on Card 08XXXY) should be biased by 180 degrees from parallel positive fills or normal junctions. For example, if a normal junction has an angle of 90 degrees and a negative fill parallels the normal junction, the correct angle for the negative fill is 270 degrees. In general, a negative fill is not a proper boundary condition and should be used with caution.

Two-phase boundary conditions can be specified for the homogeneous equilibrium model, where the phase velocities and temperatures are equal, by appropriate specification of the mixture enthalpy. However, for situations where vapor (or noncondensable gas) and liquid with different temperatures or velocities are the desired boundary conditions, separate single-phase fills must be supplied, e.g., one for the vapor and another for the liquid. A separate fill junction (Card 08XXXY) must be used for each fill.

NFLL (Card 01000Y) sets of cards must be entered with XX = 01, 02, ..., NFLL. YY is a card sequence number for each set ranging from 00 to 99, but YY need not start at 00 and need not be consecutive. An arbitrary number of items may be entered on each card. At least one table pair must be entered.

12.1 HEM Fill Table Data Cards

W1-I	NFILL	=	Number of table data points ($\|NFILL\| \geq 1$) Positive value indicates no extrapolation; negative value permits extrapolation. = 0, when fill enthalpy and fill pressure are to be controlled by control system
W2-I	ITFILL	=	Trip ID number to start the fill ($ITFILL \geq 2$) 1000, for fill controlled by control system. If NFILL = 0, then ITFILL must equal 1000.

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If ITFILL ≠ 1000

W3-I	JX	=	Independent variable flag in fill table JX = 0, time (sec) JX > 0, pressure ($p_{vol} + p_{grav}$) (psia) JX < 0, differential pressure ($p_{vol} + p_{grav} - p_{fill}$) (psia)
W4-I	JY	=	XY, multi-field flags described below. X = Flag to specify that the fill is for noncondensable gas (defined on Card 010010) rather than water = 0, (or blank) water (default) ≥ 1, noncondensable gas Y = Flow type flag. = -1, mass flow in lbm/sec = 0, mass flux in lbm/sec-ft^2 = 1, mass flux in gpm/ft^2
W5-R	FILTBL(1)	=	Time (sec) or pressure (psia),
W6-R	FILTBL(2)	=	Flux (lbm/sec-ft^2 or gpm/ft^2) or mass flow (lbm/sec) This flux is multiplied by the time-dependent junction area to obtain the junction mass flow rate.
W7-R	FILENT(1)	=	Enthalpy of fill fluid (Btu/lbm). The enthalpy is not used when flow is negative, but a nonzero value must be supplied.
W8-R	FILPRS(1)	=	Fill system pressure (psia). The pressure is not used when flow is negative and JX ≥ 0, but a nonzero value must be supplied. Repeat for |NFILL| data points where a data point consists of FILTBL(1), FILTBL(2), FILENT(1), and FILPRS(1). The independent variables must be supplied in ascending order.

If ITFILL = 1000

W3-I	JX	=	ID of control block controlling fill flux
W4-I	JY	=	Multi-field flag (as described above).

If ITFILL = 1000 and NFILL = 0

W5-R	FILTBL(1)	=	ID of control block controlling fill enthalpy.

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W6-R	FILTBL(2)	=	ID of control block controlling fill pressure. NOTE: Both IDs must be entered as floating point numbers. Words W7-R and W8-R should not be supplied.

If ITFILL = 1000 and NFILL = 1

W5-R	FILTBL(1)	=	Dummy value (0.0)
W6-R	FILTBL(2)	=	Dummy value (0.0)
W7-R	FILENT(1)	=	Constant value for enthalpy of fill fluid (Btu/lbm).
W8-R	FILPRS(1)	=	Constant value for fill system pressure (psia).

13.0 POINT KINETICS CONSTANTS DATA CARD 140000

The normalized thermal power generation may be computed by use of the point reactor kinetics equation with reactivity feedback if the power calculation indicator, NODEL (Card 01000Y), is equal to 1. Six groups of delayed neutrons are used in the power calculation. The user also has the option of including fission product decay heat and actinide decay in the power calculation if the Decay Heat Option Description Data Card (146000) is supplied.

The driving function for the point reactor kinetics equations is the reactivity. Contributions to the reactivity include a time-dependent control (scram) reactivity and reactivity due to feedback effects in each core region from changes in fuel and moderator properties. Reactivity feedback effects can be modeled in several different ways. For changes in fuel properties, reactivity feedback can be modeled by supplying a fuel temperature coefficient or, if nonlinear behavior is desired, a table can be supplied describing any desired reactivity function related to fuel temperature. Typically either a coefficient or table is used; however, the model allows use of both. The same options are available for the reactivity feedback resulting from moderator property changes; a water temperature coefficient can be supplied and/or a reactivity versus moderator density table can be input. In addition, any desired reactivity feedback function can be supplied through the use of the control system and input on the Scram Table Data Cards 141XYY.

The dependent variable for fuel property feedback can be defined as the average fuel temperature or the square root of the average fuel temperature. If reactivity tables are input, a "global" table can be used for all core regions or separate tables can be supplied for each core region.

The total power in a core conductor is the sum of the direct fission power and the radioactive decay power. The inclusion of the decay heat terms gives a more realistic shutdown power calculation. All power need not be generated in the fuel elements. Direct gamma heating of the coolant may be considered with the direct moderator heating option.

Two fission product decay heat models are available as options in RETRAN-3D, the 1979 ANS standard and the 1973 proposed standard. The decay heat data are input on the 146000 and 146010 cards. The user also can have nonequilibrium initial conditions with either decay heat model. These data are input on the 14700X cards. These two models are discussed in detail in Volume 1: Theory and Numerics.

A Point Kinetics Data Card is required if NCOR (Card 01000Y) is greater than 0 and NODEL (Card 01000Y) is equal to 1. Word 1 must be provided, while the others are optional.

W1-R	BOVL	=	β/Λ, the effective delayed neutron fraction divided by the prompt generation time (sec^{-1})
W2-A	DPVAR	=	Fuel temperature reactivity units = 'DEG F' temperature (F) = 'SQRT F' square root temperature $\left(\sqrt{T(F)}\right)$ = 'SQRT R' square root temperature $\left(\sqrt{T(R)}\right)$ NOTE: If DPVAR is blank or omitted, the default units ('DEG F') will be used.
W3-R	RHOIN	=	Initial total core reactivity ($), default = 0.

13.1 Delayed Neutron Data Override Cards 14000Y

Default values for delayed neutron decay constants and yield fractions may be overridden. If only six values are supplied, they will be interpreted as decay constant replacements and the default yield fraction values will be used. If the yield fractions (Words 7 to 12) are supplied, the condition:

$$\sum_{i=1}^{6} \frac{\beta_i}{\beta} = 1.0$$

must be met or further input processing will be terminated.

Y is a card sequence number ranging from 1 to 9.

W1-R	DLAMDA(1)	=	Decay constants for six delayed neutron groups.
.	.		
.	.		
.	.		
.	.		
W6-R	DLAMDA(6)		

W7-R	AJOVRJ(1)	=	Yield fractions β_i/β for six delayed groups.
.	.		
.	.		
.	.		
.	.		
W12-R	AJOVRJ(6)		

13.2 Reactivity Coefficient Data Cards 140XXY

NCOR (Card 01000Y) sets of cards are required if NODEL is equal to 1 (Card 01000Y) where XX = 01, 02, ..., NCOR. A discussion of the reactivity coefficient data as used by the RETRAN code is found in Volume 1: Theory and Numerics.

If global reactivity tables are used, the sum of the density weighting factor (DENWT) should equal 1.0 and the sum of the fuel temperature weighting factor (FTWT) should equal 1.0. Some users obtain reactivity data from auxilliary calculations (such as the SIGTRAN code) on a core region basis, rather than a core-wide or global basis. If a reactivity table is supplied for each core region, the weighing factors need not sum to 1.0. It is at the user's discretion whether the weighing factors are built into the tables. If the regional data are generated from the SIGTRAN code, a weight factor of 1.0 for each region is correct since the weight factors are already included in the reactivity data. However, users are free to select any weighting factor.

W1-R	DENWT	=	Density weighting factor.
W2-R	FTWT	=	Fuel temperature weighting factor.
W3-R	ALPHTM	=	Fuel temperature coefficient, including any region weighting desired; the units are in ($/reactivity unit) consistent with the units specified on Card 140000.
W4-R	ALPHTW	=	Water temperature coefficient, including any region weighting desired ($/F).

13.3 Scram Table Data Cards 141XYY

Scram Table Data Cards are required if NCOR (Card 01000Y) is greater than 0 and NODEL (Card 01000Y) is equal to 1. The Scram Table is a reactivity versus time table. A maximum of ten reactivity tables ($0 \leq X \leq 9$), may be input specifying the control reactivity as a function of time. Each table is activated by a trip signal. The total control reactivity is summed over all tables which have been tripped. The scram model treatment of trip controls is such that once tripped, the trip must stay on. The scram can be reversed only by having a second reactivity table which is tripped to add positive reactivity. Also, at any given entry, the time variable is the elapsed time since the trip, not the problem time. YY is the card sequence number for the set and ranges from 00 to 99. YY need not start at 00 and need not be consecutive.

W1-I	NSCR	=	Number of data points (|NSCR| ≥ 1) Positive value indicates no extrapolation; negative value permits extrapolation. NSCR = IDC of control block if ITSCRM = 1000
W2-I	ITSCRM	=	Trip ID number to activate scram (ITSCRM ≥ 2) NOTE: Reset trips are not recognized by the scram model and will not reverse the scram.
		=	1000, for reactivity controlled by control system
W3-I	KTBL	=	Flag for units of scram curve = 0, table is "second" vs. "$" as in RETRAN-02 > 0, the general data table containing data toconvert "seconds after scram" to "feet inserted" when the scram table is given in "feet" vs. "$".
W4-R	TSCR(1)	=	Time (sec) if KTBL = 0. Position (ft) if KTBL > 0.
W5-R	TSCR(2)	=	Reactivity in dollars
W6-R, W7-R,	TSCR(3), TSCR(4),		until NSCR points are entered, where time values are in ascending order or position values vary from the initial position to the final position.

NOTE: If ITSCRM = 1000, zero points are to be entered.

13.4 Density Reactivity Table Data Cards 142XXY

This set of cards is required if NCOR (Card 01000Y) is greater than 0 and NODEL (Card 01000Y) is equal to 1. If XX = 00, the table is a global one and is the only one present. This is the same as the 1420XX cards in RETRAN-02 decks. To use the regional reactivity model, supply a data table for each core region. With this option XX ranges from 01 to NCOR. Y ranges from 0 to 9.

W1-I	NDEN	=	Number of data points Positive value indicates no extrapolation; negative value permits extrapolation. = 1, reactivity is a constant value = 0, reactivity is always zero

W2-R	VOIDRO(1)	=	Density (lbm/ft^3)
W3-R	VOIDRO(2)	=	Reactivity ($)
W4-R,	VOIDRO(3),		until NDEN points are entered,
W5-R,	VOIDR0(4),		density values are in ascending order.
.	.		
.	.		
.	.		

13.5 Doppler Table Data Cards 143XXY

This set of cards is required if NCOR (Card 01000Y) is greater than 0 and NODEL (Card 01000Y) is equal to 1. If XX = 00, the table is a global one and is the only one present. This is the same as the 1420XX cards in RETRAN-02 decks. To use the regional reactivity model, supply a data table for each core region. With this option XX ranges from 01 to NCOR. Y ranges from 0 to 9.

W1-I	NDOP	=	Number of data points Positive value indicates no extrapolation; negative value permits extrapolation. = 1, reactivity is a constant value = 0, reactivity is always zero
W2-R	DOPRO(1)	=	Temperature coefficient in units of fuel temperature reactivity
W3-R	DOPRO(2)	=	Reactivity ($)
W4-R,	DOPRO(3),		until NDOP points are entered, where temperature
W5-R,	DOPRO(4),		values are in ascending order.
.	.		
.	.		

14.0 NORMALIZED POWER TABLE DATA CARDS 141XYY

Normalized power cards are required if NCOR (Card 01000Y) is greater than 0 and NODEL (Card 01000Y) is equal to 0. The normalized power table is used as a table of normalized power (normalized to POWER on Card 010005) versus time. A maximum of ten normalized power tables ($0 \leq X \leq 9$) may be input specifying normalized power as a function of time. Each table is activated by a trip signal. The total control normalized power is summed over all tables which have been tripped. The trip controls are treated such that once tripped, the trip must stay on. Also, at any given entry, the time variable is the elapsed time since the trip, not the problem

time. YY is the card sequence number for the set and ranges from 00 to 99. YY need not start at 00 and need not be consecutive.

W1-I	NPNRM	=	Number of data points ($\|NPNRM\| \geq 1$) Positive value indicates no extrapolation; negative value permits extrapolation. NPNRM = IDC of control block if ITPNRM = 1000
W2-I	ITPNRM	=	Trip ID number for table activation ($ITPNRM \geq 2$)
		=	1000, for normalized core power controlled by control system
W3-I	IDUM	=	Dummy variable, reserved for future use
W4-R	TPNRM(1)	=	Time (sec)
W5-R	TPNRM(2)	=	Normalized core power
W6-R, W7-R,	TPNRM(3), TPNRM(4),		until NPNRM points are entered, where time values are in ascending order.

NOTE: If ITPNRM = 1000, zero points are to be entered.

15.0 DIRECT MODERATOR HEATING DATA CARDS 144XXX

This set of cards is optional and may be supplied only if NCOR > 0 (Card 01000Y) and if NODEL > 0 (Card 01000Y). This model allows the user to account for direct energy deposition into the fluid volume due to gamma heating. Parameters specified on this card determine how the power generated in each core conductor section is split between an internal heat source for the conductor and a direct heat source into the fluid volume. Two parameters, QPMOD and QDMOD, must be supplied for each core conductor section if this model is used. If the multidimensional kinetics option is used (NODEL = 3 on Card 01000Y), the 144XXX card series is not required for direct moderator heating. See Section IV.28 for the input requirements for this option. XXX is the card sequence number ranging from 000 to 999. The number of parameters to be supplied on this card is 2*NCOR.

W1-R	QPMOD(1)	=	Fraction of prompt power generated in core section 1 to be deposited directly into the fluid volume.

W2-R	QDMOD(1)	=	Fraction of decay heat generated in core section 1 to be deposited directly into the fluid volume.
	.		
	.		
	.		
W(2*NCOR-1)-R	QPMOD(NCOR)	=	Fraction of prompt power generated in core section NCOR to be deposited directly into the fluid volume.
W(2*NCOR)-R	QDMOD(NCOR)	=	Fraction of decay heat generated in core section NCOR to be deposited directly into the fluid volume.

15.1 Direct Moderator Heating Multiplier Data Cards 145XXX

The multiplier for direct moderator heating is either a user supplied value or a default value. The default value is the ratio of the initial fluid specific volume to the time "t" specific volume value. If the default value method is selected, the 145XXX cards are not input.

This set of cards is optional and is supplied only if NCOR > 0 (Card 01000Y), NODEL (Card 01000Y) is equal to 1, 2, or 3, and the user does not want to use the default model for the multiplier. XXX is the card sequence number ranging from 000 to 999. XXX need not start at 000 and need not be consecutive. An arbitrary number of items may be entered on each card.

W1-I	NMODHT	=	Number of data points in the table. Positive value indicates no extrapolation; negative value permits extrapolation.
W2-R	WEIGHT(1)	=	Fluid density (lbm/ft^3)
W3-R	WEIGHT(2)	=	Moderator heating rate multiplier (dimensionless)
W4-R, W5-R,	WEIGHT(3), WEIGHT(4),		Until NMODHT points are entered, where fluid density values are in ascending order

16.0 DECAY HEAT OPTION DESCRIPTION DATA CARD 146000

This card is required if the 1979 ANS decay heat standard,[IV.16-1] the 1971 proposed standard,[IV.16-2] or nonequilibrium initial conditions for either the 1979 or 1971 model are desired. The decay heat model is available for use by all kinetics options (NODEL = 1, 2, or 3). If this data card is not supplied, decay heat will not be included in the power calculation. Note that the default model uses the 1979 standard, whereas the proposed 1971 standard is the default

model for RETRAN-02. The 1979 standard is recommended for new applications since it supersedes the older proposed standard.

W1-I	IANS	=	Decay heat calculation type. = 0, 1979 ANS standard (default). = 1, 1971 proposed ANS standard.
W2-I	IHIST	=	Number of power history intervals. This parameter is used when the nonequilibrium decay precursor initialization (finite forming time) is desired. = 0, infinite operation is assumed (default). = N, number of histories entered on the 1470XX cards. $1 \leq N \leq 99$.
W3-I	ISOTOP	=	Number of isotopes to use in the decay heat calculation for the 1979 standard (IANS = 0). = 1, decay data for U-235 will be used (required for the 1972 proposed ANS standard (IANS = 1)). = 3, decay data for U-235, Pu-239, and U-238 will be used.
W4-R	KMUL	=	Multiplying factor for decay energy. < 0, indicates control block ID to give KMUL as a function of time, = 0, use multiplier of 1.0 with ANS decay energy. > 0, multiply ANS energy contribution by constant KMUL. NOTE: KMUL < 0 should be used to account for the effects of neutron capture and uncertainty as defined by the 1979 standard.
W5-I	IACT	=	Actinide selection flag. = 0, no contribution to decay heat from U-239 and Np-239. = 1, include contribution to decay heat from U-239 and Np-239 without applying KMUL to them. =2, include contribution to decay heat from U-239 and NP-239 and apply KMUL to them
W6-R	UDUF	=	Breeding ratio; number of Pu-239 atoms produced per U-235 atoms fissioned. Default = 1.0.

16.1 Decay Heat Floating Point Data 146010

The 1979 decay heat option can use data from three fissionable nuclides, U-235, Pu-239, and U-238. The user has the ability to specify the fraction that each will contribute. This card is required only to change the default values of energy released per fission or the isotopic fractions

if the 1979 Standard, three-isotope model is selected on the 146000 card. The values of FRC are used only if IANS = 0 and ISOTOP = 3 on the 146000 card. This card is not required if the 1973 proposed standard is selected on Card 146000.

W1-R	QFTS	=	Mev per fission. Default is 200.0.
W2-R	FRC(1)	=	Fraction of decay power due to U-235. Default = 0.98.
W3-R	FRC(2)	=	Fraction of decay power due to Pu-239. Default = 0.01.
W4-R	FRC(3)	=	Fraction of decay power due to U-238. Default = 0.01 NOTE: The sum of the FRC(I) must be 1.0.

16.2 Decay Heat Power History Interval Data 1470XX

RETRAN-3D has the option to compute nonequilibrium initial precursor concentrations for use with the decay heat model. The data required to perform this calculation are entered on the 1470XX cards. The option is used only if IHIST > 0 on the 146000 card. One card is required for each power history interval. An interval is defined as the time interval that the reactor operates at a specified power. Shutdown periods can be modeled by entering zero power. XX ranges from 1 to IHIST with one card required for each power history interval starting with the first or oldest interval. The kinetics model assumes that at t=0.0, the normalized power must be 1.0. So the last interval must end with a normalized power of 1.0.

W1-R	FIPRM	=	Normalized power (relative to a steady-state initialization value of 1.0).
W2-R	TIME	=	Length of the time interval.
W3-C	UNITS	= = = = = =	Units of time for the interval. 'SEC', seconds, 'MIN', minutes, 'HR', hours, 'DAY', days, 'WK', weeks.
W4-R	FRC(1)	=	Fraction of decay power due to U-235 for this interval. Default = 0.98.
W5-R	FRC(2)	=	Fraction of decay power due to Pu-239 for this interval. Default = 0.01.

W6-R	FRC(3)	=	Fraction of decay power due to U-238 for this interval. Default = 0.01. NOTE: The sum of the FRC(I) must be 1.0.

17.0 HEAT CONDUCTOR DATA CARDS 15XXXY

A heat conductor can be described to represent one or more materials which conduct heat into the fluid of a volume, or between the fluids in two different volumes. In the former case, the conductor may represent core fuel rods, or a material insulated on one side and with no internal heat generation. The later case may represent piping or a flat plate separating two volumes. When a conductor connects two volumes, it may be thought of as being analogous to a junction, where heat rather than fluid is flowing from one volume to the other. Powered conductors or core sections are described in a manner similar to passive conductors, with the exception that powered conductors require an extended description supplied on the Core Section Data Cards (16XXX0).

When the multidimensional neutronics model is used (NODEL = 3 on Card 01000Y), core conductor information is not input through the heat conductor data cards. See Section IV.28, Multidimensional Neutronics Input, for the input requirements for this option. NSLB (Card 01000Y) does not include the number of core conductors if multidimensional neutronics is used.

NSLB (Card 01000Y) sets of cards must be entered with XXX equal to the heat conductor number. XXX need not start at 001 and need not be consecutive. Y is a card sequence number ranging from 1 to 9 for each set, starting at 1, and must be consecutive.

W1-I	IVSL	=	Volume number of the fluid volume (refers to XXX on the 05XXXY cards) at left conductor surface.
W2-I	IVSR	=	Volume number of the fluid volume (refers to XXX on the 05XXXY cards) at right conductor surface.

A value of zero for either IVSL or IVSR means that the conductor surface does not conduct heat across the boundary. The user can also model a heat conductor with fluid volumes on both sides. For steam generator conductors with fluid volumes on both sides, the left volume must be connected to the primary side of the system and the right volume to the secondary side of the system. At least one of the quantities IVSL or IVSR must be greater than 0. IVSL must be 0 for solid cylindrical heat conductors.

An option is available to allow the user to specify a Dittus-Boelter heat transfer correlation for a given conductor. The user can optionally select vapor or liquid. This option preempts any code selected heat transfer correlation selection.

W3-I	IGOM	=	Geometry index (Refers to XX on the 17XXYY cards) ($1 \leq$ IGOM $\leq$ NGOM)

W4-R	CELEV	=	Elevation of the vertical midpoint of conductor in feet from the bottom of the volume on the side (left or right) which uses local conditions heat transfer or the condensation model. If the local conditions heat transfer option or the condensation model is not used for this conductor, 0.0 is adequate.
W5-I	IMCL	=	Indicator for heat transfer correlations at left surface. < 0, use specified heat transfer coefficient |IMCL| defined on Card 015XXX, where |IMCL| = X 0, use Groeneveld 5.9 } Stable film boiling correlation selection 1, use Groeneveld 5.7 2, use Dougall-Rohsenow 3, use Catton-Swanson and Groenveld 5.9 4, use Catton-Swanson and Groenveld 5.7 5, use Catton-Swanson and Dougal-Rohsenow 1Z, use G.E. CHF correlation (ten's place digit = 1) 2Z, use EPRI CHF correlation (ten's place digit = 2) 3Z, no CHF calculation, use pre-CHF heat transfer (ten's place digit = 3) 1YZ, wall heat flux is held constant (hundred's place digit = 1) Z and Y are described above. 41, use Dittus-Boelter forced convection to liquid for this conductor. 48, use Dittus-Boelter forced convection to vapor for this conductor.
W6-I	IMCR	=	Indicator for heat transfer correlations at right surface. Same as IMCL above.
W7-R	ASUL	=	Heat transfer area at left surface (ft^2) ASUL = 0.0 if IVSL = 0 ASUL > 0.0 if IVSL ≠ 0
W8-R	ASUR	=	Heat transfer area at right surface (ft^2) ASUR = 0.0 if IVSR = 0 ASUR > 0.0 if IVSR ≠ 0
W9-R	VOLS	=	Total volume of conductor (ft^3) VOLS > 0.0

W10-R	HDML	=	Left side hydraulic diameter (ft) HDML $\geq$ 0. If HDML = 0.0 and IVSL > 0, HDML will be set equal to DIAMV (Card 05XXXY) for volume IVSL
W11-R	HDMR	=	Right side hydraulic diameter (ft) HDMR $\geq$ 0. If HDMR = 0.0 and IVSR > 0, HDMR will be set equal to DIAMV (Card 05XXXY) for volume IVSR
W12-R	DHEL	=	Left side heated equivalent diameter (ft) DHEL $\geq$ 0. If DHEL = 0.0 and IVSL > 0, DHEL will be set equal to HDML
W13-R	DHER	=	Right side heated equivalent diameter (ft) DHER $\geq$ 0. If DHER = 0.0 and IVSR > 0, DHER will be set equal to HDMR
W14-R	CHNL	=	Channel length on left side (ft) If CHNL = 0.0 and IVSL > 0, CHNL will be set equal to ZVOL (Card 05XXXY) for volume IVSL
		=	Conductor height, bottom to top (ft) on left side if local conditions heat transfer model is used on left side. (NSTK > 0 on Card 01000Y)
W15-R	CHNR	=	Channel length on right side (ft) If CHNR = 0.0 and IVSR > 0, CHNR will be set equal to ZVOL (Card 05XXXY) for volume IVSR.
		=	Conductor height, bottom to top (ft) on right side if local conditions heat transfer model is used on right side. (NSTK > 0 on Card 010001)
W16-I	IHXQF	=	IHXQF > 0 if the heat conductor is used to model a steam generator. Additionally, IVSR and IVSL must be > 0 and IVSL must be the primary-side volume. IHXQF is an arbitrary positive integer representative of the assigned steam generator number (ISGNUM) defined on Cards 230XXY. The overall heat transfer coefficient of the heat conductor is adjusted to achieve a steady-state energy balance. IHXQF = 0 if the heat conductor is not used to model a steam generator (default=0).

Words 17 through 20 are optional input parameters and need not be supplied if the optional models are not used.

W17-I	ICONDN	=	Condensation correlation selection flag. Condensation models are available only if IHTMAP = 1 on Card 01000Y (default = 0) = -2, Chun and Seban or Siddique correlation for condensation on stacked vertical surfaces; requires heat conductor stack data on 2200XY and value for CNDL (W18). The Siddique correlation is used when noncondensables are present, otherwise the Chun and Seban correlation is used. = -1, Bell et al. correlation or Carpenter and Colburn correlation for condensation inside a horizontal tube = 0, Chun and Seban correlation for condensation on vertical surface of a single conductor = 1, Nusselt correlation for a vertical plate; often used in pressurizer applications = N, Collier correlation for condensation on the outside surface of a bank of horizontal tubes; N is the number of tubes in the bank and must be greater than 1.
W18-R	CNDL	=	Conductor length (ft) for use with condensation heat transfer (ICONDN = -2) or the dynamic gap conduction model.
W19-I	INJL	=	Left side inlet junction number. (Required only with the EPRI CHF model if IMCL = 2Z.)
W20-I	INJR	=	Right side inlet junction number. (Required only with the EPRI CHF model if IMCR = 2Z.)

17.1 Heat Conductor Input User Guidelines

Many of the parameters supplied for a volume are geometric or connection data which require no additional guidance. A few other input parameters deserve a little more discussion.

W5-I	IMCL	This parameter is used to select the film boiling heat transfer correlation that will be used should film boiling be predicted. It also serves a second purpose to select the critical heat flux correlation (other than the default) that will be used. The film boiling heat transfer correlations in RETRAN-3D are all quite dated. The limiting criteria for most transients is that CHF is not exceeded, therefore film boiling heat transfer is generally not a concern for the types of

		transients RETRAN-3D is used for. Of the film boiling heat transfer correlations available in RETRAN-3D, the default Groenveld 5.9, is the best general choice. The default CHF correlations used in RETRAN-3D are a pressure dependent combination of the Barnett, modified Barnett and B&W-2 correlations. Among the options is the EPRI CHF correlation. This correlation was validated against a large body of critical flow data and covers a much wider range of pressures, flows and qualities than the individual correlations that comprise the default model.
W6-I	IMCR	Refer to the IMCL discussion above.
W17-I	ICONDN	This parameter selects the appropriate condensation correlation to use should condensation be predicted by RETRAN-3D. These correlations are dependent on the geometry of the surface, orientation and whether a noncondensable is present. A proper choice for the specific application should be made.

17.2 Specified Heat Transfer Coefficient Data Cards 015XXX

The specified heat transfer coefficient option in RETRAN is either: (1) the condensing heat transfer coefficient correlation discussed in this section, (2) a constant value, or (3) one which is specified by the control system. The condensing heat transfer correlation allows the user to model a PWR containment for reflood back pressure calculations. The general form of the correlation [IV.17-1, IV.17-2, IV.17-3] is given by:

- prior to blowdown,

  $$HTC = HMIN$$

- during blowdown,

  $$HTC = HMIN + (TAGMUL*HTAG - HMIN)/BLOTMIN)\ \Delta T_B$$

  where

  $$HTAG = 72.5*(QOVRV/BLOTIM)^{0.62}$$

  ΔT_B = elapsed time since blowdown initiation

  and

- post blowdown transition and long term

  HTC = UCHMUL*HUCHID + (HMAX - UCHMUL*HUCHID)*EXP(-TRNCON*ΔT_T)

  where

  HUCHID = heat transfer coefficient from standard Uchida correlation

  HMAX = maximum value of HTC reached during the blowdown phase

  ΔT_T = elapsed time since end of blowdown.

The Uchida correlation was developed for condensing in a large volume, such as a containment. Better results may be obtained if a separated volume is used in conjunction with this correlation with the region above the mixture level composed of a steam-air mixture.

All parameters not specifically defined above are input parameters which are defined below. Four different specified heat transfer coefficient options are available, two of which are degenerate forms of the correlation defined above.

The card numbers used for the specified heat transfer coefficient option in RETRAN-3D have been changed to allow more heat transfer coefficient data cards to be supplied. The old card numbering scheme (15000X) only allowed 9 cards. The new scheme allows for 999 cards and XXX must be sequential from 1 to NCHT (Word W24-I on card 01000Y). Note that XXX must correspond to |IMCL| or |IMCR| on the heat conductor (15XXXY) cards.

W1-I	MODE	=	Specified heat transfer coefficient option. ($1 \leq$ MODE ≤ 3, or MODE = 1000)

<u>If MODE=1</u>

W2-R	BLOTIM	=	Estimated length of blowdown phase (sec)
W3-I	IBLO	=	Trip ID used to initiate blowdown
W4-R	QOVRV	=	Ratio of primary coolant energy to net free containment volume (Btu/ft^3)
W5-R	TAGMUL	=	Tagami correlation multiplier (0.0 defaults to 4.0)
W6-R	HMIN	=	Minimum pre-blowdown heat transfer coefficient (0.0 defaults to 8.0, $Btu/hr\text{-}ft^2\text{-}F$)
W7-R	UCHMUL	=	Uchida correlation multiplier (0.0 defaults to 1.2)

W8-R	TRNCON	=	Transition decay constant (input is optional, default = 0.025 1/sec) The default parameters noted above were taken from Reference IV.17-1.

If MODE=2

W2-R	UCHMUL	=	Multiplier to be used with the Uchida correlation

If MODE=3

W2-R	HCONST	=	Constant heat transfer coefficient (Btu/hr-ft^2-F)

If MODE=1000

W2-R	HID	=	ID of control block controlling heat transfer coefficient. The output of the control block must have the units (Btu/hr-ft^2-F). The initial heat transfer coefficient is obtained from the initial condition specification of the control block.

17.3 Core Section Data Cards 16XXX0

Any heat conductor may have internal heat generation. If a conductor does have internal heat generation, it is considered to be a core conductor and must be defined using a Core Section Data Card.

If the multidimensional kinetics option is used (NODEL = 3 on Card 01000Y), the 16XXX0 card series is not required. See Section IV.28 for the input requirements for this option. NCOR (Card 01000Y) should be 0.

NCOR (Card 01000Y) cards must be entered with XXX = 001, 002, ..., NCOR. If the profile fit void fraction option (IVOID = 1 on 01000Y card) is used with point kinetics, the core sections must be stacked beginning with the first core conductor.

W1-I	ISLB	=	Conductor number (refers to XXX on Card 15XXXY).
W2-R	CLTI	=	Initial cladding thickness (ft) If CLTI > 0.0, then metal-water reaction is calculated for this core section, provided MWREAC (Card 01000Y) is greater than zero. If CLTI = 0.0, then no metal-water reaction is calculated for this core section.

W3-R	QFRAC	=	Fraction of power generated in core section ($0.0 \leq$ QFRAC ≤ 1.0) (NODEL ≤ 1 on Card 01000Y).

$$\sum_{i=1}^{NCOR} QFRAC_i \text{ must} = 1.0$$

		=	Control block number from which the power fraction for this conductor is obtained. The power fractions for all core conductors must be obtained from a control block if this option is used. The core section power fractions need not sum to 1.0 for this option, however, the power fractions will be normalized by the code so the sum is 1.0.

For NODEL = 2 only, Words 3 through 6 are supplied as described below.

W3-R	QFRACR	=	Fraction of power generated in a neutronic region or series of neutronic regions to be used as an internal heat source for this core section.
W4-I	IRGF	=	First neutronic region number (refers to XX on Card 310XXY) from which core section XXX obtains power.
W5-I	IRGL	=	Last neutronic region number (refers to XX on Card 310XXY) from which core section XXX obtains power. All neutronic regions ranging between and including IRGF and IRGL are included as power source for core section XXX.

17.4 Conductor Geometry Data Cards 17XXYY

The description of a heat conductor geometry proceeds from left to right, so that node one is at the left surface for rectangular geometry and at the center of the conductor for cylindrical geometry. A geometry description, provided by one set of Conductor Geometry Data Cards, includes the region width, node spacing, and material index for each region in the conductor. If the conductor is a core section, a ratio, PF, of the region power to total core section power must be specified for each region in the core section.

When the multidimensional neutronics model is used (NODEL = 3 on Card 01000Y), core conductor geometry information is not input on the conductor geometry data cards. See Section IV.28 for the input requirements for this option.

A simple gap-expansion model is available for cylindrical geometries. The expansion model is also appropriate for rectangular geometries for which the left boundary of the conductor is fixed and cannot move due to expansion. The model does not provide for any changes in volume or surface areas, but only calculates a modified conductivity in a gap due to expansion in adjacent

regions. Linear coefficients of expansion with respect to temperature for the materials on either side of the gap are used to form a ratio of cold gap width to hot gap width. This ratio is then used as a multiplier in calculating gap conductivity. A gap is considered like any other region in the conductor; that is, its width, nodal spacing, and thermal properties are described in the problem input. A dynamic gap conductance model is also available. It requires additional data input on the 225XXY cards. The number of space steps for a region using the gap-expansion model must be =1. NGOM (Card 01000Y) sets of cards must be entered with XX = 01, 02, ..., NGOM. One card is required for each region and YY is the region number.

RETRAN-3D allows the user to control the values of the region conductivity in two ways. First if Word 8 on Card 17XX01 or Word 6 on Card 17XXYY, YY > 01, is a positive floating point value, it provides a multiplier on the value for the conductivity in that region. If the input value is negative it points to a control block with ID of NINT (value) that can be used to supply a user-defined, time-dependent multiplier on the conductivity for the region. This allows the user to control the gap model (or any other region conductivity) as a function of time.

For YY = 01,

W1-I	IG	=	Geometry type 1, Rectangular 2, Cylindrical
W2-I	NR	=	Number of regions (NR $\geq$ 1)
W3-I	IM	=	Material index (1 $\leq$ IM $\leq$ NMAT)
W4-I	NDX	=	Number of space steps (NDX $\geq$ 1)
W5-R	XO	=	Radial distance to left surface (ft) XO = 0.0 for a solid rod
W6-R	XR	=	Region width (ft)
W7-R	PF	=	Fraction of conductor power generated in region.
W8-R	MULT	=	> 0, Thermal conductivity multiplier < 0, Control block ID for conductivity multiplier, NINT (MULT) 0.0 or Blank, No multiplier (default)

For YY = 02, 03, ..., NR,

W1-I	IGP	=	Gap indicator = -1, dynamic gap conductance and fuel-clad deformation model desired = 0, no gap expansion model used = 1, gap expansion model used
W2-I	IM	=	Material index. (if IGP = -1, IM is the dynamic gap model index; IM = XX on the 225XXY gap model card)
W3-I	NDX	=	Number of space steps in Region YY
W4-R	XR	=	Width (ft) of Region YY
W5-R	PF	=	Fraction of conductor power generated in region
W6-R	MULT	=	Thermal conductivity multiplier

17.5 Thermal Conductivity Data Cards 18XXYY

NMAT (Card 01000Y) sets of data must be entered with XX indicating the material number, XX = 01, 02, ..., NMAT. YY is the card sequence number for each set ranging from 00 to 99. The cards are ordered by YY, but YY need not start at 00 and need not be consecutive. An arbitrary number of items may be entered on each card. At least one table pair must be entered.

W1-I	NKP	=	Number of points in thermal conductivity table ($\|NKP\| \geq 1$) Positive value indicates no extrapolation; negative value permits extrapolation. NKP = 1, a constant value
W2-R	TPK(1)	=	Temperature (F)
W3-R	TPK(2)	=	Thermal conductivity (Btu/ft-hr-F)
W4-R, W5-R, . .	TPK(3) TPK(4), . .		Until |NKP| points are entered, temperature values are in ascending order.

17.6 Volumetric Heat Capacity Data Cards 19XXYY

NMAT (Card 01000Y) sets of data must be entered with XX indicating the material number, XX = 01, 02, ..., NMAT. YY is the card sequence number for each set ranging from 00 to 99. The cards are ordered by YY, but YY need not start at 00 and need not be consecutive. An arbitrary number of items can be entered on each card. At least one table pair must be entered.

W1-I	NCP	=	Number of points in heat capacity table ($\|NCP\| \geq 1$) Positive value indicates no extrapolation; negative value permits extrapolation NCP = 1, a constant value
W2-R	TPC(1)	=	Temperature (F)
W3-R	TPC(2)	=	Volumetric heat capacity (Btu/F-ft^3)
W4-R,	TPC(3),		Until |NCP| points are entered, where temperature values
W5-R,	TPC(4),		are in ascending order.
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.	.		
.	.		

17.6.1 Fuel Density Cards 119XXYY

Fuel density cards are optional and when present activate the fuel enthalpy calculations. XX indicates the fuel region number. YY is the card sequence number ranging from 00 to 99. The cards are ordered by YY, but YY need not start at 00 and need not be consecutive. An arbitrary number of items can be entered on each card.

Note that the temperature range covered by this table must cover the range of the corresponding volumetric heat capacity table (19XXYY), which will be used with this table to generate a fuel enthalpy table. Also remember that the first temperature in the volumetric heat capacity table will define the reference temperature for the enthalpy calculation.

W1-I	ND	=	Number of points in density table >1, positive value indicates no extrapolation; negative value permits extrapolation. = 1, a constant value.
W2-I	TD(1)	=	Temperature (F).
W3-R	TD(2)	=	Density (lb/ft^3).

W4-R	TD(3)	=	Until |ND| points are entered.
W5-R	TD(4)	=	Where temperature values are in ascending order.

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17.7 Linear Expansion Coefficient Data Cards 20XXYY

These cards are required for each material if and only if any heat conductor specifies the gap expansion model; that is, if IGP on any 17XXYY card is 1, NMAT (Card 010001) sets are entered with XX indicating the material number, XX = 01, 02, ..., NMAT. YY is the card sequence number for each set ranging from 00 to 99. The cards are ordered by YY, but YY need not start at 00 and need not be consecutive. An arbitrary number of items may be entered on each card.

W1-I	NXP	=	Number of points in linear expansion coefficient table (|NXP| ≥ 1) Positive value indicates no extrapolation; negative value permits extrapolation NXP = 1, a constant value
W2-R	TPX(1)	=	Temperature (F)
W3-R	TPX(2)	=	Linear expansion coefficient, F^{-1}
W4-R, W5-R, . . .	TPX(3), TPX(4), . . .		Until |NXP| points are entered, where temperature values values are in ascending order.

17.8 Heat Conductor Stack Cards 2200XY

The Heat Conductor Stack Cards are used in conjunction with either the local conditions heat transfer model, the dynamic gap conductance model, or for film condensation on a vertical surface, and should be supplied only if NSTK > 0 (Card 01000Y). NSTK must be > 0 if NGAP > 0 (Card 01000Y) or if ICONDN = -2 (Card 15XXXY). X is the stack number and ranges from 1 to NSTK. Y is the sequence number and ranges from 1 to 9. To use this model, a minimum of two conductors must be specified for each stack.

W1-I ISHD = Flag to indicate the application of the conductor stack.
- = 2, stack used with Chun and Seban correlation for film condensation on vertical surface on left side of conductor
- = 1, stack used with Chun and Seban correlation for film condensation on vertical surface on right side of conductor
- = 0, stack used only with dynamic gap conductance model.
- = -1, local conditions modeling invoked on right side of conductor.
- = -2, local conditions modeling invoked on left side of conductor.

NOTE: The dynamic gap conductance model can be used for the stack for any value of ISHD; the dynamic gap is selected on the conductor geometry data card 17XXYY. If NODEL = 3, the dynamic gap model is selected on channel data card 672XXX and no conductor stacks are supplied.

W2-I	NCON(1)=	List of conductor numbers in the stack starting at
W3-I	NCON(2)	the bottom of the stack.
W4-I	NCON(3)	
.	.	
.	.	
.	.	

17.9 Feedwater Heater Data Cards 240XXY

These cards are optional when using steady-state initialization and should not be supplied if steady-state initialization is not used. These cards are used to describe a conductor or set of conductors in which a desired specific amount of energy is to be transferred from one volume or set of volumes to another volume or set of volumes within the same hydraulic loop, such as feedwater heaters. The information supplied on this card, in conjunction with steady-state initialization, forces the specified energy transfer rate across a conductor or set of conductors at time zero by adjusting conductor surface area. All conductors input on this card must have a volume on the left and right side, and the direction of energy flow must be from the right to left side of the conductor during steady-state initialization. XX is the feedwater heater number ranging from 01 to 99, Y is a sequence number ranging from 0 to 9.

W1-R QFWH = Desired heat transfer rate (Btu/hr)

W2-I	IFWHC(1)	=	List of conductor numbers belonging to this feedwater heater
W3-I	IFWHC(2)		
W4-I	IFWHC(3)		
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.	.		
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17.10 Dynamic Gap Conductance Model Data Cards 225XXY

The dynamic gap conductance model is selected by IGP = -1 on conductor geometry data card 17XXYY and IM indicates the corresponding gap model used. The data are input on 225XXY where XX ranges from 1 to NGAP. This option also requires conductor stack data cards 2200XY; note that NGAP ≤ NSTK ≤ 99. If the multidimensional kinetics option is used (NODEL = 3), the dynamic gap conductance model is selected on channel data cards 672XXX; note that for NODEL = 3, NGAP is ignored.

W1-R	PGAS	=	Cold pin fill gap pressure (psia).
W2-R	ROUFF	=	Surface roughness of nuclear fuel pellet (in.). Default = 0.00004
W3-R	ROUFC	=	Roughness of clad inner surface (in.). Default = 0.00002
W4-R	FTDENS	=	Fuel theoretical density fraction. $0.0 < FTDENS \leq 1.0$
W5-R	VPLEN	=	Volume of gas plenum (in^3).
W6-R	GSFRAC(1)	=	Molar fraction of Helium in fill gas. $0.0 \leq GSFRAC(1) \leq 1.0$. Default = 0.0
W7-R	GSFRAC(2)	=	Molar fraction of Xenon in fill gas. $0.0 \leq GSFRAC(2) \leq 1.0$. Default = 0.0
W8-R	GSFRAC(3)	=	Molar fraction of Argon in fill gas. $0.0 \leq GSFRAC(3) \leq 1.0$. Default = 0.0
W9-R	GSFRAC(4)	=	Molar fraction of Krypton in fill gas. $0.0 \leq GSFRAC(4) \leq 1.0$. Default = 0.0

W10-R GSFRAC(5) = Molar fraction of Hydrogen in fill gas. $0.0 \leq$ GSFRAC(5) ≤ 1.0.
Default = 0.0

W11-R GSFRAC(6) = Molar fraction of Nitrogen in fill gas. $0.0 \leq$ GSFRAC(6) ≤ 1.0.
Default = 0.0

17.11 Optional Heat Transfer Coefficient Multipliers

The heat transfer coefficient multiplier option allows users to modify calculated heat transfer coefficients by applying a multiplier. Currently, the multiplier can be applied to the following heat transfer modes.

Mode	Correlation
1	Dittus Boelter (liquid)
2	Thom
3	Shrock-Grossman
5	Groenveld
6	Berenson
7	Pool Boiling Interpolation
8	Dittus Boelter (vapor)
9	Dougall-Rohsenow
10	Collier (liquid)
14	Collier (vapor)
17	Interpolation of 2 and 3
18	Interpolation of 3 and 9
20	Interpolation of 1 and 2

For the interpolation modes, the multipliers for the two bounding heat transfer modes are used to insure continuous behavior. The multiplier for the interpolation modes is only used if the minimum heat transfer coefficient is used.

When a non-unity multiplier is applied to a heat transfer mode, the resulting heat transfer is generally changed by the multiplier value. However, since modes 6, 7, 10, 14 and 20 are non-linear and the heat transfer coefficient is determined from an iterative solution that depends upon the correlation including the multiplier, and the heat flux boundary conditions, the resulting value of heat transfer coefficient may not be the simple multiple of the multiplier and unmodified correlation value. For these iterative heat transfer correlations, the heat transfer coefficient multiplier is applied to the specific correlations, which form a part of the iterative solution. If the user desires a specific result, a few cases may be required to adjust the heat transfer multiplier to target a given heat transfer coefficient.

For mode 20, the wall heat flux is comprised of two components, one the wall heat flux that heats liquid and another that boils liquid. The liquid heating heat flux is driven by the difference between the wall temperature and the liquid temperature, while the boiling component is driven by the square of the difference between the wall and saturation temperatures. The mode 1 multiplier is applied to the liquid heating heat transfer coefficient and the mode 2 multiplier is applied the boiling heat transfer coefficient. The effective heat transfer coefficient printed for mode 20 is given by dividing the sum of the liquid heating and boiling heat fluxes by the difference between the wall and saturation temperatures. As a result the edited heat transfer coefficient will not be changed by the multiplier (assuming the same value is used for modes 1 and 2) unless the liquid temperature approaches the saturation temperature.

17.11.1 Optional Heat Transfer Coefficient Multiplier - Data Cards 15000X

Optional heat transfer coefficient multipliers can be used to modify the code calculated heat transfer coefficients based on heat transfer regime maps. While not all heat transfer modes are available for modification, the more common boiling and single phase regimes noted above can be changed through input. Using Method, a heat transfer multiplier will be applied to both steady-state and transient heat transfer coefficients for the modes identified above.

Heat transfer coefficient multipliers can be supplied on input record 15000X, where X is the sequence number ranging from 0 to 9. They are ordered by X and need to be consecutive.

Two methods are available for supplying heat transfer multipliers. They are discussed below.

Method - 1 Define a single heat transfer multiplier that is applied to all correlations that belong to the subset of allowed correlations identified above. If this option is selected, a multiplier will be applied to all of the heat transfer correlations listed above.

W1-R	HTMULT	=	Heat transfer coefficient multiplier applied to modes described above. > 0.0 HTC multiplier 0.0 or blank = default value 1.0

Method - 2 Define a data pair consisting of a heat transfer mode and a heat transfer coefficient multiplier for that mode.

W1-I	IHTMOD	=	Heat transfer mode (Allowed values given above)
W2-R	HTMULT	=	Heat transfer coefficient multiplier (0.0 is a default value of 1.0)

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W3-I IHTMOD = Heat transfer mode

W4-R HTMULT = Heat transfer coefficient multiplier

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..... until pairs for all heat transfer modes to be altered are entered

18.0 NONCONDUCTING HEAT EXCHANGER DATA CARDS 21XXYY

Heat may be transferred by means of a volume-associated heat exchanger model which does not consider conduction. This option provides eight models which may be used to add or remove heat from the fluid of a volume. The enthalpy transport model may be used in conjunction with a heat exchanger if a continuous enthalpy profile through the volume is desired.

NHTX (Card 01000Y) sets of data must be entered with XX = 01, 02, ..., NHTX. YY is the card sequence number for each set ranging from 00 to 99. The cards are ordered by YY, but YY need not start at 00 and need not be consecutive. An arbitrary number of items may be entered on each card and, if a table is entered, at least one table pair must be entered.

W1-I IHTX =

Number of data points for IHTYPE = 2, 3, or 4.
Positive value indicates no extrapolation,
negative value permits extrapolation.
= 1, indicates a constant value.

Unused for IHTYPE = -1, 1, and 5. Supply a dummy integer as a placeholder.

For IHTYPE = 6 or 7, the ID of control block specifying rate of heat removal.

W2-I ITHTXQ =

For IHTYPE $\leq$ 5, ID of trip activating (tripping on) heat exchanger. ($2 \leq$ ITHTXQ ≤ 999)
For IHTYPE $\geq$ 6, ITHTXQ = 1000.

W3-I JVOL =

Control volume number. (If the pressurizer stratification model is used, JVOL must be the top pressurizer node.)

W4-I IHTYPE =

Type of heat exchanger option desired.
= 1, flow and temperature-dependent heat exchanger with constant secondary sink temperature. Volume mass flow must be nonzero.
= -1, temperature-dependent heat exchanger with constant secondary sink temperature.

= 2, flow and temperature-dependent heat exchanger with time-dependent secondary-sink temperature. A time versus temperature table is supplied by the user.

= 3, time-dependent heat exchanger. This option requires a table of time versus normalized power. The normalized power represents the fraction of total thermal power generated at any given time to be removed by the heat exchanger. The thermal power is the sum of the power added by core conductors, pumps, and nonconducting heat exchangers that add heat. Thermal power is not the power supplied on the 010005 input data.

= 4, time-dependent heat exchanger. This option requires a table of time versus power. Power represents the heat removal rate of the heat exchanger in megawatts and is not based on the fraction of power generated.

= 5, pressurizer heater model.

= 6, control system heat exchanger. Output of control blocks specified by IHTX determines the heat removal rate in units of normalized total thermal power.

= 7, control system heat exchanger. Output of control block specified by IHTX determines the heat removal rate in units of megawatts.

<u>If IHTYPE = -1, 1, or 2</u>

W5-R	HTQ	=	Fraction of power removed by heat exchanger
W6-R	TSEC	=	Secondary-side temperature (F)
W7-R	HTXCO	=	Heat transfer coefficient (Btu-sec/hr-F-lbm) for IHTYPE = 1 (Btu/hr-F) for IHTYPE = -1. If HTXCO is entered as zero, the program calculates the steady-state value of HTXCO as the heat removal rate divided by the product of initial flow and the temperature difference between the primary fluid and secondary fluid. If the heat exchanger is not tripped on at time zero, HTXCO must be nonzero. If initial flow is zero for IHTYPE = 1, the user must put in a nonzero value for HTXCO.

The program will always use the input value of HTXCO if it is nonzero.

If IHTYPE = 2

W8-R	HTXTBL(1)	=	Time (sec)
W9-R	HTXTBL(2)	=	Secondary temperature (F)
W10-R, W11-R,	HTXTBL(3), HTXTBL(4),	= =	Until IHTX points are entered, where time values are in ascending order.

If IHTYPE = 3 or 4

W5-R	HTXTBL(1)	=	Time (sec)
W6-R	HTXTBL(2)	=	Normalized power or power (MW)
W7-R, W8-R,	HTXTBL(3), HTXTBL(4),		Until IHTX points are entered, where time values are in ascending order.

If IHTYPE = 5

W5-R	QHTR	=	Pressurizer heat capability (kW)
W6-R	QTAU	=	Pressurizer heater time constant (sec)
W7-R	ELEVH	=	The pressurizer heater elevation. The pressurizer stratification model uses the elevation to determine the subnode the heater power will be added to.

If IHTYPE = 6 or 7

W5-R			Not used but must be supplied as 0.0.
W6-R			Not used but must be supplied as 0.0.

19.0 STEADY-STATE INITIALIZATION

The steady-state initialization option requires input data to identify the particular solution options that are to be invoked, to provide iteration and convergence control parameters, and to supply initial conditions. JSST = 0 on Card 01000Y activates the steady-state solution, which is active by default. The steady-state information provided on the data cards described in the following sections is optional.

19.1 Steady-State Initialization Convergence Criteria Data Card 230000

The steady-state initialization convergence criteria card is optional. If this card is not supplied, default values are employed if the steady-state option is active. The criteria used for the steady-state initialization are edited, as are all parameters computed for the steady-state condition. Any zero value supplied by a user is considered to be a flag specifying the default value is to be used. This card should not be supplied when steady state is not being used.

W1-I	LCOUNT	=	Maximum number of steady-state iterations. If a negative number is specified, execution will continue even if the convergence criteria for acceleration pressure, slip acceleration or vapor-phase mass error, and enthalpy are not met within |LCOUNT| iterations (default = 25).
W2-R	ACEPSI	=	Maximum junction acceleration pressure (psia) (default = 5.E-5).
W3-R	HEPSE	=	Maximum enthalpy error (Btu/lbm) (default = 5.E-6).
W4-R	EPSIM	=	Maximum mass imbalance (fraction) (default = 5.E-7).
W5-R	VEPSI	=	Maximum slip acceleration error (default = 5.E-5).
W6-R	EPSIMG	=	Maximum mass imbalance (fraction) for vapor phase (default = 5.E-5).

A value of 0 for any of the above fields leaves the default parameters unchanged.

19.2 Steady-State Power Removal System Data Cards 230XXY

These cards are optional when using steady-state initialization but should not be supplied if steady-state initialization is not used. The energy balance capabilities for steady state allow multiple PWR steam generators or BWR feedwater systems. This card allows the user to describe how the power generated in the system is to be removed and which junction enthalpy to bias to make power generation and removal rates equal. If the low power steam generator initialization option is used (JSST = 2 on Card 01000Y), additional input data are required from the 2350XY cards.

IHXQF on the heat conductor cards (150XXY series) is to be set equal to the steam generator number, IGGNUM (see below), it is used to model (Word 1 on Cards 230XXY). Y is a sequence number varying from 1 to 9. XX is the power removal system number ranging from 01 to 99.

W1-I	ISGNUM	=	A unique, arbitrary number assigned to the steam generator (also equal to IHXQF on the appropriate heat conductor Cards 150XXY). For a feedwater system, this variable should be set to 0.
W2-I	JBIAS	=	Junction number for which the enthalpy is to be biased. This junction must be a positive fill junction.
W3-I	JBAL	=	Outlet junction number for the power removal system (junction through which the power is removed).
W4-R	POWF	=	Fraction of the total thermal power removed by this steam generator or feedwater system. Sum of all POWF's on Cards 230XXY must be equal to 1.0.

19.3 Volume Initial Thermodynamic Conditions Cards 231XXX

Thermodynamic conditions input can be specified on either the 05XXXY, or 231XXX data cards. However, any specifications for values using the 231XXX data will override the corresponding 05XXXY data. Input specification via the 231XXX cards is recommended since the input structure is more intuitive. The 231XXX input data are required to specify the initial thermodynamic conditions for a five-equation nonequilibrium volume or a volume with a noncondensable gas.

The thermodynamic input for a fluid volume can consist of three cases:

- no thermodynamic input for a volume is supplied on these data cards which implies that steady-state initialization will compute the initial conditions,
- two or more thermodynamic variables are supplied on these data cards for a volume which completely specifies the initial fluid state, or
- one thermodynamic variable (either pressure or enthalpy) is supplied on these cards for a volume which implies that the fluid state is only partially specified and steady-state initialization will compute the initial conditions.

For Case 1, this data card is not necessary. For Case 2, use Table IV.19-1 as a guide for the proper input form. For Case 3 use Table IV.19-3 as a guide for the proper input form.

It is also possible to change previous specified volume input by using higher number 231XXX cards specifying the same volume. For example, if Card 231001 specifies input to Volume 5 and Card 231005 also specifies input to Volume 5, the input values on Card 231005 will override those on Card 231001 and any thermodynamic input (pressure, temperature, enthalpy, and/or quality) from Card 05005Y.

Table IV.19-1

Fluid Condition Specification for Volumes Using Equilibrium Equation of State - User Specifies Initial Fluid Properties

Volume Filled with Water Only (XNC = 0)

Conditions Present	Quantity Specification
Superheated Vapor	1) P>0.0, H>0.0, X=0.0, or 2) P>0.0, T>0.0, X=0.0.
Saturated Vapor	1) P=0.0, T>0.0, X=1.0, 2) P>0.0, T=0.0, X=1.0, or 3) P>0.0, H>0.0, X=0.0 (flag).
Saturated Liquid	1) P>0.0, T=0.0, X=-1.0 (flag), 2) P=0.0, T>0.0, X=-1.0 (flag), or 3) P>0.0, H>0.0, X=0.0 (flag).
Subcooled Liquid	1) P>0.0, H>0.0, X=0.0, or 2) P>0.0, T>0.0, X=0.0.
Two-Phase Mixture	1) P>0.0, T=0.0, 0.0<X<1.0, or 2) P=0.0, T>0.0, 0.0<X<1.0, or 3) P>0.0, H>0.0, X=0.0.
Separated Volume (0 < ZM < ZVOL) NOTE: X_m = quality of fluid below the mixture level	1) P>0.0, T=0.0, $0.0 \leq X_m < 1.0$, or 2) P=0.0, T>0.0, $0.0 \leq X_m < 1.0$, or 3) P>0.0, H>0.0, X=-1.0 (flag). (X_m input in X field)

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Table IV.19-1 (Cont'd)

Volume Contains Noncondensable (XNC≠0)

Conditions Present	Quantity Specification
Noncondensable Only	P>0.0, T>0.0, XNC=-1.
Vapor and Noncondensable	P>0.0, T>0.0, X=1.0 and 0.0<XNC<1 (XNC = humidity).
Liquid, Vapor, and Noncondensable	P>0.0, T>0.0, 0.0<X<1.0 and XNC=1.0 (flag).
Separated Volume (0 < ZM < ZVOL) NOTE: Xm = quality of fluid below mixture level	
Saturated NCG Over Saturated Liquid	P>0.0, T>0.0, 0.0<Xm<1.0, XNC=1.0 (flag). (Xm input in X field)
Accumulator Volume with NCG Over Liquid	P>0.0, T>0.0, XNC=1.0

where

P	=	pressure
T	=	temperature
H	=	enthalpy
X	=	quality (mass of gaseous mixture/total mass)
XNC	=	relative humidity or logic flag as described in the accompanying text
ZM	=	mixture level (bubble rise model)
ZVOL	=	volume height

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Table IV.19-2

Fluid Condition Specification for Volumes Using Nonequilibrium Equation of State - User Supplies Initial Fluid Properties

Conditions Present		Input Quantity Specification
Two-Phase Mixture		P>0.0, 0.0<X<1.0, T>0.0; liquid-phase temperature, or P>0.0, 0.0<X<1.0, HW>0.0 and equal to liquid-phase enthalpy
Liquid, Vapor, Noncondensable	1)	P>0.0, T>0.0, HW>0.0, 0.0<X<1.0 and XNC = 1.0 (flag), where T is the vapor temperature and HW is the liquid enthalpy
	or 2)	P>0.0, T>0.0, HW<0.0, 0.0<X<1.0 and XNC = 1.0, where T is the vapor temperature and HW is the liquid temperature

where

P = pressure
T = temperature
HW = enthalpy
X = quality (mass of gaseous mixture/total mass)
XNC = humidity flag

Table IV.19-3

Fluid Condition Specification for Volumes
Steady-State Computes Initial Fluid Properties

Volume Filled with Water Only (X_{nc} = 0) Equilibrium Volume

Conditions Present		Quantity Specification
Superheated Vapor		Any of the three below
Saturated Liquid		
Saturated Vapor	1)	P=0.0, H=0.0, (do not supply 231XXX data card)
Subcooled Liquid	or 2)	P>0.0, H=0.0, X=0.0 (flag),
Two-Phase Mixture	or 3)	P=0.0, H>0.0, X=0.0 (flag).
Separated Volume (0 < ZM < ZVOL)		Any of the three below
	1)	P=0.0, H=0.0, (do not supply 231XXX data card),
	or 2)	P>0.0, H=0.0, X=-1.0 (flag),
	or 3)	P=0.0, H>0.0, X=-1.0 (flag).

where
P = pressure (Word 2 - P)
H = enthalpy (Word 4 - HW)
X = utilized as a logic flag (Word 5 - X)

Volume Filled with Water Only (X_{nc} = 0) Nonequilibrium Volume

Conditions Present		Quantity Specification
Two-Phase		Do not supply 231XXX data card for this volume.
Superheated Vapor		Any of the three below
Saturated Liquid		
Saturated Vapor	1)	P=0.0, H=0.0, (do not supply 231XXX data card)
Subcooled Liquid	or 2)	P>0.0, H=0.0, X=0.0 (flag),
	or 3)	P=0.0, H>0.0, X=0.0 (flag).

Volume Filled with Noncondensable or Noncondensable and Water

Conditions Present	Quantity Specification
Noncondensable Only Vapor & Noncondensable Liquid & Noncondensable Liquid, Vapor, & Noncondensable	Partial specification of the state (P or H only) is not possible for these fluid conditions. Steady state initialization will compute the state. To specify a P, all other conditions, as noted in Tables IV.19-1 or IV.19-2, must be specified.

Words 2 through 6 of cards 231XXX are used to define the thermodynamic state of the volume specified in Word 1. The various input combinations for these variables are summarized in Table IV.19-1. Any combination of input may be used; however, care should be used to not overspecify the system when JSST = 0 or underspecify the system when JSST = 2 (JSST on card 01000Y). Any of the five thermodynamic condition input variables not specifically listed in Table IV.19-1 should be entered as zero. With respect to the noncondensable, care must be taken to assure a physically meaningful set of input. In particular, the input XNC parameter has three distinct meanings as follows.

- If XNC = -1, then the volume contains noncondensable gas only (no water).
- If $0 < XNC < 1$, then X_{nc} is interpreted as humidity (HUM) where $HUM = P_{vp}/P_{sat}(T)$ and P_{vp} = water vapor partial pressure.
- If XNC = 1, the humidity is 1.0 (required if liquid is present).

The first of these meanings provides a mechanism to specify noncondensable only. The second provides the user the ability to specify water vapor/noncondensables in terms of a commonly used parameter (humidity). The third permits the description of water/noncondensable mixtures for saturated noncondensable with liquid.

Five-equation volumes can be initialized to thermal equilibrium initial conditions using Table IV.19-1. However, if nonequilibrium initial conditions are desired, Table IV.19-2 should be used.

In addition, it should be noted that in any volume where a noncondensable gas is present on initialization, the thermodynamic state must be either described completely, or it must be left entirely to the RETRAN steady-state initialization process (all thermodynamic properties input as zero).

In the RETRAN-3D noncondensable models, the fluid volume can be in one of seven possible thermodynamic states. These states are:

- liquid only;
- vapor only;
- noncondensable only;
- liquid and noncondensable;
- vapor and noncondensable;
- vapor and liquid; and
- vapor, liquid, and noncondensable.

When noncondensable gases are present, the fluid components (liquid, vapor, and noncondensable) may be either in thermodynamic equilibrium (four-equation model) or nonequilibrium (five-equation model). If equilibrium, the thermodynamic conditions within any fluid volume can be determined from a subset of the five variables, pressure, temperature, enthalpy, quality, and relative humidity (or noncondensable mass fraction). If nonequilibrium, an additional variable, either liquid-temperature or liquid enthalpy, is required to define the thermodynamic state.

The input required for this card set are as follows. XXX may range from 000 to 999 and need not start at 000 and need not be consecutive. Data items following the last nonzero item can either be omitted or entered as 0. Zeros are entered for parameters not defined.

W1-I	LVOL	=	The volume number to which the initial condition specifications are to be assigned. It must be a legitimate volume number.
W2-R	P	=	Pressure (psia)
W3-R	TEMP	=	Temperature (F)
W4-R	HW	=	Thermodynamic enthalpy (BTU/lbm)
W5-R	X	=	Gas quality or mass fraction. Includes all noncondensable gases and steam that is present in the gaseous mixture.
W6-R	XNC	=	XNC = noncondensable gas specification = -1, volume contains only noncondensable (no water) 0 < XNC < 1, XNC = humidity of gaseous mixture 1 < XNC < 2, (XNC - 1) is the noncondensable mass fraction

19.4 Junction Initial Condition Specification Data Card 232XXX

The junction initial condition specification cards are used to supply initial conditions related to junctions. Initial conditions for options JESTW = 0 and 1 can be supplied on the particular junction data cards 08XXXY by using the WP and FJUNF variables. Mixtures of initial conditions specified using 08XXXY and 232XXX cards are acceptable, but might lead to confusion. Values specified on 232XXX cards have precedence over those input on 08XXXY cards. It is recommended that the 232XXX cards be used solely, since they isolate the junction initial conditions into a small set of data cards. This can be accomplished by moving the nonzero flows to 232XXX cards and then setting the values on the 08XXXY cards to zero. XXX (on 232XXX card) is a sequence number ranging from 001 to 999. It need not start at 001 and need not be consecutive.

For three-dimensional core models, individual fuel assembly flow fractions are available from the CDI file and will be used by default. Card 67000Y can be used to define the total core flow

and the 672XXX card can be used to redefine the RETRAN lumped channel flows fractions as an option. Furthermore, these lumped channel model flows can be used as is to define flow initial conditions, or as estimates to start the flow split option. The flows defined by the channel model are applied to the inlet junctions.

232XXX cards can be used to override channel model definitions for individual junctions. 232XXX cards take precedence over the channel model values. When overriding channel model flows, remember that they are specified for the inlet junctions. If a 232XXX card is used to define the flow for a junction other than the inlet, a mass imbalance will occur. The junction numbers for channels are assigned automatically, where (1000*NCH + 1) is the inlet junction and (1000*NCH + NAX + 1) is the outlet. NCH is the channel number and NAX is the number of axial nodes.

A major purpose of the 232XXX cards is to define the steady-state flow split model. In general, the model involves the calculation of the flows for a set of parallel flow paths that have a common upstream and downstream boundary volumes. For each of the flow paths, a so-called orientation junction must be defined by assigning JESTW = 2 on a 232XXX card. An orientation junction is the start of a flow calculation path and it originates from the upstream boundary volume. For example, to define flow splits for a multiple parallel channel BWR core, the lower plenum should be the upstream boundary volume, the upper plenum should be the downstream boundary volume, and the core inlet junction of each channel should be defined as an orientation junction.

The junction initial condition data cards are used to define consistent initial conditions. In the case of FIBWR junctions, they are used to supply initial estimates of the channel, water rod, leakage, and bypass flows. For these estimates, JESTW = 2 should be used, but the plenum volume number data is not needed. The total core flow can be specified by setting JUN = -1 and JESTW = 0. If this card is not present, the core pressure drop boundary condition (described below) is assumed applied.

For the core pressure drop boundary condition, it is assumed that the lower and upper plenum pressures are known either through direct specification or by propagation from the system model specification. The active core and bypass channels are not legitimate paths for the pressure propagation. The core pressure drop boundary condition is not a proper boundary condition when a system is modeled, i.e., the excore components that connect the two plenums are modeled. In these connecting regions, the flows will be specified. They will define the flows out of the upper plenum and into the lower plenum. The core pressure drop will define the flows out of the lower plenum and into the upper plenum. It will be fortuitous if these flows yield mass balances in the plenums. A loss coefficient can be tuned to give a mass balance, but this will require a manual user adjustment (probably an iterative one). The core pressure drop boundary condition was originally intended for applications where the plenums are the boundaries of the model.

When the total core flow boundary condition is applied, the upper plenum pressure must be known, either by direct specification or by propagation, but not through the active core or bypass channels. The lower plenum pressure is obtained by propagating the pressure from the upper plenum down through the bypass channel. The active channel (and water rod) pressures are

obtained by propagating the lower plenum pressure upward to the upper plenum. The bypass flow is obtained by subtracting the active channel exit flows from the total flow specified on Data Card 232XXX.

Data items following the last nonzero item can be omitted.

W1-I	JUN	=	The junction number associated with the following initial conditions.
W2-I	JESTW	=	Initial condition option flag. = 0, a junction flow initial condition is specified in WP. = 1, calculate the loss coefficient for junction JUN (equivalent to FJUNF = -1.0). A value for WP can also be supplied. If it is not supplied, it must be possible to propagate a value from the continuity equation and flow initial conditions for other junctions. = 2, calculate the flow for junction JUN using the flow split feature. The estimated flow can be supplied in WP, or it can be obtained from other flow specifications. For example, it can be obtained from the channel initial conditions obtained from the CDI file, the total flow specified on Card 67000Y, or individual channel flows from Cards 672XXX. It also can be propagated from a flow initial condition for another junction and the associated continuity equations.
W3-R	WP	=	Junction mass flow rate (lbm/sec). For JESTW < 2, nonzero values of WP are treated as fixed flow initial conditions. For JESTW = 2 and JUN is not part of a FIBRW channel, nonzero values of WP are treated as flow estimates for the flow split option (default = 0.0).
W4-R	SPLTV1	=	Volume number corresponding to the upstream boundary pressure (P1). Required if JESTW = 2 and JUN is not part of a FIBRW channel, otherwise omit.
W5-R	SPLTV2	=	Volume number corresponding to the downstream boundary pressure (P2). Required if JESTW = 2 and JUN is not part of FIBRW chanel, otherwise omit.

19.5 Low Power Steam Generator Steady-State Initialization Input Cards 2350XY

These cards are required only if the low power initialization option (JSST = 2 on Card 01000Y) is being used. When any other steady-state option is used, these cards should not be supplied. X

is the steam generator number (Word 1 on Card 230XXY) and Y is a sequence number that can range from 0 to 9.

The standard steady-state initialization option will adjust the steam generator conductor areas to achieve the correct total energy transfer rate. In some instances, particularly for low power initialization, the amount of the heat transfer surface area adjustment may be unacceptable. In addition, the heat conduction solution is not solved simultaneously with the energy, momentum and dynamic slip equations which can cause steady-state convergence problems in the steam generator.

In the low power steady-state solution scheme, the steady-state heat conduction and fluid equations are solved together in finite difference form. With this option the steam generator heat conductor area will not be adjusted. However, either the secondary-side pressure or inlet enthalpy to the secondary tube bundle will be adjusted (based on user selection) to achieve an overall primary to secondary energy balance.

There are some practical limitations as to how much influence either the pressure adjustment or the inlet enthalpy adjustment will have on the overall energy balance and the user must supply reasonable estimates for initial conditions and must have reasonable expectations of this scheme. As an example, if the shell side of the tubes is mostly two phase, a secondary-side pressure adjustment will have the most direct influence on the heat transfer rate since the pressure determines the secondary temperature. An enthalpy adjustment would have some effect but it would be much less than pressure adjustment. Consequently, pressure would be the logical choice for the code to adjust. There is a practical limit to how much the pressure can be adjusted to change the heat transfer rate. If the pressure is increased to the point that all the fluid is subcooled, further adjustment would be meaningless. If this occurs, the user must review the consistency of the input.

If the shell side is mostly subcooled liquid or superheated vapor, the logical choice for the user is to allow the code to adjust bundle inlet enthalpy since it would have a direct effect on secondary temperature. In this situation, pressure adjustment would have only a minor influence on the energy transfer rate. Consequently, it is incumbent on the user to select the appropriate parameter for adjustment and to review the amount of adjustment to be sure it is reasonable.

The user has the option to provide an initial estimate of the fraction of the total power that is removed from the primary system by each conductor or to use an initial estimate based only on the ratio of the conductor heat transfer area to the total steam generator heat transfer area. The area ratio approach is generally adequate for full power conditions in U-tube and once-through steam generators (UTSG and OTSG) and in some intermediate UTSG cases. An initial estimate based on the expected energy removal fractions is generally required for low power OTSG cases. When the user supplies the initial estimate of the energy removal profile, the data are supplied on a conductor-by-conductor basis, beginning with the conductor at the inlet entrance of the primary side and continuing sequentially through to the exit. For OTSG, this is the conductor at the top of the conductor stack. For UTSG, the first conductor is the one associated with the bottom bundle region volume on the secondary side.

There are no specific limitations related to volume and conductor numbering. Logic within the model will determine the solution order for the heat conductor and primary volumes by first identifying the primary inlet volume and associated heat conductor and then moving to the volume downstream. As such, the heat conductor solution order will be determined by the order of the associated primary volume. This allows UTSG tube regions to be split into two vertical stacks for use with the local condition model.

With this option, the user specifies the type of steam generator being modeled, whether the secondary pressure or bundle inlet enthalpy is to be adjusted, the volume number in which the secondary pressure is supplied and an optional initial estimate for energy transfer distribution through the steam generator conductors.

W1-I	ISGTYP	=	0, OTSG 1, UTSG
W2-I	IPHFLG	=	0, bundle inlet enthalpy adjusted 1, secondary pressure adjusted
W3-I	IPVOL	=	Secondary-side volume number in which the pressure is input. NOTE: The user can input pressure in only one volume per steam generator if IPHFLG = 1.
W4-R	SGFRAC(1)	=	Normalized energy transfer rates through each conductor in this steam generator. These quantities are used as initial estimates to start the steady-state initialization iterations. These parameters are optional and if they are not supplied, the code will default to using ratios of individual heat conductor area values to the total steam generator heat transfer surface area for the estimate. If supplied, the NC values of SGFRAC are normalized so they sum to 1.0.
W(4+NC)-R	SGFRAC(NC)=		NC is the number of conductors in this steam generator.

19.6 RETRAN Off-Rated Power Initialization Procedure

The RETRAN Off-Rated Power Initialization Procedure (ORIP) is designed to simplify the process of initializing a U-tube PWR model at different power levels. Tables of key parameters as a function of percent power are used to calculate the initial conditions for a user-specified power level. This model performs outer loop steady-state calculations to converge on key parameters that would otherwise require multiple manual steady-state calculations. The calculated initial conditions can then be used to begin a transient calculation directly, or be specified as initial conditions in the normal manner in an input deck which then does not require this model to be activated. A table of the calculated parameters are printed in the output file at the beginning of the steady-state results output.

Tables of key parameters as a function of percent power are required. The RETRAN General Data Table Cards (12XXYY) are used for this input. Input provisions have been made to allow application of a bias to many of the parameters supplied by the tables. Thus, for these parameters, an uncertainty can be independently applied to a specific parameter without changing the table lookup value for the other parameters.

The ORIP includes two additional models. The user has the option of having the code adjust the steam generator pressure to minimize the steam generator tube heat transfer area adjustment that is normally preformed by RETRAN steady state to achieve a primary-to-secondary energy balance. The target for this model is to eliminate the area adjustment of the heat conductors representing the secondary side of the SG U-tubes. The user also has the option of activating a model that adjusts the RCS pump rated torque to achieve a user-specified value for the total power added to the coolant from the RCS pumps.

Input for the ORIP procedure must be consistent with the initial condition specification requirements of the standard initialization method. For example, flow specifications must be adequate to define all flow splits and they must sat5isfy the continuity equation. Loss coefficients must be computed for parallel flow paths and somewhere in each loop. The RCS and steam generator pressures and enthalpies must also be supplied.

Initialization of a model at different power levels may result in steady-state error or warning messages. For example, the reduced flow rates may result in calculation of a negative loss coefficient. Or inconsistencies in the supplied power dependent input may result in a bad enthalpy or energy imbalance. Some user intervention may be required. Guidelines and suggestions are provided in Section 19.7.

The RETRAN data cards for the off-rated power initialization procedure are divided into four sections. Cards 236000 and 2360XY activate the model and define the general options and volume/junction mapping input. Cards 237000 and 2370XY allow the users to specify the flow rate for leakage and bypass junctions as a fraction of RCS flow (primary) or steam generator feedwater flow (secondary). Cards 238000 and 2380XY activate a model for adjusting the primary specified enthalpy and loop flows to achieve target values for total RCS volumetric flow and loop average temperature. A model to achieve a target steam generator secondary level or mass inventory is activated by supplying the data on Cards 2390XY.

19.6.1 General Options and Primary Side Parameters Data Card 23600Y

Only one data record is required for the 23600Y cards where Y is a sequence number. At least one data item must be supplied on the 23600Y card. Items not supplied will default to 0 unless noted otherwise.

W1-R	FULPOW	=	Nominal full core power (MW). This value is compared to power specified on the Initial Power Data Card 010005 to determine the percent power used as the independent variable for general table parameter lookup.

W2-I	IEBAL	=	Energy balance option. = 0, Off - adjust steam generator heat transfer surface area for energy balance. = 1, On - adjust steam generator pressure to achieve energy balance.
W3-R	PPOWER	=	Pump power adjustment option. = 0.0, Do not adjust pump rated torque. > 0.0, Enter desired target total pump power (MW).
W4-I	IPZR	=	Pressurizer volume number. Used for specification of pressurizer pressure and level. Enter as 0 if neither the pressurizer pressure nor level are functions of power (see IGTPRS and IGTPZL below).
W5-I	ITVJUN	=	Turbine control valve junction number. Used for specification of total steam flow. Enter 0 if flow specification is not required. Enter a negative value if the flow specification requires a negative flow specification (negative fill).
W6-I	IGTPRS	=	General data table number for pressurizer pressure (psia) as a function of percent power. If IGTPRS = 0, the pressurizer pressure will not be set by the initialization procedure.
W7-I	IGTPZL	=	General data table number for pressurizer level (ft) as a function of percent power. If IGTPZL = 0, the pressurizer level will not be set by the initialization procedure.
W8-I	ITOLIM	=	Maximum number of steady-state outer loop iterations. (Default = 25.)

The following three words are optional. This input allows the user to perform a sensitivity analyses where specific parameters are biased without modifying the other table lookup values used for initialization. Initial conditions specified will be the table lookup value plus the bias supplied below.

W9-R	BIAPOW	=	Power bias to be applied to power specified on the Initial Power Data Card 010005 (MW).
W10-R	BIAPRS	=	Pressure bias to be applied to table lookup for pressurizer pressure (psia).
W11-R	BIALEV	=	Level bias to be applied to table lookup for pressurizer level (ft).

19.6.2 Secondary Side Loop Parameters Data Card 2360XY

For the 2360XY cards, one card must be supplied for each steam generator modeled. The X corresponds to the steam generator (or RCS loop) and should be consistent with the steam generator number (ISGNUM) supplied on the Steady-State Power Removal Data Cards (230XXY). X is the steam generator number (Word 1 on Card 230XXY) and can range from 1 to 4. Y is a sequence number that can range from 0 to 9. One card is required for each loop modeled. At least the first word item must be supplied for each steam generator. All others will default to 0.

W1-I	ISGVOL	=	Steam generator head volume number used for specification of specify the secondary pressure.
W2-I	IRRJUN	=	Recirculation path junction number used for specification of recirculation flow. Junction should correspond to the flow path from the upper downcomer separated volume to the lower downcomer. Enter as zero if IGTSGR = 0.
W3-I	IFWJUN	=	Main feedwater junction number used for specification of feedwater flow. Enter as 0 if IGTFWS = 0.
W4-I	ISTJUN	=	Steam flow junction number used for specification of steam generator steam flow. Enter as 0 if IGTFWS = 0.
W5-I	IGTSGP	=	General data table number for steam generator pressure (psia) as a function of percent power. If IGTSGP = 0, the steam generator pressure will not be set by the initialization procedure.
W6-I	IGTSGR	=	General data table number for steam generator recirculation as a function of percent power. If IGTSGR = 0, the steam generator recirculation flow will not be set by the initialization procedure.
W7-I	IGTFWS	=	General data table number for steam generator feedwater/steam flowlbm/sec) as a function of percent power. If IGTFWS = 0, the pressurizer level will not be set by the initialization procedure. Must be 0 if IFWJUN > 0; otherwise, = 0.

The following words are optional. This input allows the user to apply an uncertainty to the table lookup value for steam generator feedwater/steam flow and pressure. The initial conditions specified will be the table lookup value plus the bias supplied below.

W8-R	BIAWSG	=	Flow bias to be applied to table lookup for steam generator feedwater/steam flow (lbm/sec).

W9-R	BIAPSG	=	Pressure bias to be applied to table lookup for steam generator pressure (psi).

19.6.3 Additional Junction Flow Specifications Data Card 2370XY

The additional junction flow specification cards are optional unless the RCS flow calculation option is used (see Card 23800Y). These data cards allow specification of bypass, leakage path, and other flow split specification flow rates as a fraction of RCS mass flow (Card 23700Y) or steam generator feedwater mass flow (Cards 2370XY). These specifications replace those that would be provided on the 23XXXY cards or the Junction Cards 08XXXY.

19.6.3.1 Additional Primary Junction Flow Specifications Data Card 23700Y.

These cards require the use of the automated RCS flow/T-average model (Cards 23800Y and 2380XY). X = 0 when making flow specifications for the primary system. Y is a sequence number.

W1-I	IAPJUN(1)	=	Junction number where flow rate is to be specified.
W2-R	RAPFRC(1)	=	Mass flow rate as a fraction of RCS flow.

IAPJUN and RAPFRC are repeated until the desired number of junction flow specifications have been entered.

19.6.3.2 Additional Secondary Junction Flow Specification Data Card 2370XY.

The additional secondary junction flow specification data card is used to specify flow specifications or splits for secondary volumes for a given steam generator. These flows that would be provided replace those on the 232XXX cards or Junction Cards 08XXXY. X is the steam generator number (Word 1 on Card 230XXY) and can range from 1 to 4. Y is a sequence number that can range from 0 to 9. One card should be supplied for each steam generator loop modeled where additional flow specifications are needed.

W1-I	IASJUN(1)	=	Junction number where flow rate is to be specified.
W2-R	RASFRC(1)	=	Mass flow rate as a fraction of steam generator feedwater flow.

IASJUN and RASFRC are repeated until the desired number of junction flow specifications have been entered.

19.6.4 RCS Flow and Average Temperature Model Data Card 23800Y

The RCS flow and average temperature model is optional and is activated by addition of Cards 23800Y and 2380XY. The model sets the RCS loop flows to achieve a target value for the total RCS volumetric flow rate. The model also adjusts the core inlet enthalpy to achieve a target average loop temperature. The calculated average loop temperature is a loop flow weighted average of the loop hot and cold leg temperatures. This input is required in the target steam generator level/mass inventory model is to be used (Card 2390XY).

19.6.4.1 RCS Flow and Average Temperature General Parameters Data Card 23800Y.

The 23800Y card defines the lower plenum volume where the enthalpy is defined and the RCS volumetric flow and core average temperature as a function of power. At least three items must be supplied.

W1-I	ILPVOL	=	Lower plenum volume number used for specification of the primary-side enthalpy.
W2-I	IGTWRS	=	General data table number for target RCS volumetric flow rate (GPM) as a function of percent power.
W3-I	IGTTAV	=	General data table number for target RCS average loop temperature (^{o}F) as a function of percent power.

The following two words are optional. This input allows the user to apply a uncertainty to the target value of the RCS flow or loop average temperature. Target values will be the table lookup value plus the bias supplied below.

W4-R	BIAWRS	=	Flow bias to be applied to the table lookup for the RCS volumetric flow (GPM).
W5-R	BIATAV	=	Temperature bias to be applied to table lookup for average loop temperature (^{o}F).

19.6.4.2 RCS Flow and Average Temperature Loop Parameters Data Card 2380XY.

X is the steam generator number (Word 1 on Card 230XXY) and can range from 1 to 4. Y is a sequence number that can range from 0 to 9. One card should be supplied for each steam generator loop modeled. Four items must be supplied for each steam generator.

W1-R	RLPFRC	=	Fraction of the RCS flow rate that is to be applied to this steam generator loop.

W2-I	IPOJUN	=	Pump outlet junction number used for loop flow specification (typically hot leg inlet or pump exit).
W3-I	IHLVOL	=	Hot leg volume number used for determination of loop average temperature.
W4-I	ICLVOL	=	Cold leg volume number used for determination of loop average temperature.

19.6.5 Target SG Level / Mass Inventory Model Parameters Data Card 2390XY

The target steam generator level/mass inventory model is optional. Addition of Card 2390XY activates a model that initializes each steam generator to achieve a target value of level or mass inventory. The model adjusts the lower downcomer enthalpy and upper downcomer level to achieve a target level or mass. The calculated value for the adjustment (level or mass) is defined by a user-defined control system.

X is the steam generator number (Word 1 on Card 230XXY) and can range from 1 to 4. Y is a sequence number that can range from 0 to 9. One card should be supplied for each steam generator loop modeled.

W1-I	ILDVOL	=	Steam generator lower downcomer volume number used for specification of the secondary-side enthalpy.
W2-I	IUDVOL	=	Steam generator upper downcomer or combined separator/upper downcomer volume number used for specification of the downcomer level. Volume IUDVOL should be separated or bubble rise volume.
W3-I	IGTMAS	=	General data table number for target steam generator level or mass inventory as a function of percent power (same units as output of ICOUTM).
W4-I	ICOUTM	=	Control block identifier for the calculated value of steam generator level or mass inventory.
W5-R	BIAMAS	=	Bias to be applied to the table lookup for the target steam generator level or mass. Enter 0.0 if a bias is not desired.

19.7 Off-Rated Initialization Power Procedure User Guidelines

In order to use the ORIP procedure, the initial condition specifications must be consistent with the initial condition specification requirements of the standard initialization method. Where flows are specified on the 232XXX (or 08XXXY) cards for the standard initialization they will be specified using the flow fractions on the 23700Y, 2370XY, and 2380XY cards for the ORIP

procedure. If flows are specified on 232XXX (or 08XXXY) cards and are not overridden by specification on the ORIP cards, mass imbalances may occur. Similarly, the ORIP cards should be used to specify the RCS and steam generator secondary pressures and enthalpies. Some input specifications in the model may have to be revised to be consistent with the ORIP procedure input.

It is suggested that the user set up the RETRAN model using the standard initialization method with initial conditions specified at the desired locations prior to adding the ORIP procedure input. Table IV.19-4 lists the volume and junctions specified in the off-rated power initialization input.

Table IV.19-4

Initial Condition Specification Locations

Parameter	Component	Location	Variable	Data Card
RCS Pressure	Pressurizer	Volume	IPZR	23600Y
Pressurizer Level	Pressurizer	Volume	IPZR	23600Y
Turbine Flow	Turbine Valve	Junction	ITVJUN	23600Y
SG Pressure	SG Head	Volume	ISGVOL	2360XY
Recirculation Flow	Recirc. Path	Junction	ISTJUN	2360XY
Feedwater Flow	Feedwater	Junction	IFWJUN	2360XY
Steam Flow	Steam Path	Junction	IFWJUN	2360XY
Primary Flows	Leakage / Bypass	Junction	IAPJUN	23700Y
Secondary Flows	Leakage / Bypass	Junction	IASJUN	2370XY
Core Enthalpy	Lower Plenum	Volume	ILVOL	23800Y
Loop Flow Rate	Pump Outlet	Junction	IPOJUN	2380XY
SG Enthalpy	Lower Downcomer	Volume	ILDVOL	2390XY
SG UD Level	Upper Downcomer	Volume	IUDVOL	2390XY

The hot and cold leg volume numbers, IHLVOL and ICLVOL, are also supplied on Data Card 2380XY. These are used to calculate the RCS average temperature and are not used for specifying an initial condition.

Power dependent input is supplied as a function of percent power using the RETRAN-3D General Data Table Data Cards (12XXYY). Required data tables are given in Table IV.19-5.

For secondary parameters (Items 5 through 8 above), the same table can be used for each steam generator modeled, or different tables can be provided. Using different tables allows the

modeling of single versus lumped loops, and also can be used to model steam generators operating under different conditions.

The input for the target steam generator level/mass inventory model requires the user to input a control block identifier (ICOUT, Card 2390XY) for the control system for either the steam generator level or mass inventory. The user defines the target parameter (level or mass inventory) by this input selection, and the units for the target steam generator level/mass inventory (Item 8, Table IV.19-5) should be consistent with the control system output.

The ORIP procedure has provisions for varying specific parameters without changing the other power-dependent data. This allows the user to perform sensitivity studies or to specify a conservative parameter value. RETRAN will first obtain the parameter value from the power-dependent data table (Table IV.19-5) then the bias will be applied. Bias variables available are summarized in Table IV.19-6.

The bias applied the steam generator pressure will only be used for the initial guess for steam generator pressure if the energy balance option is activated (IEBAL = 1, Card 23600Y).

Table IV.19-5

Power-Dependent Data

Item	Parameter	Units	Variable	Data Card
1.	Pressurizer Pressure	psia	IGTPRS	23600Y
2.	Pressurizer Level	ft	IGTPZL	23600Y
3.	RCS Tavg	°F	IGTTAV	23800Y
4.	RCS Volumetric Flow	gpm	IGTWRS	23800Y
5.	Steam Generator Pressure	psia	IGTSGP	2360XY
6.	Steam Generator Recirculation Ratio	-	IGTSGR	2360XY
7.	Steam Generator Feedwater/Steam Mass Flow	lbm/sec	IGTFWS	2360XY
8.	Target Steam Generator Level or Mass Inventory	ft or lbm	IGTMAS	2390XY

Table IV.19-6

Bias Variables

Parameter	Units	Variable	Data Card
System Power	MW	BIAPOW	23600Y
RCS Pressure	psia	BIAPRS	23600Y
Pressurizer Level	ft	BIALEV	23600Y
Steam Generator Feedwater/Steam Flow	lbm/sec	BIAWSG	2360XY
Steam Generator Pressure	psia	BIAPSG	2360XY
RCS Volumetric Flow	gpm	BIAWRS	23800Y
RCS Average Temperature	°F	BIATAV	23800Y
Target Steam Generator Level/Mass	-	BIAMAS	2390XY

19.7.1 General Options and Primary-Side Parameter User Guidelines

The parameters on the General Options and Primary-Side Data Card include mapping variables and option activation. Guidelines for some of these variables are discussed below.

W1-R FULPOW = The nominal full core power (MW) is input for this parameter. The power level is input in the normal manner on the Initial Power Data Card 010005. The percent power used for table lookup is calculated by dividing the initial power by this parameter. Note: the power bias (BIAPOW) is applied after the percent power is calculated.

W2-I IEBAL = This energy balance option is activated by setting IEBAL = 1. The steam generator pressure is adjusted to minimize the change in tube heat conductor area performed by steady state. The target for this model is zero area adjustment on the secondary side. A minimal area adjustment may still occur on the primary side of the heat conductors. Convergence of this model may require that the maximum number of steady-state iterates be increased (LCOUNT, Card 230000). LCOUNT is usually set to a value slightly greater than required for the standard steady-state solution method to converge. If the energy balance option is activated, approximately 20 iterates should be added to the value of LCOUNT.

W3-R	PPOWER	=	The pump power adjustment option is activated when this variable is greater than zero. The desired total pump power (sum of all RCS pumps) should be entered in units of MW. A multiplier will be applied to the pump rated torque in order to achieve the specified pump power. The same multiplier will be applied to all pumps. The pump power multiplier and resulting pump torque for each pump will be reported in the off-rated power summary in the output file.
W5-R	ITVJUN	=	The turbine stop valve junction number should be supplied if the RETRAN model requires that the total steam flow be specified at a junction. RETRAN will set the flow to the sum of the steam flows for all the steam generator loops, as defined by General Table IGTFWS on Card 2360XY. The negative of this junction number should be entered if the flow needs to be specified as a negative number. This may be required if the total steam flow is modeled as a negative fill.
W8-I	ITOLIM	=	The ORIP procedure performs multiple (outer loop) steady-state calculations to achieve convergence. The maximum number performed before the procedure aborts (if convergence has not been achieved) is specified by this parameter. In general, a value of 25 iterates is sufficient to achieve convergence.

19.7.2 Additional Junction Flow Specifications User Guidelines

The parameters on these cards allow the user to specify flow rates that are not specifically defined in the ORIP procedure, i.e., the RCS loop flows. Dependent on the complexity of and configuration of the RETRAN model, additional flow specification may be required to define the flow for parallel paths due to leakage or bypass flows. Common usage in the reactor vessel is for core, head, and nozzle bypass channels. If the steam generator model has the separator and upper downcomer modeled as separate RETRAN volumes, the steam bypass flow from the upper downcomer will need to be defined.

The additional RCS junction flow rates are not defined as a function of percent power, put rather as a fraction of the RCS flow on the primary side, and as a fraction of the feedwater flow on the secondary side. Note that the steam generator number in the card designation (X in 2370XY) defines which feedwater flow to use.

19.7.3 RCS Flow and Average Temperature User Guidelines

The RCS flow and average temperature model adjusts the core lower plenum enthalpy and loop flow rates to achieve power-dependent specifications of RCS volumetric flow and average temperature. The two parameters are combined due to the dependency of the cold leg density (used to convert volumetric to mass flow) on the RCS enthalpy (adjusted to achieve the specified average loop temperatures). The input of the hot and cold leg volume numbers is used to calculate the flow weighted average temperature.

19.7.4 Target Steam Generator Level/Mass Inventory Model User Guidelines

The target steam generator level/mass inventory model adjusts the steam generation lower downcomer enthalpy and upper downcomer level to achieve a power-dependent target value. The user defines whether the level or mass inventory target is used by the selection of the control block identifier specified for parameter ICOUTM. The units of the control block must be consistent with the target value defined by the general data table defined by parameter IGTMAS. Each steam generator requires a different input card and each loop calculation is performed independently. Thus, both lumped and single-loop steam generators can be modeled, and steam generators can be initialized at a different target level or mass.

If the target mass or level cannot be achieved by lowering the downcomer enthalpy, the model will adjust the upper downcomer level. When the limit on enthalpy adjustment is encountered, the quality at the recirculation junction begins to approach zero. The model will maintain a near zero quality at the recirculation junction and raise the downcomer level to reach the target level or mass. If the target cannot be achieved, the output will reflect the maximum level or mass achieved.

19.7.5 Steady-State Convergence Problems User Guidelines

The ORIP procedure may converge on the specified target values, but steady-state convergence may fail. Also, the procedure may abort due to a fatal steady-state error. Suggestions and guidelines for specific steady-state errors are provided in this section.

19.7.5.1 Negative Loss Coefficient Calculated.

The most common steady-state error encountered using the initialization procedure, is a negative junction loss coefficient in the steam generator. As the power level changes, flow and density changes result in different calculated pressure differentials which can result in calculation of a negative loss coefficient. The type of corrective action required is dependent on the location of the junction and the model configuration.

Often, a negative loss coefficient will occur at the junction between the separator and upper downcomer volume (if these regions are modeled separately). There are several methods for

changing the magnitude of the calculated loss coefficient. The driving head from the separator can be increased by raising the separator mixture level. Also, the user can modify the steam flow split from these two volumes. A reduction in the steam flow bypass from the upper downcomer to the head tends to increase the calculated loss. Also, the unspecified loss for this parallel path can be moved from the separator-to-downcomer junction to the separator steam outlet.

A negative loss coefficient at other locations in the steam generator recirculation loop usually requires a reduction in a specified junction loss coefficient. Alternately, the location of the unspecified loss coefficient can be moved to a junction where a large coefficient has been specified.

19.7.5.2 No Power Available for Removal by Steam Generator.

This message, when encountered, usually occurs when initializing at a low power level. If the primary-to-secondary temperature differential is small or negative, little or reverse heat transfer may be predicted across the steam generator tubes. At low power, a small increase in the specified value for the RCS average temperature (General Table IGTTAV) should eliminate this problem.

19.7.5.3 Error Evaluating Junction Properties (Bad Enthalpy at Feedwater Junction).

The RETRAN steady-steady solution adjusts the enthalpy at the feedwater junction fill to achieve a system energy balance. Occasionally, the calculated junction enthalpy will be out of range of the steam properties and this error message will be displayed. The enthalpy may be correct for the specified boundary conditions (i.e., core thermal power, steam flow, etc). This error usually occurs at low power levels where the RCS pump power may be a significant portion of the system power addition. This problem can usually be corrected by small adjustments to the specified steam flow or by modifying the pump power (see pump power option, PPOWER on Card 23600Y). This error can also occur if wet steam is exiting the separator or upper downcomer steam junction. This maybe the result of modeling the steam junction as a vertical junction (JVERT = 1, Card 08XXXY). If the mixture level is within the vertical region defined by the junction diameter, the volume mixture level does not have to reach the junction elevation before carryover is predicted. Setting JVERT to 0 for the steam outlet junction will prevent this from occurring.

19.7.5.4 Energy Convected Out of Separated Volume Exceeds the Energy Convected In.

This error message can occur in a bubble rise volume. For the ORIP procedure, this message usually indicates that the enthalpy of the incoming fluid is lower than that necessary to support any carryunder (i.e., the quality of the recirculation path has dropped to zero). The target steam generator level/mass inventory model of the ORIP procedure adjusts the steam generator lower

downcomer enthalpy to achieve the target level or mass. The model monitors the quality at the recirculation junction to try and prevent this condition. But, under some circumstances, the error may be encountered. This usually occurs when the separator and upper downcomer are modeled as separate RETRAN bubble rise volumes. At low powers, the quality of the separator volume recirculation path may fall to zero before the upper downcomer. The quality at the separator recirculation path is partially a function of the junction elevation (with respect to the bottom of the volume) and the value of the bubble gradient parameter (ALPH, Card 060XXY). Lowering the bubble gradient slightly may prevent the error from occurring.

19.8 Pressurizer Steady-State Initialization Option

The pressurizer steady-state initialization option allows the pressurizer spray flow to be determined from a specified initial heater power. It includes the affects of wall condensation associated with environmental heat loss, cooling of the liquid region, inter-region heat transfer, and rainout if these processes are include in the input model. The energy and mass transfer to the liquid region from the spray and condensation mass flow rates is balanced by pressurizer heater induced flashing. The pressurizer initialization feature works as a stand alone option that will be updated once each steady-state iteration for the system balances equations.

During steady-state operation, the spray valve is normally closed but there is leakage flow passing through it. When the transient begins, the valve can be opened to increase the flow as determined by a control system. The new steady-state initialization will compute the leakage area required to give the computed spray flow, while balancing the pressure drop across the spray line. A special valve is required for steady-state initialization. W-1 on Valve Data Card 11XXX0 can be set to be a special spray valve.

The pressurizer steady-state initialization feature, will be activated when the spray junction flow is specified on the input and the steady-state initialization option is activated. W-20 ISP on Junction Data Cards 08XXXY can be set to 1 to activate pressurizer steady-state initialization.

Two-sided conductors may be used to model the pressurizer vessel environmental heat losses. The left boundary volume to the conductor is the pressurizer and the appropriate liquid and vapor region dependent properties are determined using the local condition model. The right boundary will typically be a time-dependent volume.

19.8.1 Pressurizer Thermal Stratification Initialization Option

Pressurizer thermal stratification option requires subnode specification for steady-state initialization. When the steady-state initialization option is not used, all subnodes (active and inactive) pressure and enthalpies must be defined such that, volumes below the mixture level are subcooled with enthalpy value same as liquid region enthalpy (one way to achieve this is to calculate hydrostatic pressure head in each subnode and specify the enthalpy the same as liquid regions enthalpy). Similarly, all subnodes above the mixture level must be defined such that the quality is one. For the case where steady-state initialization is used, specifying only the enthalpy

in the subnodes is sufficient (the pressure will be calculated by steady state and steady-state convergence will be achieved). A subcooled temperature gradient can also be established in the subnodes below the pressurizer by using the 231XXX volume initial condition data cards. The initial conditions for the pressurizer region will be determined from conditions either input or calculated for node N.

All mesh enthalpies for the temperature transport delay time model will be initialized to the corresponding node enthalpy as is currently done for single-phase nodes.

The requirements specified above apply for both situations where subnodes are created manually or using the automatic subnodalization option.

20.0 ONE-DIMENSIONAL KINETICS OPTION

The one-dimensional kinetics model is a one-dimensional, two-energy group, one-dimensional kinetics model. It is selected by setting NODEL = 2 on the problem description card (01000Y). The one-dimensional kinetics model provides the ability to model one-dimensional spacial kinetics effects of a reactor core. The fission energy is divided into prompt and delayed components and can be split between internal heat generation in a fuel rod and direct moderator heating (Cards 1440XX and 1450XX). A complete discussion of this model is given in Chapter V of Volume 1: Theory and Numerics.

RETRAN-3D uses the multi-state control rod model. A one-dimensional neutronics data file must be supplied along with the pertinent data cards. This file must be in character format and must be defined as FORTRAN Unit 40 (Tape 40) in the JCL. The format requirements for the neutronics data file are defined in Chapter V of Volume 2: Programmer's Manual.

Several decay heat options are available for use with the one-dimensional kinetics option. The decay heat options are defined and initial condition data are input on the 146000, 146010, and 1470XX cards.

20.1 One-Dimensional Kinetics Constant Data Card 30000Y

Card 30000Y is required if NODEL = 2 (Card 01000Y). The data on this card define the parameters and boundary conditions for the one-dimensional kinetics option. Y is a sequence number ranging from 1 to 9.

W1-I	NORIN	=	Number of neutronic regions (NORIN $\geq$ 1)
W2-I	NOGIN	=	Number of neutron energy groups (NOGIN $\leq$ 2)
W3-1	NCSIN	=	Actual number of control states including the base case (NCSIN $\geq$ 1)

W4-I KONIN = Inner boundary condition option. Inner refers to boundary with smallest dimension.
= 0, for zero gradient.
= 1, for zero flux.

W5-I KONOUT = Outer boundary condition option. Outer refers to boundary with greatest dimension.
= 0, for zero flux.
= 1, for zero gradient.

W6-I MAXIN = Flux iteration limit.
= 0, default of 100.

W7-I KUDYS = Shape function time derivative option.
= 1, for improved quasi-static model
= 2, for factorized model with shape function extrapolation (2 is recommended).

In most classical quasistatic methods, the time partial derivative of the shape function which appears in the factorized equations is neglected. The range of applicability of the quasistatic model in RETRAN is extended through the use of the flag KUDYS which invokes two different methods of including the effects of a shape function derivative. In both cases, the time derivative of the shape function is approximated by a backwards difference of the first order.

$$\frac{\partial}{\partial t}\psi(z,t) = \frac{\psi(z,t) - \psi(z,t - \Delta t)}{\Delta t}$$

where $t-\Delta t$ is the time of the last shape function. Δt is the shape function time-step size which can be greater than the amplitude function step.

When KUDYS is 1, the shape function used to integrate the amplitude and precursor equations is constant over the interval Δt. Thus, the previous time-step shape function is used to integrate the amplitude function to the new time value. When KUDYS = 2, evolution of the shape function over the Δt step is extrapolated based on previous time-step behavior for use in integrating the amplitude function equations. KUDYS = 2 is preferred since it can yield to faster converging and better behaved solutions.

W8-I	KUPK =	Point kinetics option flag = 1, for point kinetics = 0, otherwise	
W9-I	NODGIN	=	Number of delayed neutron energy groups (NODG $\geq$ i of NOFIN $\geq$ 1)
W10-I	NOFIN	=	Number of delayed neutron families (0 $\leq$ NOFIN $\leq$ 1)
W11-I	ICRXP	=	Cross-section debug edit. = -1, perform cross-section perturbation calculation, edit result, and execute problem. = 1, cross-section perturbation calculation and edit only. = 0, no edit, normal problem execution only.
W12-I	ILIM	=	Upper and lower limits for all cross sections can be supplied on the cross-section data file if desired. = 0, limits are not supplied. = 1, limits are supplied.

20.2 Neutronic Region Data Cards 310XXY

The Neutronic Region Data Cards must be supplied if NODEL = 2 (Card 01000Y). This series of cards supplies information needed for each neutronic region. NORIN (Card 30000Y) sets of cards must be entered with XX equal to the region number. XX must start at 01 and end at NORIN. Region 01 must be the bottom neutronic region and region NORIN must be the top neutronic region. Regions are assumed to be stacked as they are numbered. Y is a sequence number for each neutronic region data set and can range from 0 to 9.

W1-I	NINT	=	Number of mesh intervals in this region. (NINT $\geq$ 1)
W2-I	IRVOL	=	RETRAN control volume number from which feedback variables (moderator void fraction and temperature) are obtained. (IRVOL $\geq$ 1).
W3-I	IRCOR	=	Core section number from which feedback fuel temperature is obtained. If the region is a reflector region, IRCOR = 0. (IRCOR $\geq$ 0)
W4-R	ELEVR	=	Elevation of the top of the region, referenced from the bottom of Region 1 (ft).
W5-R	DELR	=	Height of the region (ft).

20.3 Control Rod Description Data Card 315000

The Control Rod Description Data Card is required if NODEL = 2 (Card 01000Y). This card describes the control rod bank, the control block from which initial position and movement is obtained, the control rod bank entry location and the mixing fraction. Only one control rod bank can currently be modeled.

W1-I	IDCNTL	=	ID number of the control block from which the position of the control rod bank tip is obtained. Output of this control block is in the units of feet measured from the bottom of the lower most neutronic region.
W2-I	IBOT	=	Rod entry flag. = 0, bottom entry (BWR) = 1, top entry (PWR)
W3-R	FSRC	=	Rod source mixing fraction ($0.0 \leq FSRC \leq 1.0$). The region outside of the core from which the rods move is defined as the rod source, and the control fraction of this region is always 1.0. This fraction moves with the rod bank unless modified by FSRC. Further discussion on the rod model is given in Volume 1: Theory and Numerics.
W4-R	RODLIM	=	Control rod limit in feet. Limiting distance the rods can move from the core boundary (not reflector boundary). The default value is the core height.

20.4 Yield Fraction Data Cards 32000Y

The Yield Fraction Data Cards must be supplied if NODG > 0 (Card 30000Y) and NODEL = 2 (Card 01000Y). This card defines β_i/β for each delayed neutron group. Y is a sequence number ranging from 0 to 9 and must be consecutive.

W1-R	YFRAC(1)	=	Yield fraction for first delayed neutron group.
.	.		
.	.		
.	.		
W(NODG)-R	YFRAC(NODG)	=	Yield fraction for delayed neutron group NODG.

20.5 Delayed Neutron Decay Constant Data Cards 32100Y

Delayed Neutron Decay Constant Data Cards must be supplied if NODG $\geq$ 1 (Card 30000Y) and NODEL = 2 (Card 01000Y). Y is a sequence number ranging from 0 to 9 and must be consecutive. Decay constants for each of the delayed neutron groups are supplied on this card.

W1-R	DECAY(1)	=	Decay constant for first delayed neutron group.
W2-R	DECAY(2)	=	Decay constant for second delayed neutron group.
.	.		
.	.		
.	.		
W(NODG)-R	DECAY(NODG)	=	Decay constant for delayed neutron group NODG.

20.6 Neutron Spectra Data Cards 330XXY

The Neutron Spectra Data Cards must be supplied if NODG > 0 (Card 30000Y) and NODEL = 2 (Card 01000Y). This series of cards define the delayed neutron energy spectra. A set of cards must be supplied for each neutron energy group. XX ranges from 01 to NOGIN (Card 30000Y). Y is a sequence number ranging from 0 to 9.

W1-R	CHID(1)	=	Neutron spectra for Delayed Group 1, Energy Group XX. ($0.0 \leq$ CHID ≤ 1.0)
W2-R	CHID(2)	=	Neutron spectra for Delayed Group 2, Energy Group XX.
.	.		
.	.		
.	.		
W(NODG)-R	CHID(NODG)	=	Neutron spectra for delayed group NODG, energy group XX.

20.7 Cross-Section Perturbation Option Data Cards 350000

The Cross-Section Perturbation Option Data Cards must be supplied if ICRXP = 1 (Card 30000Y) and NODEL = 2 (Card 01000Y). If this option is selected, RETRAN will edit the coefficients supplied on the cross-section data file, perturb the feedback variables as described on this card, and compute and edit associated cross sections. The number of perturbations should be 1+n to account for the initial zero perturbation edit. The number of perturbations must be at least 1, even if the desired increment is zero.

W1-R	DELU	=	Incremental change in normalized density
		=	$\frac{\rho(0) - \rho(t)}{\rho(0)}$
W2-I	NU	=	Number of times the change in normalized density is to be changed by DELU. ($NU \geq 1$)

W3-R DELTF = Incremental change in fuel temperature feedback quantity

$= \left(\sqrt{T_f(0)} - \sqrt{T_f(t)}\right).$

W4-I NTF = Number of times the change in fuel temperature feedback quantity is to be changed by DELTF. (NTF $\geq$ 1)

W5-R DLTM = Incremental change in moderator temperature

$= \left(T_m(0) - T_m(t)\right).$

W6-I NMT = Number of times the change in moderator temperature is to be incremented by DLTM. (NMT $\geq$ 1)

20.8 Absorption Cross-Section Modification Data Cards 36000Y

The Absorption Cross-Section Modification Data Card must be supplied to modify the Energy Groups 1 and 2 macroscopic absorption cross sections with the control system. This option is available to account for changes in the absorption cross- sections due to phenomena that cannot be accounted for directly in the cross-section feedback model. The most common use of this option would be to model the feedback from boron injection but the model is not limited to this application.

The input supplied on this card defines a control block number (for each energy group and neutronic region) for which the control block output is added directly to the particular macroscopic absorption cross section. The control block output can be positive or negative and must be in the units of 1/cm. As with any control system defined parameter, the functional dependence is strictly up to the user.

2*NOR entries are required if this card is supplied. An input has to be supplied for each neutronic region in Energy Group 1 and each neutronic region in Energy Group 2. Y is a sequence number ranging from 0 to 9.

W1-I IDABS(1) = Control block ID.

- < 0, ID of control block specifying the amount to be added to the Group 1 Region 1 macroscopic absorption cross section. The control block output should have units of cm^{-1}.
- = 0, the macroscopic absorption cross section will not be modified via the control system.

W2-I IDABS(2) = Same as W1 for Group 1 Region 2.

W(NOR)-I IDABS(NOR) = Same as W1 for Group 1 Region NOR.

W(NOR+1) IDABS(NOR+1) = Same as W1 for Group 2 Region 1.

.
.
.

W(2*NOR) IDABS(2*NOR) = Same as W1 for Group 2 Region NOR.

21.0 ITERATIVE SOLUTION SCHEME FOR THE FLUID DYNAMICS EQUATIONS (PURDUE NUMERICS - THERMAL HYDRAULICS)

The iterative solution scheme was developed for solving the linear system of the fluid dynamics equations when the size of the linear system is very large. It is composed of the preconditioned Generalized Minimum Residual (GMRES) method and the Multiplicative Schwarz method which is used for domain decomposition preconditioning. The computation time of this scheme is about linearly proportional to the number of variables in the linear system and to the number of iterations that the preconditioned GMRES method takes to converge. Since the Gaussian elimination which is used in conjunction with the sparse matrix block elimination scheme has a computation time proportional to the cubic of the number of variables, the iterative solution scheme can be more efficient than the sparse block elimination scheme for a problem that has a very large linear system. It is recommended that the user choose the iterative solution scheme for the problems with a reactor core model that consists of more than 20 hydraulic channels, or if there are a large number of cross flow junctions. The Purdue numerical solution is activated by setting NSOL34 = 2 on Card 01000Y.

21.1 Iteration Control Parameters and Geometry Description Data Cards 380000

The iterative solution scheme uses the preconditioned Generalized Minimum Residual (GMRES) method with domain decomposition preconditioning (the Multiplicative Schwarz method). This data card is designed so that the user can specify the GMRES iteration control parameters and the domain decomposition for the core model. Also, the user is required to give a minimum amount of information about the core geometry.

W1-I NCOAXL = Number of core axial planes.

W2-I NCOCHN = Number of core vertical channels.

W3-I NCOROW = Number of rows in core radial layout.

W4-I ICTYPE = Type of core model (0/square, 1/quarter, 2/half, 3/full, and -1/others).

(1) The square type of core is defined as the core models that consist of *n*-by-*n* vertical channels with a square radial layout, in which each core volume is

connected with its adjacent volumes by horizontal cross flow junctions.

(2) The user can specify the core model as one of the three core types (quarter, half, or full) only if the thermal-hydraulic mesh is equal to the fuel assembly mesh (i.e., each RETRAN core channel represents a fuel assembly) or is equal to the neutronics mesh (i.e., each RETRAN core volume represents a neutronics node), and each core volume is connected with its horizontally adjacent volumes by cross flow junctions.

(3) For the problems with a core model that has horizontal cross flow junctions but does not belong to any of the four core types defined above, the iterative solution scheme cannot be applied.

(4) The other type (-1) of core applies to any core model that does not have horizontal cross flow junctions. For example, a BWR core with parallel isolated channels or a multichannel PWR core in which the cross flow effect is ignored. If the core type is -1, the number of rows in core radial layout (NCOROW) must be specified as 1, and NVOL01 in Card 3801XX must be equal to NCOCHN. With the information of core radial layout (from input Card 3801XX) and the specified NPCOND, the iterative solution scheme can determine the appropriate domain decomposition for the reactor core.

W5-I MOITER = Maximum number of GMRES iterations (default=100, maximum=150).

W6-I NPCOND = Option of domain decomposition for the core model.
0 : one channel per subdomain.
1 : 4 (2-by-2) channels per subdomain.
2 : 9 (3-by-3) channels per subdomain.
3 : 16 (4-by-4) channels per subdomain.
For the iterative solution scheme, the core subdomain can only be of square shape, i.e., composed of *n*-by-*n* channels (*n* = 1~4).
If there are cross flow junctions in the core, the core domain must be decomposed into overlapping subdomains. In this case, the user has to set NPCOND as either 1, 2, or 3. (It is recommended to use subdomains as large as possible.)

			If there is no cross flow junctions in the core, NPCOND must be set as 0.
W7-I	NSUBDM	=	Number of subdomains in the core model. The user can define his/her domain decomposition for the core domain by specifying NSUBUM and the 3802XX data cards. If NSUBDM = 0, the code will try to determine the domain decomposition for the core.
W8-I	NMDSUB	=	Choice of the model subdomain (default=1). For a reactor core with cross flow junctions, by looking at the core radial layout, a model subdomain is defined as any subdomain that every one of its channels has an adjacent channel in the east and an adjacent channel in the south. Therefore, any subdomain which has a channel on the eastern or southern boundaries of the core is not a model subdomain. Model subdomain is meaningless to a reactor core without cross flow junctions.
W9-R	EPSGMR	=	Convergence criterion of GMRES (default = 1.e-7)
W10-R	EPSROR	=	Criterion of reorthogonalization (default=0.1) The good convergence behavior of GMRES can be severely deteriorated by the loss of orthogonality among the Krylov vectors. This phenomenon is often due to the arithmetic cancellation occurs during the Modified Gram-Schmidt process. Loss of orthogonality, however, can be effectively avoided by performing reorthogonalization. If a slow convergence has been observed, e.g., more than 40 iterations are required for GMRES to converge, then the criterion of reorthogonalization should be enlarged so as to increase the frequency of reorthogonalization.

21.2 Core Radial Layout Data Cards 3801XX

This card provides the information of the radial layout of the core model. The user inputs the number of volumes in each row sequentially. If the core type (ICTYPE) is -1, the number of rows (NCOROW) must be specified as 1, and NVOL01 must be equal to NCOCHN.

W1-I	NVOL01	=	Number of volumes in row 1.

W2-I	NVOL02	=	Number of volumes in row 2.
.	.		
.	.		
W(NCOROW)-I		=	Number of volumes in the last row.

21.3 User-Defined Domain Decomposition Data Cards 3802XX

The domain decomposition of the core model is based on the channel-wise core radial layout. The channels are numbered from west to east, and then from north to south. For each subdomain, the user inputs the sequence number of the leading channel (i.e., the channel at the upper-left corner of the subdomain). Using the information of this card and NPCOND, the code will determine the location, shape, and size of each subdomain.

W1-I	=	Sequence number of the leading channel in Subdomain 1.
W2-I	=	Sequence number of the leading channel in Subdomain 2.
. .		
. .		
W(NSUBDM)-I	=	Sequence number of the leading channel in the last subdomain.

22.0 GENERAL TRANSPORT MODEL VOLUME CARDS 4520XX

The general transport model is an option selected by setting IGNTR to ± 1 (Card 01000Y). The vapor phase is the transport medium if IGNTR = 1 and the liquid phase is the transport medium if IGNTR = -1. A General Transport Model Volume Card must be supplied for each volume containing either an impurity source or sink or having an initial concentration other than the initial concentration of the system. XX is a number ranging from 1 to 99 and need not be sequential.

W1-I	NGSV	=	Volume index (NGSV $\geq$ 1).
W2-I	NGSVCB	=	ID of control block controlling source or sink of volume NGSV in lbm/sec. = 0, no source is in volume NGSV.
W3-I	RSVB	=	Concentration bias of volume NGSV (in ppm) from initial system concentration (RSVB $\geq$ -TPPMIN).

22.1 General Transport Model Junction Cards 4530XX

A General Transport Model Junction Card must be supplied for each junction where the efficiency is to be other than 1.0 or where the junction concentration is to be controlled by a control system.

W1-I	NGSJ	=	Junction index (NGSJ $\geq$ 1).
W2-I	NGSJCC	=	ID of control block controlling fill junction NGSJ concentration (IW1 of junction NGSJ must be zero). = 0, junction concentration not controlled by control system.
W3-I	NGSJCE	=	ID of control block controlling junction NGSJ efficiency. = 0, junction efficiency not controlled by control system.

22.2 Initial Impurity Concentration Card 454001

An Initial Impurity Concentration Card is required if the entire system modeled is to have an initial impurity concentration other than zero. Concentration is defined herein using the typical formulation of parts per million (ppm) as

$$C = \frac{(\text{Mass Impurity})\,(1.E+6)}{(\text{Mass Transport Medium}) + (\text{Mass Impurity})}$$

The initial impurity concentration must be used with some discretion at this time since it is not applicable to all situations. The initial concentration in this form would only apply to single-phase systems such as boron transport in a PWR. If the user wants the initial impurity concentration to be nonzero for BWR applications, the concentration is not equal throughout the system due to the fact that the transport medium is not equally distributed.

W1-R	TPPMIN	=	Initial impurity concentration in ppm to be applied to entire system (TPPMIN $\geq$ 0.0). Default is 0.0.

23.0 TURBINE SHAFT DESCRIPTION DATA CARDS 500XXY

These cards are required when the turbine model option is being used (NTSH > 0 on Card 01000Y). If the option is not selected they should not be supplied. There are NTSH sets of these cards with XX ranging from 01 to NTSH. Y is a sequence number ranging from 0 to 9.

W1-I	NTURS	=	The number of turbines on this shaft, NTURS $\leq$ 9.
W2-I	ISIN	=	Turbine shaft speed integration flag. If ISIN $\neq$ 0 the optional speed integration is performed for this shaft at each time step. If the speed integration is desired, then ISIN must be set to the Control System control block ID which supplies the generator torque. A negative value for the generator torque tends to retard rotation and would be representative of the typical generator load, while a

			positive torque value would provide an angular acceleration. The supplied torque is normalized to the initial steady-state operating value. If ISIN = 0, no speed integration is performed.
W3-R	SHRPM	=	Initial shaft speed (RPM).
W4-R	SHPOW	=	Demand power from this shaft (megawatts).
W5-R	SHIR	=	Shaft moment of inertia (lbf-ft-sec^2). Not required when ISIN = 0.

23.1 Turbine Description Data Cards 5010XY

These cards are required when the turbine model option is being used (NTSH > 0 on Card 01000Y). If the turbine option is not selected they should not be supplied. There are NTURS (Card 500XXY) sets of these cards required for each turbine shaft. X is the turbine number ranging from 1 to NTURS. Y is a sequence number ranging from 0 to 9.

W1-I	ITSHA	=	Turbine shaft number on which turbine X is located. (Equals XX on the corresponding turbine shaft data card.)
W2-I	NG	=	Number of stage groups in this turbine. NG equals the number of RETRAN control volumes used to model the turbine.
W3-I	JINTUR	=	RETRAN junction number (refers to XXX on junction data cards 08XXXY) of the turbine inlet.
W4-R	CN	=	Turbine nozzle coefficient (dimensionless). If zero is input, the default value is used (Default = .98).
W5-R	TINH	=	Turbine inlet enthalpy at design operating conditions (Btu/lbm).
W6-R	TINP	=	Turbine inlet pressure at design operating conditions (psia).
W7-R	TINW	=	Turbine inlet flow at design operating conditions lbm/sec. (Design flow in junction JINTUR.)

When the turbine option is used, volume initial condition card (231XXX) and junction initial condition card (232XXX) must be supplied. Volume initial condition must be specified for each volume which is inlet to the junction specified here by JINTUR i.e., upstream volume to the junction specified by JINTUR. Pressure specified on Card 231XXX must match the turbine inlet pressure (TINP) specified here. Similarly, junction initial condition must be specified for each

junction specified here by JINTUR. Junction number and flow rate (JUN and WP) specified on Card 232XXX should match the junction number and turbine inlet flow rate (JINTUR and TINW) specified here.

If volume and junction initial conditions are not specified when using turbine option or initial pressure and flow rate specified does not match with pressure and flow rate specified here, steady-state initialization or convergence problems may occur.

23.2 Turbine Stage Group Description Data Cards 51XYYZ

These cards are required when the turbine model option is being used (NTSH > 0 on Card 01000Y). If the option is not selected they should not be supplied. There are NG sets of these cards required for each turbine. X is the turbine number with X ranging from 1 to NTURS (Card 500XXY). YY is the stage group number with YY ranging from 01 to NG (Card 5010XY). Z is a sequence number ranging from 0 to 9. Each stage group corresponds to one RETRAN control volume. Those items for which a default value is indicated will be set to the default value if zero is entered on the card.

W1-I	NS	=	Number of stages represented by this stage group. NS = 1 for a governing stage.
W2-I	IVOLSG	=	RETRAN control volume number (refers to XXX on volume data cards 05XXXY) for this stage group.
W3-I	IJUNSG	=	The inlet junction number (XXX on junction data cards 08XXXY) linking the previous stage group volume to IVOLSG.
W4-R	GBLC	=	Group blade loss coefficient (dimensionless) (default = .92).
W5-R	GRLC	=	Group reaction loss coefficient (dimensionless) (default = .95).
W6-R	GNA	=	Group nozzle angle (degrees) (default = 20. for governing stage, 13. for other stages).
W7-R	GEA	=	Group exit angle (degrees) (default = 20. for governing stage, 24. for other stages).
W8-R	DTP	=	Exhaust pressure in group at initial load operating condition (psia).
W9-R	DTH	=	Exhaust enthalpy in group at initial load operating condition (Btu/lbm).

W10-R	DWP	=	Flow in junction IJUNSG at initial load operating condition (lbm/sec).
W11-R	GXE	=	Fraction of reaction energy (default = .5).

Data Items 12-15 apply only to a governing stage. If these are supplied, a governing stage is assumed and NS must equal 1.

W12-R	GFLC	=	Fixed blade loss coefficient (dimensionless) (default = .92).
W13-R	G2MLC	=	Second moving blade loss coefficient (dimensionless) (default = .92).
W14-R	EAFB	=	Exit angle from the fixed blade (degrees) (default = 26).
W15-R	EA2MB	=	Exit angle from the second moving blade (degrees) (default = 35).

When the turbine option is used, volume initial condition card (231XXX) and junction initial condition card (232XXX) must be supplied. Volume initial condition must be specified for each volume which is inlet to the junction specified here by IVOLSG. The pressure specified on Card 231XXX must match the exhaust pressure (DTP) specified here. Similarly, junction initial condition must be specified for each junction specified here by IJUNSG. Junction number and flow rate (JUN and WP) specified on Card 232XXX should match the junction number and flow rate (IJUNSG and DWP) specified here.

If volume and junction initial conditions are not specified when using turbine option or initial pressure and flow rate specified does not match with pressure and flow rate specified here, steady-state initialization or convergence problems may occur.

24.0 SEPARATOR DESCRIPTION DATA CARDS 60XXXY

Separator description data cards are required only when the two-region separator model is used (NSEPR > 0 on Card 01000Y). There are NSEPR sets of these cards, one for each separator volume. XXX is the separator number ranging from 001 to NSEPR. Y is a card sequence number from 0 through 9.

Separator volumes also require bubble rise (60XXXY) and two-region nonequilibrium (610XXX) data cards to complete their description. The mixture level is used from the bubble rise data. **Caution:** If a nonzero gradient parameter is supplied with the bubble rise data for a separator, steady-state initialization will use it to determine the liquid region quality, which may differ from the exit junction carryunder (quality). **Note:** A value of 0.0 should be supplied for the gradient to reproduce RETRAN-02 results. This will give equal qualities in the recirculation junction and the liquid region. The bubble rise velocity is not used with the separator model. As such, it is recommended that a zero value be input to avoid confusion.

Under certain conditions, the rainout velocity and interregion heat transfer options defined on the two-region nonequilibrium data cards, 610XXX, will be used. Refer to Section VI.3.4 of Volume 1 for a description of the conditions where these models may be used.

To be consistent with the assumptions of the model, slip is not allowed in the recirculation and steam flow junctions. If slip is specified for these junctions, it will be disregarded.

W1-I	ISEV	=	RETRAN volume number for this separator.
W2-I	JIN	=	RETRAN junction number which is the separator inlet.
W3-I	JSTM	=	RETRAN junction number which is the separator steam line.
W4-I	JRSC	=	RETRAN junction number which is the separator recirculation line.
W5-I	IUDC	=	Volume number of the associated (upper) downcomer (for mixture level reference).
W6-R	ZVANE	=	Height to the bottom of the swirl vanes measured from the bottom of the separator volume (feet).
W7-R	COVI	=	Initial separator carryover.

The remaining input items may be omitted if the steady-state initialization option is used. If they are omitted, the default values will be used as indicated. The default carryover and carryunder data[IV.24-1] apply to BWR separator performance. Performance data for steam-water separators in steam generators can be found in Reference.[IV.24-2]

W8-R	XIND	=	Separator design inlet flowing quality (default = 0.12).
W9-R	ZMD	=	Design level relative to the bottom of the separator swirl vanes (default = 2.0833 feet).
W10-I	ICO1	=	The number of the General Data Table (Cards 12XXYY) containing carryover multiplier as a function of normalized inlet quality (default = 0). Note that the dependent variables are actually one minus the carryover. = 0, the default data table of carryover multiplier as a function of normalized inlet quality will be used. = 1000, the carryover is determined by the control system.

W11-I	ICO2	=	The number of the General Data Table containing carryover multiplier as function of normalized mixture level (default = 0). Note that the dependent variables are actually one minus the carryover. = 0, the default data table of carryover multiplier as a function of normalized mixture level will be used. = Control block ID for one minus the carryover if ICO1 = 1000.
W12-I	ICU1	=	The number of the General Data Table containing carryunder multiplier as a function of normalized inlet quality (default = 0). = 0, the default data table of carryunder multiplier as a function of normalized inlet quality will be used. = 1000, the carryunder is determined by the control system.
W13-I	ICU2	=	The number of the General Data Table containing carryunder multiplier as a function of normalized mixture level (default = 0). = 0, the default data table of carryunder multiplier as a function of normalized mixture level will be used. = Control block ID for carryunder if ICU1 = 1000.
W14-I	ISEPN	=	The total number of separators.
W15-R	THETA	=	The angle of the separator vanes relative to horizontal (degrees).
W16-R	RHUB	=	Separator hub radius (inches).
W17-R	RRNG	=	Separator pick-off ring radius (inches).
W18-R	HDFS	=	Height of the separating barrel (inches).
W19-R	VOLFS	=	Separator first stage volume (cubic feet).

An optional model is available to account for the pressure change from the centrifugal force in the swirling vortex region of the separator. The equations are used with the BWR separator model to calculate the water layer pressure increase due to the centrifugal force at the pick off rings in the steam separator. The calculated pressure increase is included in the momentum equation for both the steady-state and transient solutions. The term will appear in the recirculation junction “pump psi” region of the RETRAN major edit.

Words 14 through 19 are required if this model is used. Otherwise the values are zero, and the model is not active.

If the steady-state initialization option is not used, i.e., JSST = 1 on Card 01000Y, the following data must be supplied, otherwise it must be omitted.

W20-R CUNI = Initial separator carryunder.

25.0 TWO-REGION NONEQUILIBRIUM VOLUME MODEL DATA CARDS 61XYYY

The simulation of PWR plant transients, (e.g., the loss of reactor coolant flow, uncontrolled rod withdrawal, and loss of feedwater flow) or certain pressurization transients which occur in BWR plants, require a special model for the PWR pressurizer or BWR upper downcomer region that considers the physical processes taking place during these types of transients. A standard RETRAN control volume state solution for these regions would assume that all of the contents are in thermal equilibrium. However, rather than behaving in an equilibrium manner, these volumes have two distinct regions such that an equilibrium state solution of the whole volume is not a proper physical representation of the processes occurring. Nonequilibrium between these regions is particularly appropriate when the transient involves a surge of subcooled liquid into the pressurizer or when a pressure wave is moving through a BWR.

The RETRAN two-region nonequilibrium model defines two separate thermodynamic regions which are not required to be in thermal equilibrium. The two regions are termed "liquid" and "vapor" regions, although each region may contain both liquid and vapor. The thermodynamic state solution for each region is determined from a distinct mass and energy balance on that region. Hence, the thermodynamic state for one region is determined without restrictions as to the other, with the vapor region superheated and the liquid region subcooled, both regions saturated, or the vapor region saturated and liquid region subcooled.

The mass and energy balances provide the total mass and energy in each region as a function of time through the transient. The solution of the thermodynamic state in each region then involves the determination of each region volume (constrained so the sum equals the total volume) such that the calculated pressure is equal in each region.

Included at the interface between the liquid and vapor regions is a flashing model which describes the movement of vapor from the liquid to the vapor region and a rainout model which describes the movement of liquid from the vapor region to the liquid region. Heat Conductors can be specified in the pressurizer. They can be insulated on one side and use local condition heat transfer or it can be two sided to model environmental heat losses. The left boundary volume in that case is pressurizer and appropriate liquid and vapor properties are determined using local condition models. If conductors are used, the input for this option must be provided on the (01000Y) problem card description (only if using the long form).

Heat conductors can be simulated within a two-region nonequilibrium volume. The main purpose for conductors is to model the vessel walls of other metal mass. The local conditions heat transfer model is required (Section IV.17.7) to track the relative heat transfer to the two regions.

There are two options to solve the pressurizer equations in RETRAN-3D. One method is the explicit technique of RETRAN-02 and the second method is a fully implicit technique. The explicit option is used if NUMRCS = 2 (Card 01000Y) and the implicit option is used if NUMRCS = 3. Additional information is given in Volume 1.

The pressurizer steady-state initialization feature allows the pressurizer spray flow to be determined from a specified initial heater power. Section IV.19.8 specifies in detail how to use the pressurizer steady-state initialization option.

Pressurizer volumes also require bubble rise (60XXXY) data cards to complete their description. The mixture level, bubble gradient, and separation velocity may be used. **Caution:** If a nonzero gradient parameter is supplied with the bubble rise data for a separated volume that is not a volume using the separator model, steady-state initialization will use it to determine the liquid region quality. This quality may differ from the exit junction quality obtained from the local energy balance on the two-region volume for the recirculation path when the model is used for a separated volume (separator or upper downcomer). **Note:** A value of 0.0 should be supplied for the gradient to reproduce RETRAN-02 results. This will give equal qualities in the recirculation junction and the liquid region.

Two different forms of input are allowed for the two-region nonequilibrium model. Cards with X = 0 provide backward compatibility with MOD004.6 and preclude use of the pressurizer stratification model and improved interregion heat transfer model. Cards with X = 1 are used to provide input for the pressurizer stratification and interregion heat transfer models added to MOD004.7.

All two-region nonequilibrium input in a model must use the same value of X, either 0 or 1.

25.1 Original Two-Region Input - 610YYY

The following input gives the two-region nonequilibrium model options that were available in RETRAN-3D MOD004.6 and earlier versions. This input option does not allow use of the pressurizer stratification option or the default interregion model. A minimum of 2 words, and no more than 5 can be provided.

W1-I	NEQVOL	=	The nonequilibrium volume number.
W2-I	ISEPFG	=	Flag to specify type of volume. = 0, pressurizer volume. = 1, separator volume.
W3-R	VRAIN	=	Rainout velocity for liquid droplets in the vapor region (ft/sec) – (default = 0).
W4-I	IHTC	=	Interregion heat transfer option flag (default = 0) = 0, interregion heat transfer is not modeled

= 1, use constant interregion heat transfer coefficient given by VLHTC (Word 5)
= 2, use interregion heat transfer coefficient from control block ID (Word 5)
= 3, use Murphy interregion heat transfer model, with mass condensation multiplier given by VLHTC (Word 5)

W5-R VLHTC = Interregion heat transfer coefficient (default = 0)
= 0.0 if IHTC = 0; no interregion heat transfer
= constant heat transfer coefficient (Btu/hr-ft2-F) if IHTC = 1
= control block ID for interregion heat transfer coefficient (Btu/hr-ft2-F) if IHTC = 2
= multiplier on mass condensation rate from spray flow, with interregion heat transfer proportional to condensation plus spray mass flow rate if IHTC = 3

25.2 Enhanced Two-Region Model Input - 611YYY

This input option is used to activate the pressurizer stratification option and/or the enhanced best estimate interregion models. A minimum of 2 words and no more than 7 can be supplied. The pressurizer stratification model is activated by setting NNODES > 0.

The interregion heat transfer model selection is made using the IHTC flag. The best-estimate value is IHTC = 0 where the heat transfer between the liquid and vapor regions is modeled using either the McAdams free convection heat transfer correlation or a model given by Murphy that enhances the heat transfer when spray flow is active. The model giving the maximum heat transfer is used. The McAdams heat transfer coefficient is multiplied by CFCV to allow for uncertainties and CTRB is a similar multiplier for the Murphy model heat transfer. The default for both multipliers is 1.0. A fixed heat transfer coefficient, specified by CFCV (Word 5), will be used if IHTC = 1. The interregion heat transfer coefficient will be determined from the control block ID specified on CFCV (Word 5) if IHTC = 2.

W1-I NEQVOL = The nonequilibrium volume number.

W2-I ISEPFG = Flag to specify type of volume.
= 0, pressurizer volume.
= 1, separator volume.

W3-I NNODEP = Number of pressurizer subnodes used in the thermal stratification model (default = 0).
= 0, no subnodes and no thermal stratification is modeled. Use 0 for nonpressurizer uses.
> 0, the number of subnodes included in the pressurizer model.

W4-I	IHTC	=	Interregion heat transfer option flag (default = 0) = 0, interregion heat transfer is modeled using free convection or spray enhanced turbulence model. = 1, use constant interregion heat transfer coefficient given by CFCV (Word 5) = 2, use interregion heat transfer coefficient from control block ID given by CFCV (Word 5)
W5-R	CFCV	=	Free convection heat transfer multiplier = if IHTC = 0; interregion heat transfer coefficient multiplier (default = 1.0). 0.0 will cause default to be set. = if IHTC = 1, constant heat transfer coefficient (Btu/hr-ft^2-F) input using CFCV (Word 5). = if IHTC = 2, control block ID for interregion heat transfer coefficient (Btu/hr-ft^2-F) is input using CFCV (Word 5).
W6-R	CTRB	=	Spray enhanced turbulent heat transfer coefficient multiplier (default = 1.0) 0.0 will cause default to be set.
W7-R	VRAIN	=	Rainout velocity for liquid droplets in the vapor region (ft/sec) (default = 15.0).

25.3 Pressurizer Thermal Stratification Model

The existing RETRAN-3D pressurizer model is adequate for conditions where a single liquid region temperature can accurately describe the behavior of the pressurizer. When an in-surge occurs where the inlet temperature changes over time as the hot leg temperature changes, thermal stratification occurs in the liquid region. The two-region nonequilibrium model does not account for the thermal stratification, but mixes in incoming fluid to obtain a single average temperature for the liquid region. The pressurizer thermal stratification model is appropriate to use for such situations. The pressurizer thermal stratification model is a hybrid model comprised of the pressurizer volume overlaid on the vessel description using subnodes, each using the temperature transport model is appropriate.

The complete pressurizer vessel will be defined using subnodes. The subnodes below the mixture level will be used to describe the subcooled liquid region in the vessel. The two-region pressurizer model will be used to describe the vapor region and a small liquid region that resides above the liquid subnode below. The domain over which the two-region model will be applied change as the liquid inventory changes. The pressurizer thermal stratification model is activated by specifying the number of subnodes (Word 3) on the two-region nonequlibrium volume data cards, 610XXX.

The subnodes can be created manually or by using the automatic subnodalization option. The automatic subnodalization option creates a number of equally sized subnodes from the base volume. For the automatic subnodalization option, refer to Section IV-32.0 for additional information. The only drawback with the automatic subnodalization option is that all subnodes will be of equal sizes. If it is desired to have different sizes for subnodes, they must be manually specified using volume and junction data cards.

When subnodes are specified manually, they must be defined using the volume data cards 05XXXY and their connections must be defined using the junction data cards 08XXXY. The exit junction at the top of a subnode must be numbered the same as the subnode. It is required that the volumes and junctions be sequential where junction 'j' is at the top of volume 'j'. The top node identified as Node N must be defined as a two-region (pressurizer volume) and subsequent bottom node be order N-1 and so on. It is also required that junctions flow direction must be from bottom node to the top node, for example, junction j must connect volume j to volume j+1, in this manner junction N-1 will connect volume N-1 to N. The top subnode (Node N) must also be identified as the pressurizer volume using the two-region nonequilibrium volume data cards 610XXX. Also the number of subnodes must be specified on 610XXX card.

The top node must have a bubble rise model associated with it. The input mixture level for the bubble rise model given on the bubble rise data card 060XXY will be relative to the bottom of the pressurizer vessel rather than the bottom of Node N. The bubble rise parameters such as the partial bubble density, partial mixture density and other related values must be specified.

If the vessel wall heat transfer is modeled, each subnode must have an associated heat conductor described using a heat conductor description data card 15XXXY, which will reside in a conductor stack. Two stacks will be required, one will include all heat conductors that reside within the liquid region, excluding the heat conductor that is adjacent to the subnode containing the mixture level. The second stack will include all heat conductors that reside within the vapor region, including the heat conductor that is adjacent to the subnode containing the mixture level. The heat conductors in the two stacks must be ordered from bottom to top. It is recommended that top node (nonequilibrium volume) use three conductors. This is done to facilitate evaluating liquid region and vapor region in cases when the pressurizer is contracted and only the top node is part of the stratified pressurizer model. Similarly, multiple conductors can be used for the bottom node in case liquid level falls and the pressurizer is expanded to cover all the nodes.

All heat conductors in stacks are included in a list and ordered by stack number and as indicated on the stack data cards 2200XY for each stack.

Pressurizer heaters must be described using the nonconducting heat exchanger description data cards 21XXYY. The elevation at the midpoint of the pressurizer heater must be specified on the nonconducting heat exchanger data card to identify the location of the heaters relative to the subnodes.

Initial conditions must be provided for the subnode description. When the steady-state initialization option is not used, all subnodes (active and inactive) pressure and enthalpies must be defined such that, volumes below the mixture level are subcooled with enthalpy value the same as liquid region enthalpy (one way to achieve this is to calculate hydrostatic pressure head

in each subnode and specify the enthalpy same as liquid regions enthalpy). Similarly, all subnodes above mixture level must be defined such that the quality is one. For the case where steady-state initialization is used, specifying only enthalpy in subnodes is sufficient (the pressure will be calculated by steady state and steady-state convergence will be achieved). A subcooled temperature gradient can also be established in the subnodes below the pressurizer by using the 231XXX volume initial condition data cards. The initial conditions for the pressurizer region will be determined from conditions either input or calculated for node N.

26.0 ACCUMULATOR DATA CARD 62XYYY

Data cards are required whenever the optional RETRAN-3D accumulator model is associated with a control volume to invoke a two-region solution where the gas region can be at a different temperature than the liquid region. One set of these data cards is required for each accumulator volume. When using the long form of the problem description card (01000Y), NACC is defined by the user, while it is determined from the number of 62XYYY cards in the input deck when the short form is used. NACC separate cards must be supplied with YYY values from 1 to NACC.

Two different forms of input are allowed. Cards with X = 0 provide backward compatibility with MOD004.6 and earlier versions where a polytropic expansion was used to model the accumulators. Cards with X = 1 are used to provide input for the revised accumulator model added to MOD004.7 that accounts for heat transfer to the vessel walls and interregion heat transfer.

All accumulator input in a model must use the same value of X, either 0 or 1.

26.1 Polytropic Expansion Model - 620YYY

Strictly speaking, the polytropic expansion model is no longer available in RETRAN-3D (as of MOD004.7). However, the current mechanistic model reproduces results for the polytropic model for isothermal and isentropic expansions. For this reason, the value of GAMMA is limited to 1.0 (isothermal) or a value greater than 1.0 (flag), which gives an isentropic expansion for the particular noncondensible gas being used. A minimum of two words must be supplied, and no more than three. The initial liquid level must be less than the volume height ZVOL. The accumulator vessel is assumed to be a right circular cylinder with flat ends.

W1-I	IDVACC	=	Volume number for accumulator.
W2-R	ACCLEV	=	Initial liquid level (ft).
W3-R	GAMMA	=	Expansion constant (default = 0) 0 or > 1.0 indicates isentropic - C_p/C_v for noncondensible gas (1.40 for air or nitrogen) = 1.0, (indicates isothermal expansion)

For an isothermal expansion, the input parameters described for the 621YYY data are automatically set to DXWALL = 1.0, CVWALL = 1.0e6 and CHWALL = CHSURF = 1.0e6. They are all set to zero for an isentropic expansion.

26.2 Mechanistic Model - 621YYY

The mechanistic accumulator model is a component model that accounts for the vessel geometry, vessel material properties, nonequilibrium between the gas and liquid regions, and heat transfer from the vessel wall and between the gas and liquid regions. Two different geometry models are available (VESGEO is used to select either flat or hemispherical ends).

If the vessel model with hemispherical heads is used, the vessel volume (VOL on the volume data card 05XXXY) will be redefined to be consistent with this geometry. The vessel height is given by ZVOL and the flow area FLOWA is used to define the vessel diameter. The vessel volume is calculated using the height and diameter according to formulas for accumulator geometry found in Table VI.7-1, page VI-62, of Volume 1.

W1-I	IDVACC	=	Volume number for accumulator.
W2-R	ACCLEV	=	Initial liquid level (ft).
W3-R	DXWALL	=	Wall thickness (ft)
W4-R	CVWALL	=	Volumetric heat capacity of the vessel wall, ρc_p, (Btu/ft^3-^{o}F)
W5-R	CHWALL	=	Wall heat transfer coefficient multiplier () (default = 1.0)
W6-R	CHSURF	=	Liquid surface heat transfer coefficient multiplier () (default = 1.0)
W7-I	VESGEO	=	Vessel geometry indicator (default = 1) = 0, right cylindrical vessel with flat ends = 1, right cylindrical vessel with hemispherical heads

If either the wall thickness, DXWALL, or the volumetric heat capacity, CVWALL, or both are input as 0, no wall heat transfer will be modeled. Likewise CHWALL and CHSURF can be input as zero, which turns off all heat transfer. This will result in the pressure response being characteristic of an isentropic expansion, where the expansion coefficient is representative of the incondensable gas used (1.4 for air or nitrogen). If the wall thickness and/or volumetric heat capacity are input as large numbers and CHWALL is a large number, the gas region temperature will remain equal to the initial temperature, which will result in the pressure response being characteristic of an isothermal expansion (expansion coefficient is 1.0).

27.0 METHOD-OF-CHARACTERISTICS TRANSPORT MODEL DATA CARD 6300XX

The method-of-characteristics (MOC) transport model is similar to the temperature transport model which is used to eliminate numerical diffusion from the RETRAN-3D solution scheme by

appropriately computing the junction enthalpy. Unlike the temperature transport model, the MOC transport model is valid for both single-phase liquid and two-phase nonequilibrium conditions. The model is designed for use in BWR cores for application to stability analyses. If a 6300XX data card is supplied, the MOC model will be used to compute the junction enthalpy for the junctions included in the junction list provided. The MOC model will be skipped if a 6300XX card is not present in the input deck. Each 6300XX data card is used to define the junctions associated with an independent channel over which the MOC solution is applied. The values of XX must be in the range from 0 to 99.

The input for the MOC transport model consists of a minimum resolution that specifies the minimum number of particles that will be present in the volume with the highest liquid velocity. Since this minimum resolution corresponds to the highest velocity volume, volumes with lower velocities will have a proportionately higher resolution (number of particles). The ratio of the exit to inlet liquid velocity defines the proportionality constant. Its sole use is for determining the space necessary to store the particle array information. Minimum resolutions in the range of 3 to 7 are generally adequate. It should be noted that the MOC model is limited by the Courant condition and as the resolution is increased, proportionately smaller time-step sizes are required to satisfy the Courant limit. This limit is not included in the time-step control algorithms and must be maintained by limiting the maximum time-step size.

In addition to the minimum resolution and velocity ratio, a list of junctions must be provided. This list defines the region where the model is to be applied. The inlet junction must be specified in the list even though the MOC model will not compute its enthalpy for normal positive flow, since the first and second junctions must connect to the same volume; the second and third junctions must connect to the same volume, and so on. Currently the MOC model can only be used if the five-equation option is used (NEQS=1 on Card 01000Y).

W1-I	IRES	=	Minimum resolution or number of discrete particles that will define the enthalpy distribution in the volume with the highest liquid velocity. (IRES > 0)
W2-R	VELRTO	=	Ratio of exit liquid velocity to the inlet liquid velocity. (Used only to estimate storage for the particle field. Storage is proportional to this number.)
W3-I	IDXJNC(1)	=	Inlet junction to the first volume where the MOC transport model is to be applied. IDXJNC must correspond to a valid junction number in the input deck.
W4-I	IDXJNC(2)	=	Exit junction for the first volume (also inlet to the next volume if it is included).
.	.		
.	.		
.	.		
W(N+2)-I	IDXJNC(N)	=	Exit junction for the last volume where the MOC transport model is to be used.

28.0 MULTIDIMENSIONAL NEUTRONICS INPUT

A multidimensional neutronics option in RETRAN-3D has been implemented by a merger of RETRAN-3D and a three-dimensional space time kinetics model based upon Analytic Nodal Method. The combined code has additional input requirements for the specification of core neutronics layout, geometry, and problem control. External data files are also required which supply the basic cross-section model, control rod descriptions and layout, composition definitions, and core wide fuel assembly layout. These files are not part of the normal RETRAN-3D input but they are described in further detail in the RETRAN-3D Programmer's Manual, Volume 2.

A typical RETRAN-3D core model consists of a number of flow channels comprised of one or more neutronics fuel assemblies. In RETRAN-3D, an axial channel is a stack of control volumes and junctions that represent a flow and energy path through the core region. RETRAN-3D obtains core wide, normalized power fractions from the neutronics code calculation and supplies, in turn, feedback parameters to the neutronics code to compute cross sections for the neutronics solution. The thermal-hydraulic parameters supplied by RETRAN-3D are control volume average densities or void fractions, control volume average temperatures, and core conductor fuel temperatures, as well as links to the RETRAN-3D control system model for control rod position dynamics and soluble boron injection.

Input data for the RETRAN-3D option is given in the next sections.

28.1 Three-Dimensional Core Geometry and Model Option Data 67000Y

When the RETRAN-3D multidimensional kinetics option is activated via NODEL = 3 on Card 01000Y, a 67000Y data card is required. It provides data that describes the core thermal-hydraulics model geometry and code option.

The multidimensional kinetics uses a new feature referred to as the channel model where single or multiple channels comprise the core description. A channel in this context is a stack of connected control volumes, junctions, and conductors that comprise a flow path through the core. A collection of channels can form a complex, interconnected flow field in a RETRAN-3D core, but the simplest element is a channel.

Through the use of this model, the user is no longer required to supply the individual volume, junction, and conductor data within the channel. The user will specify a small amount of data to characterize the channel and options used in all of the elements of the channel, and RETRAN-3D will expand and unfold this data internally into the conventional volume and junction connection matrix.

A key feature of the model is an auxiliary file generated by the CORETRAN code. It contains the core physics options and thermal-hydraulic geometry. This interface file (the CORETRAN data interface) supplies the key information required by RETRAN-3D to generate the core geometry. A detailed description of the CDI file is found in Volume 2.

The channel model is used in the following way. The user supplies all of the problem dimension information on Card 01000Y for the system model, excluding the active core. This is the model from plenum to plenum. The channel model will compute the required values and correct the dimensional data.

A channel model is used to describe that portion of the kinetics model that forms the feedback basis for the neutronics calculation. The channel conductor temperatures are used to form the fuel temperature dependent cross sections and the channel fluid density or void fraction is used to form the moderator feedback.

The user has complete freedom about how to 'overlay' the thermal-hydraulic channels onto the neutronic nodes. The core is usually represented neutronically as individual fuel assemblies while a channel can be used as a 'one-to-one' or more course (i.e., one channel for many neutronics) representation.

The following input is used to describe the channel model. The first six items are required and the remaining items are optional. All optional items default to 0. Y is a sequence number ranging from 1 to 9.

W1-I NCHANR = Number of RETRAN channels.

W2-I NBYPSS = Number of bypass paths.

W3-I NCROSS = Number of cross-flow paths.

W4-I IHQCH = Junction enthalpy model.
= 0, Donor.
= 1, Enthalpy transport.
= 2, MOC option.

W5-I JPMJCH = Two-phase friction multiplier flag.
= -1, no wall friction,
= 0, use Baroczy two-phase multiplier (static quality) with Fanning friction,
= 1, use homogeneous two-phase multiplier with Fanning friction,
= 2, use EPRI two-phase multiplier with Fanning friction,
= 3, use Baroczy two-phase multiplier (flowing quality) with Fanning friction.

W6-I IMCRCH = Heat transfer correlation indicator.
All of the options that are described for heat conductor parameter IMCR (Word 6 on Card 15XXXY) are available for use. The user is cautioned that this selection will be used for all conductors and all channels. Kinetics

convergence problems might be encountered if options that define the core wide heat transfer coefficient are selected.

W7-R	QPMDCH	=	Prompt direct moderator heat fraction.
W8-R	QDMDCH	=	Delayed direct moderator heat fraction.
W9-R	QBMDCH	=	Bypass direct heat fraction.
W10-R	EWCH	=	Wall roughness.
W11-R	WCRECH	=	Total core flow (lbm/sec).
W12-I	IEQCH	=	Balance equation selection for the five-equation model (only used when NEWEQS = 1 on Card 01000Y). = 0, use five-equation model for the core (default) = 1, use four-equation model for the core
W13-I	IMPCH	=	Volume orientation flag for the five-equation model (only used when NEWEQS = 1 on Card 01000Y). = 0, vertical volume (default) = 1, horizontal volume = 2, horizontal volume with rectangular cross section
W14-I	MOCCH	=	MOC minimum particle resolution. (Required if IHQCH = 2)
W15-R	VELRCH	=	Ratio of core exit liquid velocity to core inlet liquid velocity. (Used only to estimate storage for the particle field. Storage is proportional to this number.) (Required if IHQCH = 2)

28.2 Edit Control Integer Data 670010

Neutronics information edits are controlled with the edit flags given below. Most edits are coupled to the RETRAN-3D major edit frequency.

W1-I	NED1	=	Input editing. = -1, No edit and no input reflection = 0, No = 1, Yes
W2-I	NED2	=	Rod position editing. = 0, No = 1, Every edit = 2, Every time step

W3-I	NED3	=	Reaction rates. = 0, No = 1, Every edit = 2, Every time step
W4-I	NED4	=	Flux editing. = 0, No = 1, Every edit = 2, Every time step
W5-I	NED5	=	Feedback values. = 0, No = 1, Every edit = 2, Every time step
W6-I	NED8	=	Nodewise XSEC. = 0, No = 1, Every edit = 2, Every time step
W7-I	NED9	=	Nodewise power. = 0, No = 1, Every edit = 2, Every time step
W8-I	NED11	=	Three-dimensional ADFS. = 0, No = 1, Yes
W9-I	NED14	=	Channel edit. = 0, Yes = 1, No

28.3 Floating Point Control Data 670020

Supply neutronics calculation floating point control information.

W1-I	NOTERS	=	Neutronics iterations per thermal-hydraulic feedback (5).
W2-I	MAXOUT	=	Maximum neutronics iterations (200). (If MAXOUT specified as negative, transient will continue even if SS neutronics does not converse in MAXOUT iterations.)

W3-I MAXRIT = Maximum thermal-hydraulic feedback iterations (50). (If MAXRIT specified as negative, transient will continue even if SS neutronics does not converge in MAXRIT feedback iterations.)

W4-I NCNCRS = Steady-state inner iterations per outer (4).

W5-I NCNCRT = TRANS inner iterations per outer (2).

W6-I IPURDU = The IPURDU flag was originally used to request use of the Purdue Numerical Method (PNM), which is now the only solution method available. Consequently, any value in the units place (Z) will be treated as if it were input as a 1. IPURDU is also used to request one of three different cross-section formulations that can be used. They are specified by use of the Y field in the tens place of IPURDU.

= YZ, Multifield flags are described below.

Z = PNM selection flag (unit's place digit).

= 1, Use PNM - all other values are treated as if entered as 1.

Y = Request flag (ten's place digit) for the cross-section formulation to use with the PNM.

= 0, or blank, use the standard BXF file format.

= 1, Use the NEMTAB style BXF file format (used in some OECD benchmark problems).

= 2, Use the special SPERT benchmark BXF file format.

The PNM requires additional integer and floating point data that control the performance. These additional data records are 670040 and 670041.

28.4 Integer Control Data 670021

W1-I NSERCH = Rod position search.

= 0, no search (default)

= N, move rod group N for position search

W2-I NBORON = Soluble boron concentration option (default=0).

= -N, soluble boron search (PWR's only) where |N| is the initial PPM guess

= N, fixed number of PPM of soluble boron

W3-I	NFREEZ	=	Feedback freeze option (default=0). = 0, no freeze - i.e., all feedback variables may affect the cross-section behavior after initial steady-state calculation = 1, freeze moderator temperature = 2, freeze fuel temperature = 3, freeze moderator density or void fraction = 4, freeze moderator and fuel temperatures = 5, freeze moderator density (or void fraction) and moderator temperature = 6, freeze moderator density (or void fraction) and fuel temperature = 7, freeze all three feedback variables = -1, freeze all three feedback variables (if specified) for the reflector regions = -2, freeze all three feedback variables (if specified) for the radial reflectors only
W4-I	NADJNT	=	Option to perform the adjoint calculation after the steady-state solution. = 0, Do not calculate (default) = 1, Calculate
W5-I	ISPECK	=	Truncated leakage treatment for compositions in double zero-flux corners. $\geq$ 0, Activate this option (default) < 0, Skip this option
W6-I	IEXPAN	=	Option to expand the core conductor volume and surface area to full core so as to match the reactor system flow and power. $\geq$ 0, Expand (default) < 0, Do not expand
W7-I	IFXISP	=	Calculation flag for fission product - Xenon, Iodine, Samarium, and Promethium (XISP) number densities. = 0, use preexisting XISP number densities which were calculated from the upstream depletion code. = 1, calculate equilibrium XISP number densities. = 2, set XISP number densities as zero.

28.5 Convergence Criterion Parameters 670030

W1-R	CONEIG	=	Eigenvalue convergence criterion.
W2-R	CONDEG	=	Eigenvalue derivative criterion.

W3-R	CONSRS	=	Steady-state pointwise convergence criterion.
W4-R	CONSRT	=	TRANS pointwise convergence criterion.
W5-R	CONPOW	=	Steady-state pointwise power convergence criterion.

28.6 Feedback Reference Data 670031

This card is supplied if NFREEZ is nonzero (input for all three values are required). For NFREEZ < 0, these values are feedback parameters for the reflector regions only and only values specified as nonzero trigger frozen feedback.

W1-R	FTMCON	=	Fixed value of moderator temperature to use in the calculation (°F).
W2-R	FTFCON	=	Fixed value of fuel temperature to use in the calculation (°F).
W3-R	FXXCON	=	Fixed value of moderator density to use in the calculation (lbm/ft^3).

28.7 Integer Parameters for Purdue Numerics Iteration Control 670040

The integers below allow the user to select various options that control the iteration performance of the PNM. This information is required.

W1-I	IFUPD	=	Flag for nodal update based on local cross-section change. The nodal update is passed on a relative comparison, for all nodes, of the maximum relative change of the total cross section for either group. If the total cross section changes by more than the amount defines by EPSXEC (Word 2-R, Record 670041), then a nodal update will be performed. = 0, Yes (default) = 1, No
W2-I	NODOPT	=	Method of solving the two-node problems for nodal update. = 1, nodal equivalence method (NEM) = 2, analytical nodal method (ANM) (default) NODOPT = 1 is recommended if the calculation shows irregular convergence, this is especially possible when the power in core periphery is high. If NODOPT = 1, the calculation will assume flat transverse leakage in the reflector region.
W3-I	NEMCY	=	Frequency of performing nodal update, i.e., the number of outer iterations before each nodal update (default = 5).

W4-I	IFSACC	=	Acceleration scheme for the fission source iteration. = 0, Wielandt Shift technique (default) = 1, Chebyshev polynomial
W5-I	ICHEB0	=	First outer iteration to begin fission source extrapolation if the Chebyshev acceleration technique is chosen (default = 3).
W6-I	IRAGGED	=	Flag of the ragged edge treatment. The ragged edge treatment refers to the method by which boundary nodes (Reflector Nodes) are treated. The ragged edge (0) option adds a single row of Radial Reflectors to the active core. The Ragged Edge (1) option solves the core as given, usually a full rectangular core. = 0, use the ragged edge treatment (default) = -1, do not use the ragged edge treatment

28.8 Floating Parameters for Iteration Control 670041

The floating point parameters are required and improve the solution under some circumstances, and/or to control the iteration and convergence performance for the PNM.

W1-R	EPSNEM	=	Criterion to turn on NEM in nodal update (default = 0.001). The choice of the solution scheme for the two-node problems is partially determined by the value of EPSNEM. If NODOPT = 2 and EPSNEM is very small, e.g., 0.00001, then only ANM will be used. It is suggested that do not specify EPSNEM too small because NEM calculation is required when there are critical nodes.
W2-R	EPSXEC	=	Criterion for performing nodal update based on cross-section change (default = 0.01). EPSXEC is a percent change among all nodes of the total cross section (Σ_{ts}).
W3-R	EPSL2	=	Convergence criterion on global fission source (default = 0.00001).
W4-R	EPSINF	=	Convergence criterion on local fission source (default = 0.0001).
W5-R	EPSR2	=	Convergence criterion on the relative *l*-2 norm of the residual vector of BICG iteration, used for transient calculation only (default = 0.001).
W6-R	EPSERF	=	Criterion of error reduction factor for nodal update (default = 0.005).
W7-R	ESHIFT	=	Eigenvalue shift value for the Wielandt shift acceleration scheme (default = 0.04).

W8-R	CETAK	=	The theta (θ) value for the kinetics calculation (default = 1.0). CETAK is the theta (θ) value used in the time differencing of the diffusion equations. CETAK = 0.5 (the Crank-Nicholson method) is recommended for rapid transients with large time-step sizes, e.g., the rod ejection transient with a 10 ms time-step size. CETAK = 1.0 is recommended for the transients that progress slowly, e.g., the PWR steam line break transient, or the problems that have very small time-step sizes, e.g., the rod ejection transient with a 1 ms time-step size.

28.9 The Fine Mesh Neutronics Calculation Option 670050

For a RETRAN-3D problem with multidimensional reactor kinetics calculation, the assembly mesh, neutronics mesh, and thermal-hydraulics mesh are defined in the CDI file. If the neutronics mesh is the same as the assembly mesh (NCOL=ID, NROW=JD, and NPLN=KD) in the CDI file, the user may want to define a finer mesh for the neutronics calculation. For example, to use four neutronics nodes per fuel assembly. This input card provides the capability of using a finer neutronics mesh than what was defined in the CDI file.

W1-I	IXTH	=	Number of neutronics nodes per assembly node in the X direction.
W2-I	IYTH	=	Number of neutronics nodes per assembly node in the Y direction.
W3-I	IZTH	=	Number of neutronics nodes per assembly node in the Z direction.

Note that the 670050 card is provided so that the user can define a fine neutronics mesh to override the coarse neutronics mesh defined in the CDI file. If the neutronics mesh in the CDI file is already finer than the assembly mesh, then RETRAN-3D will ignore this card and use the neutronics mesh defined in the CDI file.

28.10 Channel Map of Neutronics Code Fuel Assemblies 671XXY

A two-dimensional mapping is required to assign or overlay the RETRAN-3D channel data to the neutronics assembly layout in order to define regions from which thermal-hydraulic feedback data are obtained. A RETRAN-3D channel number is assigned to each neutronics assembly. In general, a one-for-one mapping is only possible for small problems and a typical RETRAN-3D problem may have many more neutronics regions than RETRAN channels. Thus, some user judgement will be required to overlay fewer RETRAN channels onto many neutronics regions. Record 671XXY requires the user to supply the RETRAN channel overlay in two dimensions. A RETRAN channel is supplied for each neutronics assembly. (This includes nonfueled channels such as baffles or bypass regions.) XX ranges from 1 to the maximum number of rows. Y is a card sequence number from 1 to 9.

All values are integer.

W(1) - W(ID)	This series describes the neutronics to RETRAN-3D channel map explicitly. Supply RETRAN-3D channel numbers for each neutronics column position for Neutronics Row 1. ID entries are required.
W(1*ID+1) - W(2*ID)	Supply RETRAN-3D channel numbers for each neutronics column positions for Neutronics Row 2. ID entries are required.
.	
W(JD-1)*ID+l - W(JD*ID)	Supply RETRAN-3D channel numbers for each neutronics column positions for the final neutronics row. ID entries are required.

28.11 Channel Data Cards 672XXX

Describe the plenum connections for each channel and the steady-state loss coefficients use flag. The channel normalized flow can be used to override the value in the CDI file for different initial conditions. The value of XXX ranges from 1 to 999 and should be sequential.

W1-I	INCHN	=	Channel inlet volume number.
W2-I	IOUTCH	=	Channel outlet volume number.
W3-I	KFLGCH	=	Unspecified loss coefficient flag (used by steady-state initialization). = 0, use CDI file value = 1, use -1.0 at channel inlet = 2, use -1.0 at channel outlet
W4-R	WJUNCH	=	Channel normalized flow.
W5-I	IGAPCH	=	Channel gap model flag. = 0, no gap model selected (default) = 1, use gap expansion model. This requires thermal expansion coefficient data. < 0, use dynamic gap conductance model, -IGAPCH = XX on 225XXY gap model card.
W6-I	IFITCH	=	Channel profile fit coefficient data set. Profile fit model is selected by IVOID (W36-I on 01000Y). = 0, use default profile fit coefficient data (default), > 0, user-specified profile fit coefficient data set, IFITCH = XX on 061XX1 profile fit data card.

W7-I IFRICH = Multi-field flag used to define optional turbulent and/or laminar wall friction model correlation number.
= 0, use the default turbulent and laminar friction models
= XXYY, multi-field flags described below.
XX = turbulent wall friction correlation number (XX on Card 2331XX)
= 0 or blank, the default turbulent model will be used.
YY = laminar wall friction correlation number (XX on Card 2332XX)
= 0, the default laminar model will be used.

W8-I IBYPCH = Bypass associated with channel. (Used for bypass heating option, only required if NBYP > 1.)

28.12 Cross-Flow Data Card 673XXX

The cross-flow data card is used to define lateral flow paths between adjacent thermal-hydraulic channels. The channel model can generate junction connections between channels using the cross-flow input fields described below. Four separate 673XXX cards will be required to connect a rectangular channel to its adjacent channels. The value of XXX ranges from 1 to 999 and should be sequential.

There are several rules that RETRAN-3D uses to construct the junctions. Junctions that are created by this model do not contain any two-dimensional or transverse momentum terms, i.e., they are the standard one-dimensional RETRAN-3D momentum formulation.

Cross-flow junctions are created at the same elevation as the channel junctions. There will be as many cross-flow junctions as normal flow junctions axially up the channel.

Cross-flow junction numbering rules are applied to avoid conflict with the internal channel junction numbers. For example the first cross-flow junction number defined from Card 673001 will be 1011, the second will be 1021 and so on until all axial locations are specified. The second set will begin with junction number 2011. In this scheme, the junctions are numbered as

XXX*1000 +10*K +1

where XXX is the cross-flow data set (card) number and K is the axial node number.

Note that this model applies to junctions connecting RETRAN-3D thermal-hydraulics channels, not neutronics fuel assemblies. In situations where the mapping between thermal-hydraulics channels is not ‘one-for-one’ with the neutronics assemblies, the cross-flow geometry may be distorted and the resultant flows may not reflect the physical situation.

The current implementation of the cross-flow model excludes use of the iterative PNM numerical solution option (Card 380000) for the thermal-hydraulics equations.

Previous studies have shown that a complete core wide kinetics model with cross flows can take significant computational time.

W1-I	INCRS	=	Inlet channel number.
W2-I	IOUTCR	=	Outlet channel number.
W3-R	FACRS	=	Cross-flow area.
W4-R	RKFCRS	=	Cross-flow forward loss coefficient.
W5-R	RKRCRS	=	Cross-flow reverse loss coefficient.
W6-R	DHYCRS	=	Cross-flow hydraulic diameter.
W7-R	CNTCRS	=	Cross-flow channel-to-channel centriod distance.
W8-R	WJNCRS	=	Cross-flow initial flow rate.

28.13 Control Rod Control Block Assignment 6740XX

RETRAN-3D control system control block identification numbers are assigned to each neutronics control rod group to specify dynamic control rod positions. The output from the RETRAN-3D control system block provides time-dependent rod tip positions for use by the neutronics code. The current implementation requires that the rod position is in units of centimeters. ICRDS must be a negative value to represent RETRAN control block identification numbers.

In cases where transient rod motion is not considered and the user does not desire to supply any information beyond that specified in the basic neutronics code input file for initial rod positions, this card is not supplied.

XX is a card sequence number ranging from 1 to 99. In general, NGRPS values are required where NGRPS is the number of independent control rod groups.

W1-I	NGP	=	Group number.
W2-I	COUT	=	Control block IDs (controls change in rod position).
W3-I	NGP	=	Group number.
W4-I	COUT	=	Control block IDs.

28.14 Core Bypass Description 675XXY

A bypass models the path through the radial reflector region of the core. More than one bypass can be defined in a model. In a bypass, the user must associate a thermal-hydraulic volume with each kinetics node to allow feedback for the kinetics solution. The number of axial kinetics nodes in the bypass is the number of axial nodes in the core plus any top or bottom reflector planes. In a bypass, a single thermal-hydraulic volume can be associated with more than one kinetics node. The data on Card 675XXY is input in sets, NVOL and NODE. NVOL is thermal-hydraulic volume number and NODE is the range of kinetics nodes to be associated with NVOL. To define NODE count the kinetics nodes starting from the bottom working upward through the total number axial nodes in the reflector. For each set, volume NVOL is associated with the previous NODE value plus 1 through the current value of NODE value. XX ranges from 1 to NBYPSS (Card 67000Y).

W1-I	NVOL	=	Volume number.
W2-I	NODE	=	Last node associated with NVOL.
W3-I	NVOL	=	Volume number.
W4-I	NODE	=	Last node associated with NVOL.

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28.15 Boron Injection Assignment 6760XX

There are two methods by which boron injection may be modeled. If the user desires to model boron injection in a manner that is similar to other neutronics code methods, RETRAN-3D control block identification numbers are supplied. The output from the control blocks are the concentration (in PPM) of the soluble boron at specific locations in the three-dimensional core. If this option is used, the entire core wide specification must be described and can involve a great deal of repetitive data input.

As an alternate, the RETRAN-3D generalized transport model (Word 41 (IGNTR) on Input Record 01000Y) may also be used. Additional data, 4520XX, 4530XX, and 454001 are required but field 6760XX is not required. The model assumes that boron is the particulate for transport and the boron concentration will be used by the neutronics cross-section generation routines.

Control block specification. All values are integer control block IDs. XX ranges from 1 to number of RETRAN channels.

W(1)-W(KD)	=	Supply RETRAN-3D control system IDs for all volumes in RETRAN-3D Channel 1. KD entries are required.

W(1*KD+1) - W(2*KD)	=	Supply RETRAN-3D control system IDs for all volumes in RETRAN-3D Channel 2. KD entries are required.
W((NCHANL-1)*KD+1)-W(NCHANL*KD)	=	Supply RETRAN-3D control system IDs for all volumes in the last RETRAN-3D channel. KD entries are required.

29.0 CONTROL SYSTEM MODELS

The response of various plant systems may have a large effect on the overall system response depending on the particular transient being analyzed. For example, in a BWR loss of feedwater heater transient, an accurate simulation of the feedwater flow response is necessary because of its large effect on the reactivity feedback. RETRAN-3D provides the capability to model a variety of such reactor control systems. The RETRAN-3D control system model models the dynamics of linear control systems. In addition, nonlinear characteristics of control elements, such as clipping, saturation, and recovery time after saturation can be modeled. These additional capabilities allow easy representation of the various controllers in common use, such as a proportional-integral-derivative (PID) controller, or any arbitrary transfer function desired by the user.

Control elements available to the user include all of the more common analog computer elements plus a few that an analog computer can model only with difficulty. The types of elements available include integrators, differentiators, weighted summers, multipliers, dividers, delays, and function generators. The choice of components and their interconnections are specified via input data and may be completely arbitrary.

29.1 Model Description

Table IV.29-1 defines the nomenclature used to describe the control system model. The letter "x" refers to signals related to the input of a control block. The letter "y" refers to signals related to the output of a control block. The letter "h" refers to time-step intervals. A scale factor "G" is used by all control blocks.

Table IV.29-2 presents the mathematical definition for each control block. The output is expressed either explicitly, as a function of the input, or implicitly, as the solution of a differential equation where the input is a given function of time. In addition, Table IV.29-2 briefly describes the numerical approximations used by the RETRAN-3D coding to represent the control block.

The object of a control system model is to determine the output of a system given the input and information characterizing the system. The input is a given function of time and the output is a function of time to be determined. When the input and output time functions can be related by a linear differential equation, the system is said to be linear. If information concerning the state of the system in terms of the initial output is known, the differential equation can be solved for the

Table IV.29-1

Control System Model Nomenclature

$F_m[\ ]$	=	functional relation defined by the user via pairs of values of the independent and dependent variables in General Data Table m (12XXYY cards).
g_1, g_2	=	user-specified gains which apply to input 1 and input 2 respectively; these gains are used by SUM block only
G	=	user-specified value for the overall gain of a control block
h_{i+1}	=	$t_{i+1} - t_i$, the ith time interval
i	=	subscript used to denote values evaluated at i^{th} value of time
IDC	=	control block identification number
m	=	General Data Table index; only the FGN block uses m
n	=	user-specified integer value denoting the number of samples taken and saved per delay interval; only used for the DLY block
s	=	complex frequency (radians per second)
t	=	time (seconds)
t'	=	dummy variable representing time
t_i	=	i^{th} value of time
t_{i+1}	=	$(i+1)^{th}$ value of time
T	=	delay time interval; T is used by a DLY block only
v_{down}	=	user-specified maximum negative rate of change for control block output, maximum "downward slew rate"; only the VLM block uses v_{down}
v_{up}	=	user-specified maximum positive rate of change for control block output, maximum "upward slew rate"; only the VLM block uses v_{up}
x_i	=	value of x_1 (t) when $t=t_i$
x_0	=	value of x_1 (t) when t=0

Table IV.29-1 (Cont'd)

$x_1(t)$	=	input 1 of control block represented as a function of time
$x_2(t)$	=	input 2 of control block represented as a function of time
$y(t)$	=	output of control block represented as a function of time
y_i	=	value of y(t) when $t=t_i$
y_{i+1}	=	value of y(t) when $t=t_{i+1}$
y_{max}	=	user-specified maximum value of y(t)
y_{min}	=	user-specified minimum value of y(t)
y_0	=	value of y(t) when t=0
α	=	ratio of time-step sizes, h_{i+1} to h_i
τ_1	=	lead time constant
τ_2	=	lag time constant

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Table IV.29-2

Models for Control Blocks

Symbol	Descriptive Name	Mathematical Definition	Numerical Approximation Used by RETRAN
ABS	Absolute Value	$y(t) = G\|x(t)\|$	$y_{i+1} = G\|x_{i+1}\|$
DER	Differentiator	$y(t) = G\,\frac{dx(t)}{dt}$	$y_{i+1} = G\left(\frac{x_{i+1} - x_i}{h_i}\right)$
DIV	Divider	$y(t) = G\,\frac{x_1(t)}{x_2(t)}$	$y_{i+1} = G\left[\frac{x_1(t_{i+1})}{x_2(t_{i+1})}\right]$
DLY	Time Delay	$y(t) = y_0$ for $0 \le t \le T$ $= G\,(t-T)$ for $t > T$	Numerical approximation used is described in the Theory Manual.
FNG	Function Generator	$y(t) = G\,F_m\,[x(t)]$	$y_{i+1} = G\,F_m\,[(x_{i+1})]$ where F_m represents linear interpolation over a table of ordered pairs of independent and dependent variables.
INT	Integrator	$y(t) = y_0 + G\int_0^t x(t')\,dt'$	$y_{i+1} = y_i + \frac{1}{2}G\,(x_{i+1} + x_i)\,h_{i+1}$ with y_0 given.
F2D	Two-Dimensional Interpolation	$Z(t) = F[x(t), y(t)]$	Numerical approximation described in text in the Theory Manual.

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Table IV.29-2 (Cont'd)

Symbol	Descriptive Name	Mathematical Definition	Numerical Approximation Used by RETRAN
LAG	Lag Compensation with $y(0) = y_0$	$y(t) + \tau_2 \frac{dy(t)}{dt} = G\, x(t)$	$y_{i+1} = \frac{(2\tau_2 - h_{i+1})\, y_i + G\,(x_{i+1} + x_i)\, h_{i+1}}{2\tau_2 + h_{i+1}}$
LLG	Lead-Lag with $y(0) = y_0$	$y(t) + \tau_2 \frac{dy(t)}{dt} = \left(G x_1(t) + \tau_1 \frac{dx_1(t)}{dt} \right)$ with y_0 given	$y_{i+1} = \frac{(2\tau_2 - h_{i+1}) y_i + G\left[(2\tau_1 + h_{i+1}) x_{i+1} + (-2\tau_1 + h_{i+1}) x_i\right]}{2\tau_2 + h_{i+1}}$
LN	Natural Logarithm	$y(t) = \ln\left[x(t) \right]$	$y_{i+1} = G\left[\ln\left(x_{i+1} \right) \right]$
MUL	Multiplier	$y(t) = x_1(t)\, x_2(t)$	$y_{i+1} = G\left[x_1\left(t_{i+1} \right)\, x_2\left(t_{i+1} \right) \right]$
MAX	Maximum	$y(t) = \max\left[x_1(t), x_2(t) \right]$	$y_{i+1} = G\left\{ \max\left[x_1\left(t_{i+1} \right), x_2\left(t_{i+1} \right) \right] \right\}$
MIN	Minimum	$y(t) = \min\left[x_1(t), x_2(t) \right]$	$y_{i+1} = G\left\{ \min\left[x_1\left(t_{i+1} \right), x_2\left(t_{i+1} \right) \right] \right\}$
RAT	Rate	$y(t) + \tau_2 \frac{dy(t)}{dt} = G \frac{dx(t)}{dt}$	$y_{i+1} = \frac{(2\tau_2 - h_{i+1})\, y_i + 2G\,(x_{i+1} - x_i)}{2\tau_2 + h_{i+1}}$

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Table IV.29-2 (Cont'd)

Symbol	Descriptive Name	Mathematical Definition	Numerical Approximation Used by RETRAN
STF	Second-Order Transfer Function	$y(t) + \tau_2 \frac{dy(t)}{dt} + \tau_1 \frac{d^2 y(t)}{dt^2} = Gx(t)$	$y_{i+1} = \frac{\left[\frac{2\tau_1}{\alpha h_i^2} + \frac{\tau_2}{h_{i+1}} - \frac{1}{2}\right] y_i - \left[\frac{2\tau_1}{(1+\alpha)h_i^2}\right] y_{i-1} + \frac{G}{2}(x_{i+1} + x_i)}{\left[\frac{2\tau_1}{\alpha(1+\alpha)h_i^2} + \frac{\tau_2}{h_{i+1}} + \frac{1}{2}\right]}$
SUM	Weighted Summer	$y(t) = G\left[g_1 x_1(t) + g_2 x_2(t)\right]$	$y_{i+1} = G\left[g_1 x_1(t_{i+1}) + g_2 x_2(t_{i+1})\right]$
SMN	Super Minimum	$y(t) = MIN\left[x_1(t), x_2(t), ..., x_n(t)\right]$	$y_{i+1} = G\left\{MIN\left[x_1(t_{i+1}), x_2(t_{i+1}), ..., x_n(t_{i+1})\right]\right\}$
SMX	Super Maximum	$y(t) = MAX\left[x_1(t), x_2(t), ..., x_n(t)\right]$	$y_{i+1} = G\left\{MAX\left[x_1(t_{i+1}), x_2(t_{i+1}), ..., x_n(t_{i+1})\right]\right\}$
SSM	Super Summer	$y(t) = G\left[x_1(t) + x_2(t) + ... + x_n(t)\right]$	$y_{i+1} = G\left[x_1(t_{i+1}) + x_2(t_{i+1}) + ... + x_n(t_{i+1})\right]$
VLM	Velocity Limiter where	$y_i = y_{down}$ if $Gx_i < y_{down}$ $= y_{up}$ if $Gx_i > y_{up}$ $= Gx_i$ otherwise $y_{down} = y_{i-1} - h_i \lvert v_{down} \rvert$ $y_{up} = y_{i-1} + h_i \lvert v_{up} \rvert$	same as mathematical definition
XPO	Exponentiation	$y_i = \left[x_1(t)\right]^{x_2(t_i)}$	$y_i = \left[x_1(t_i)\right]^{x_2(t_i)}$

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output given an arbitrary input. The DER, INT, LAG, LLG, RAT, and STF control blocks represent systems which are linear. RETRAN solves the differential equation characterizing the DER block by using a forward difference approximation and solves the equation for the other linear blocks using a two-point trapezoid approximation. Solving the resulting difference equation for y_{i+1} in terms of x_{i+1}, x_i, y_i, and h_{i+1} represents an explicit formula for calculating the output of each block for each time step. This formula applies as long as the linear difference equation is a good approximation to the differential equation and the differential equation accurately represents the actual hardware.

In reality the input-output relation of the hardware can be represented by a linear system over only a finite range. To model this nonlinear characteristic, RETRAN assumes that a control block is linear whenever its output is greater than y_{min} and less than y_{max}. If the linear model predicts an output greater than y_{max}, then the output is assumed to be equal to y_{max}. If the linear model predicts an output less than y_{min}, then the output is y_{min}. The user specifies the parameters y_{min} and y_{max}. In addition, RETRAN provides nonlinear control blocks such as the FNG and VLM blocks to allow the user to model other types of nonlinear behavior which may be in the hardware.

The numerical approximations used for the control blocks are straight-forward. The DER, INT, LAG, LLG, RAT and STF blocks were discussed above. The ABS, DIV, MUL, SMN, SMX, SSM, and SUM blocks simply take the inputs at time t_i and perform the operations indicated by their names to calculate the output. The FNG and FZD blocks take the input at time t_i and linearly interpolate over the user-supplied table(s) to calculate the output. The VLM block calculates the maximum and minimum values the output may have without exceeding the user-specified rate limitations and calculates the output according to the conditions described in Table IV.29-2.

The FZD control block provides a two-dimensional interpolation capability. It is used to give $Z = F(x,y)$, where F is described pointwise through a combination of three general data tables. Two of these data tables are used to describe a rectangular grid of points. The third table contains the functional values assigned to each one of these grid points. For any point (x,y) within the rectangular grid, the functional value is then found by two-dimensional interpolation within the four-point grid space enclosing the point (x,y). The first step in the interpolation is to find four points on the grid, (x_i,y_j), (x_{i+1},y_j), (x_i,y_{j+1}) and (x_{i+1},y_{j+1}), such that the rectangle formed by these points encloses the point (x,y). For each of y_j and y_{j+1}, the functional valves are converted to $Z(x_i)$ and $Z(x_{i+1})$ on which x is interpolated to give $Z(x_i,y_j)$ and $Z(x_j,y_{i+1})$. This resulting pair of points is then interpolated with respect to y to give $Z = F(x,y)$. Hence, this process may be thought of as a two-step linear interpolation within the four bounding points.

The method used to model the DLY block is conceptually simple, but difficult to describe symbolically. The details are described here to explain the significance of the n parameter required by the DLY block. The DLY block stores the values of the input for the past T seconds. The output of the DLY block at time t_i is the input that it had at time $(t_i - T)$ multiplied by the scale factor G. The manner in which the DLY block stores the input values is to make a stepwise continuous function out of the input, sample the input at fixed time intervals equal to (t/n), and save each sample for T seconds. Thus, n is equal to the number of samples of the input the DLY block has stored over the past T seconds. A larger value of n results in a more accurate

representation of the past input at the cost of more storage. The user should strive to choose the smallest value of n consistent with acceptable accuracy.

29.2 Limitations, Precautions, and Instructions

The OUT block does not represent an actual control element. Its function is to provide the user with a convenient means to monitor the output of any control block output or control input for the purposes of debugging. Use of the OUT block will result in the printing of the output of the specified control block or control input signal at every time step.

From Table IV.29-2 it can be seen that the control blocks which have to be initialized are only the DLY, INT, LAG, LLG, STF, and VLM blocks. These are the only blocks which require past values of the output to calculate the new value of the output y_i. However, it is recommended that all control blocks and all control inputs be assigned an initial value of output by the user on the input data cards. Control block initial values may be used as initial values for variables that control blocks can control. For instance, initial junction form loss coefficients and conductor heat transfer coefficients are obtained from the initial control block specification of the block controlling them. Also control blocks that are monitored by trips require an initial specification. It is recommended that the user initialize all values as accurately as practical. If the user wishes to cut corners, he may choose the initial value such that no trip monitoring that control signal will be activated by the initial value input. The consequence of this approach is to delay by one time step the actuation of a trip which might have occurred at time zero.

29.3 Control System Solution

The equations representing the control blocks contained in a control system are stored in a matrix in the following form:

$$Ak = C$$

where A is the coefficient matrix, k is the unknown output and C is the known input. The matrix is solved one equation at a time using a Gauss-Seidel iterative solution. This solution technique uses only the nonzero elements of the matrix, requiring less storage space. Solution convergence is determined by comparing the computed output with the output of the previous iteration. The iterations are continued until a converged solution is obtained. A maximum of 20 iterations are allowed.

Solving the control block equations simultaneously results in several differences between RETRAN-3D and RETRAN-02. With the Gauss-Seidel method of RETRAN-3D, the solution is no longer dependent on the order in which the control blocks were input. In addition, the equations can be solved at the n+1 time level with the iterative technique.

The control system model is available in both RETRAN-02 and RETRAN-3D. However, a number of functional improvements have been made in RETRAN-3D related to the control system modeling capability. First, four new blocks have been added; they are an absolute value block, a rate block, a second-order transfer function block, and a two-dimensional function

generator block. The most significant improvement in the RETRAN-3D control system model is the numerical solution scheme employed to solve the governing equations for the various control blocks. In RETRAN-3D the governing equations are treated as a system of coupled equations that are solved using matrix techniques, where as RETRAN-02 uses an explicit method that simply solves one equation at a time in the order defined in the input. This may lead to a situation where the results are dependent on the block ordering.

While the improved RETRAN-3D solution method is order independent and all unknowns are updated consistently to the new time level values, it may lead to differences when attempting to perform RETRAN-02 mode (RETRAN-3D) comparisons with RETRAN-02. In the event that differences in the control system results are observed, it may be necessary to re-evaluate the RETRAN-02 control system model by using smaller time steps or rearranging the block order. Another option is to force the control system to use a smaller time-step size than the hydrodynamics.

Many control system models contain feedback loops where the output of a control block is used as the input for a previous control block. The Gauss-Seidel solution method used in RETRAN-3D may not converge for this situation. If the control system solution fails to converge, it may be necessary to increase the iteration count, ITMAX, found on the Control System Problem Dimensions Data Card 701000.

Another approach that helps to obtain a converged solution requires a slight modification to the input model. Where feedback loops occur, the block output that is fed back should first be fed into a control input that then replaces the direct feedback signal input. This clamps the feedback input to the previous time-step value, which remains constant during the Gauss-Seidel solution.

A final solution for reducing convergence problems is to reduce the convergence criterion, CNTEPS, also found on the Control System Problem Dimensions Data Card 701000. This is a quick fix that can be helpful for initial debug, but is not recommended as a long-term solution.

29.4 Control System Problem Dimensions Data Card 701000

The Control System Problem Dimensions Data Card (701000) is an optional data card. If the data card is omitted, the program will determine the number of control inputs (NCI) and the number of control blocks (NCB) that are supplied in the input deck.

W1-I	NCI	=	Number of control input definition cards supplied. If > 0, NCI must agree with the number of 702XXX cards supplied. If NCI is input as 0, the RETRAN will count the control input cards. (Default = 0)
W2-I	NCB	=	Number of control block description cards supplied. If > 0, NCB must agree with the number of 703XXX cards supplied. If NCB is input as 0, RETRAN will count the control input cards. (Default = 0.)

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W3-R	DTCMAX	=	Maximum time-step size for control system
W4-R	CNTEPS	=	Control system solution convergence criteria. (Default = 0.0005).
W5-I	ITMAX	=	Number of iterations for control system solution convergence (Default = 20).
W6-I	INIT	=	Control system solution option flag. ≤ 0, Use RETRAN-3D solution method which is independent of control block numbering order and gives steady-state conditions for LAG, LLG, VLM, DLY, DER, and STF block outputs. (Default = 0.) = 1, Use appropriate RETRAN-02 solution method which provides a method to reproduce RETRAN-02 initial conditions and transient results for the blocks identified above. > 1, Use RETRAN-02 method but make INIT initializing calls to the control system solution. In RETRAN-02, a single initializing call is made after steady-state allowing one pass through the control system solution to set initial control block out. By default in RETRAN-02, a single initializing call is made after the thermal-hydraulic steady-state initialization is complete, allowing one pass through the control system solution. If INIT > 1, INIT calls are made to provide a more converged initial control system solution, in addition to using the RETRAN-02 solution method.

29.5 Control Input Definition Data Cards 702XXX

The Control Input Definition Data Cards specify the input variables which the control system is to monitor and assign a unique identification number (IDC) to each variable. IDC may have any integer value greater than or equal to 1 and need not have any relation to XXX. XXX need not start at 001 and need not be consecutive. If an identical value of IDC is used on more than one card, the last such card will replace all earlier definitions.

W1-I	IDC	=	Control input ID or identification number (IDC ≥ 1)
W2-A	CSYM	=	Variable symbol. See tables in Section IV.4. All variables in these tables plus CONS can be used.
W3-I	IREG	=	Region number. See tables in Section IV.4. (For CONS block type IREG is 0.)
W4-R	GAIN	=	Input gain (gain is value of constant if CONS block type is specified)

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W5-R	CIC	=	Optional input retained for consistency with RETRAN-02 input (default = 0.0) If the user defines a system parameter, such as a fill enthalpy, with a control input rather than a control block, this CIC value may be required for correct steady-state initialization.

29.6 Control Block Description Data Cards 703XXX

The Control Block Description Cards select the types of control blocks the user needs, assign a unique identification number (IDC) to each block, specify the values of parameters for each block, and describe the interconnections between all blocks and all input variables. IDC need not have any relation to XXX. XXX need not start at 001 and need not be consecutive. The types of control blocks the user may select are listed in Table IV.29-3. The number of control parameters needed to describe each block depends on the block type. These parameters are outlined in Table IV.29-3. Each block has only one output; therefore, the output of a block may be referenced by the IDC of the block. This allows the interconnections of the blocks to be specified by associating each input of a block with the IDC of the block whose output provides the input.

W1-I	IDC	=	Control Block ID or identification number ($-NCB \leq IDC \leq -1$)
W2-I	ITYPE	=	Control Block type = ABS for absolute value (INC1) = DER for differentiator, s = DIV for divider, (INC1)/(INC2) = DLY for delays, e^{-Ts} = FNG for function generator with no dynamic response = F2D for two-dimensional function generator = INT for integrator, 1/s = LAG for lag network, $(1/1+\tau_2 s)$ = LLG for lead-lag network, $(1+\tau_1 s)/(1+\tau_2 s)$ = LN for natural logarithm, 1n((INC1)) = MAX for Max((INC1), (INC2)) = MIN for Min((INC1), (INC2)) = MUL for multiplier, (INC1)*(INC2) = OUT for listed output of control blocks and input signals at each time step = RAT for rate network, (INC1 with time constant CP1) = STF for second-order transfer function, $(1/1 + \tau_2 s + \tau_1 s^2)$ = SUM for sum of two inputs, $g_1(INC1) + g_2(INC2)$ = SMN for minimum of several inputs (requires 704XXX data card)

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Table IV.29-3

Control Block Parameters

Symbol	Description	INC1	INC2	CGAIN	CP1	CP2	CIC	CMIN	CMAX
ABS	Absolute value	IDC for $x_1(t)$	0	G	0.0	0.0	y_0	y_{min}	y_{max}
DER	Differentiator	IDC for $x_1(t)$	0	G	0.0	0.0	y_0	y_{min}	y_{max}
DIV	Divider	IDC for $x_1(t)$	IDC for $x_2(t)$	G	0.0	0.0	y_0	y_{min}	y_{max}
DLY	Time delay	IDC for $x_1(t)$	n	G	T	0.0	y_0	y_{min}	y_{max}
FNG	Function generator	IDC for $x_1(t)$	m	G	0.0	0.0	y_0	y_{min}	y_{max}
F2D	Function generator (two-dimensional)	IDC for $x_1(t)$	IDC for $x_2(t)$	Table index	Table index	Table index	y_0	y_{min}	y_{max}
INT	Integrator	IDC for $x_1(t)$	0	G	0.0	0.0	y_0	y_{min}	y_{max}
LAG	Lag compensation	IDC for $x_1(t)$	0	G	τ_2	0.0	y_0	y_{min}	y_{max}
LLG	Lead-lag compensation	IDC for $x_1(t)$	0	G	τ_1	τ_2	y_0	y_{min}	y_{max}

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Table IV.29-3 (Cont'd)

Symbol	Description	INC1	INC2	CGAIN	CP1	CP2	CIC	CMIN	CMAX
LN	Natural logarithm	IDC for $x_1(t)$	0	G	0.0	0.0	y_0	y_{min}	y_{max}
MAX	Maximum	IDC for $x_1(t)$	IDC for $x_2(t)$	G	0.0	0.0	y_0	y_{min}	y_{max}
MIN	Minimum	IDC for $x_1(t)$	IDC for $x_2(t)$	G	0.0	0.0	y_0	y_{min}	y_{max}
MUL	Multiplier	IDC for $x_1(t)$	IDC for $x_2(t)$	G	0.0	0.0	y_0	y_{min}	y_{max}
OUT	Output	IDC for $x_1(t)$	IDC for $x_2(t)$	-	-	-	-	-	-
RAT	Rate	IDC for $x_1(t)$	0	G	τ_2	0.0	y_0	y_{min}	y_{max}
STF	Second-Order Transfer Function	IDC for $x_1(t)$	0	G	τ_1	τ_2	y_0	y_{min}	y_{max}
SMN	Super Minimun	Input Index	Format Flag	G	0.0	0.0	y_0	y_{min}	y_{max}
SMX	Super Maximum	Input Index	Format Flag	G	0.0	0.0	y_0	y_{min}	y_{max}
SSM	Super Summer	Input Index	Format Flag	G	0.0	0.0	y_0	y_{min}	y_{max}
SUM	Weighted summer	IDC for	IDC for	G	g_1	g_2	y_0	y_{min}	y_{max}

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Table IV.29-3 (Cont'd)

Symbol	Description	INC1	INC2	CGAIN	CP1	CP2	CIC	CMIN	CMAX
VLM	Velocity limiter	IDC for $x_1(t)$	0	G	v_{up}	v_{down}	y_0	y_{min}	y_{max}
XPO	Exponentiation	IDC for $x_1(t)$	IDC for $x_2(t)$	G	0.0	0.0	y_0	y_{min}	y_{max}

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		=	SMX for maximum of several inputs (requires 704XXX data card)
		=	SSM for sum of several inputs (requires 704XXX data card)
		=	VLM for rate limited output,- |DOWNLIM| < (dy/dt) < |UPLIM|
		=	XPO for exponentiation, (INC1)**(INC2) NOTE: (INC1) and (INC2) denote the output of control blocks with ID equal to INC1 and INC2, respectively.
W3-I	INC1	=	Input ID (INC1 $\geq$ 1) for input signals (INC1 $\leq$ 1) for control blocks
		=	Input ID for x value if ITYPE = F2D
		=	XXX on 704XXX data card if ITYPE = SSM, SMN, or SMX
W4-I	INC2	=	Input ID for second input if ITYPE = SUM, MUL, or OUT
		=	General Data Table index if ITYPE = FNG (XX on Card 12XXYY)
		=	Number of samples in delay interval if ITYPE = DLY
		=	Input ID for divisor if ITYPE = DIV
		=	Input ID for exponent if ITYPE = XPO
		=	0 otherwise
		=	Input ID for y value if ITYPE = F2D
		=	Input format flag if ITYPE = SSM, SMN, or SMX (see Section 29.7 for a description).
			NOTE: If ITYPE = OUT, the following parameters may be omitted.
W5-R	CGAIN	=	General table index for x values if ITYPE = F2D
		=	0.0 if ITYPE = OUT
		=	Gain at output for all other blocks
W6-R	CP1	=	Control parameter 1
		=	T time delay (sec) if ITYPE = DLY and CP2 = 0.0
		=	0.0 if variable time delay (CP2 $\neq$ 0.0), ITYPE = DLY
		=	General table index for y values if ITYPE = F2D
		=	τ_2 lag time constant (sec) if ITYPE = LAG
		=	τ_1 lead time constant (sec) if ITYPE = LLG
		=	τ_2 time constant (sec^{-1}) if ITYPE = RAT

		=	g_1, gain on input INC1 if ITYPE = SUM UPLIM per sec if ITYPE = VLM
		=	0.0 otherwise
W7-R	CP2	=	Control parameter 2
		=	General table index for z values if ITYPE = F2D
		=	τ_2 lag time constant (sec) if ITYPE = LLG g_2, gain in input INC2 if ITYPE = SUM
		=	DOWNLIM per sec if ITYPE = VLM
		=	Control block ID when time delay is to be controlled by another control block if ITYPE = DLY
		=	0.0 otherwise
W8-R	CIC	=	Output initial conditions
		=	0.0 if ITYPE = OUT
			NOTE: The following parameters may be omitted, in which case they will assume their default values.
W9-R	CMIN	=	Output minimum limit. Default = -10^{+75}
W10-R	CMAX	=	Output maximum limit. Default = $+10^{+75}$

29.7 Super Block Data Cards 704XXX

The super block data cards specify input for a super minimum (SMN), super maximum (SMX), or super summer (SSM) control block. For a super control block INC1 (W3-I on 703XXX) defines the super summer data card (INC1 = XXX on 704XXX). INC2 (W4-I on 703XXX) specifies the format on Data Card 704XXX. If INC2 = 0, the super summer data are a series of like minor edits; the first word, W1-A, is the minor edit symbol and the remaining words, W2-I...Wn-I, are the series of minor edit regions to sum. INC2 = 1 is used when the mirror edit symbols are not the same. The data are pairs of minor edit symbols and regions to be summed. INC2 = 2 is used when a single minor edit variable and the region numbers are sequential. The data are the minor edit symbol and a lower and upper limiting region number.

If INC2 = 0:

W1-A	=	Minor edit symbol (i.e., FMAS, TEMP)
W2-I	=	First minor edit region to sum
.		
.		
.		
Wn-I	=	Last minor edit region to sum

If INC2 = 1:

W1-A	=	First minor edit symbol
W2-I	=	First minor edit region
.		
.		
.		
Wn-1-A	=	Last minor edit symbol
Wn-I	=	Last minor edit region

If INC2 = 2

W1-A	=	Minor edit symbol
W2-I	=	Lower limit minor edit region
W3-I	=	Upper limit minor edit region

29.8 Extended Control Input Definition Data Cards 702XXXX

The extended control input definition data cards are identical to the 702XXX cards. The extended cards make more control inputs available to the user.

29.9 Extended Control Block Description Data Cards 703XXXX

The extended control block description data cards are identical to the 703XXX cards. The extended cards make more control blocks available to the user.

30.0 PWR AUXILIARY DNB CALCULATION

The majority of the transients to be analyzed will not exceed the critical heat flux (CHF) for hot rod conditions. Indeed, acceptable margin above the Minimum Departure from Nucleate Boiling Ratio (MDNBR) is a design requirement for the less severe PWR plant transients. For such transients a detailed core-wide DNB analysis is not required. These transients can be analyzed via a subchannel model available in RETRAN. The subchannel model in RETRAN is not intended to replace a detailed analysis and should be used only for scoping studies. This model performs a separate hydraulic analysis on a single hot subchannel using RETRAN boundary conditions during the transient. The DNB option is applicable only to a model with three or more conductor core nodes. Input of the DNB routine consists of modeling options, miscellaneous input, and standard heat flux and hot channel factors commonly used in DNB analyses for PWRs. Model options available include common CHF correlations, an axial correction factor for CHF, a grid space flow mixing correlation, an approximation for turbulent cross flow mixing, and a "cold wall" CHF correction factor. A summary of the model is presented in Table IV.30-1.

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Table IV.30-1

PWR Auxiliary DNB Modeling

Model	Formation
Subchannel array	Single channel, normalized to multiple subchannel array
Heat flux factors and flow redistribution factors	Input from design assumptions or detailed hydraulic analysis
Engineering enthalpy rise factor	Output at initialization of RETRAN
CHF correlations	B&W-2, W-3, MacBeth, Barnett, Janssen and Levy, or Bowring correlations
Nonuniform axial power shape correction	B&W or Westinghouse available, values vary with time and position
Grid spacer mixing and cold wall effects	Westinghouse correlations available
DNB calculation	Calculated at three-inch intervals between input axial limits
Subchannel mass velocity	Varies with time and position as interpolated from RETRAN

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30.1 Auxiliary DNB Problem Dimension Data Cards 8001XX

The problem dimension data cards must be entered only if IDNBC (Card 01000Y) is greater than 0. XX is a sequence number which may range from 00 to 99.

W1-I	LWR	=	Reactor type = 0, Auxiliary DNB routine not used = 1, PWR = 2, BWR
W2-I	ICW	=	Flag for cold wall = 0, no correction, recommended choice = 1, Westinghouse correlation (use only with W-3 correlation)
W3-I	NUH	=	Flag for heat flux profile correction, F factor = 0, Uniform profile = 1, Westinghouse correlation = 2, B&W correlation
W4-I	ICHF	=	Flag for CHF correlation = 0, Flag not used = 1, W-3 correlation = 2, B&W-2 correlation = 3, MacBeth correlation = 4, Barnett correlation = 5, Bowring correlation = 6, Janssen and Levy correlation
W5-I	ISPCR	=	Flag for spacer grid = 0, Nonmixing vane grid correlation = 1, Westinghouse R-Grid mixing vane correlation (use only with W-3 correlation) = 2, Westinghouse L-Grid mixing vane correlation (use only with W-3 correlation)
W6-I	NOA	=	Number of axial profile data sets
W7-I	N1	=	Number of volumes used for the DNB calculation

30.2 DNB Peaking Function Data Card 8002XX

The data cards must be entered only if IDNBC (Card 01000Y) is greater than 0. XX is a sequence number which may range from 00 to 99.

W1-R	FQENG	=	Engineering heat flux factor, F_Q^E
W2-R	FRN	=	Total nuclear radial heat flux factor, either for the hot rod (PWR), F_R^N x F_L^N, or for the average hot bundle (BWR), F_R^N.
W3-R	FQUNC	=	Heat flux uncertainty factor, F_Q^{UN}
W4-R	FDHCOR	=	Adjustment factor on hot bundle mass flux.
W5-R	FDELH	=	Channel enthalpy adjustment factor to account for the effects of turbulent cross flow enthalpy mixing.
W6-R	ZMIN	=	Minimum height of channel for CHF calculation (ft), (must be > 0.)
W7-R	ZMAX	=	Maximum height of channel of CHF calculation (ft)

30.3 DNB Geometry Data Cards 8003XX

The geometry data cards must be entered only if IDNBC (Card 01000Y) is greater than 0. XX is a sequence number which may range from 00 to 99.

W1-R	PITCH	=	Rod to rod pitch (ft)
W2-R	RODIA	=	Fuel rod diameter (ft)
W3-R	EQDIA	=	Equivalent diameter based on wetted perimeter per assembly (ft)
W4-R	TDC	=	Thermal diffusivity parameter, 0.0 is recommended
W5-R	FRPOW	=	Fraction of power generated in fuel rod
W6-R	RGRID	=	Factor dependent on axial grid spacing. (If ISPGR ≠ 0, this must be input. Otherwise this is optional.)
W7-R	HEATL	=	Heat length (ft) (If ISPGR ≠ 0, this must be input. Otherwise this is optional.)

30.4 DNB Axial Power Profile Data Cards 8004XX

The hot rod initial axial power profile data cards must be entered only if IDNBC (Card 01000Y) is greater than 0. XX is a sequence number which may range from 00 to 99. The average core power profile is computed using a polynomial fit of the core section powers.

W1-R	Y(1)	=	Position (Z/L) is height measured from the bottom of the active length L.
W2-R	AXIAL(1)	=	Initial hot rod axial power profile, normalized to unity
W3-R W4-R	Y(2) AXIAL(2)	=	Until NOA data points are filled

30.5 DNB Volume Data Cards 8005XX

The volume numbers for which the DNB calculation will be done should be entered sequentially (bottom of core to top of core) on the 8005XX cards. The total number of entries should be equal to N1 on the 8001XX cards. XX is a sequence number which may range from 00 to 99.

W1-I	NVLDNB(1)	=	Index number of first core volume used for DNB calculation (bottom of core)
W2-I	NVLDNB(2)	=	Index number of second core volume used for DNB calculation
W3-I	NVLDNB(3)	=	Index number of third core volume used for DNB calculation
.	.		
.	.		
.	.		
WN1-I	NVLDNB(N1)	=	Index number of last core volume used for DNB calculation (top of core)

31.0 INPUT DATA FOR THE FIBWR MODEL FOR MODELS OTHER THAN THREE-DIMENSIONAL KINETICS

RETRAN-3D contains options that account for BWR fuel assembly leakage paths in core regions. These models provide representation of multiple, lateral leakage flow paths, water rods, and part length rod fuel assemblies. There is also an option for a more generalized form of the fuel assembly grid loss coefficient model.

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The models were originally designed for use in the three-dimensional kinetics model via the CDI file (Fortran Unit 78) specification, but they can be applied to other core kinetics models as well. The following input discussion describes the FIBWR style model core leakage model for non-three-dimensional kinetics core power options.

31.1 FIBWR Leakage Model Data Card 635000

A FIBWR Leakage Model Data Card is used to define the information for the model including the number of axial regions below, within, and above the active fuel region. The channel inlet junctions are also defined. This card is not used for three-dimensional kinetics models where the CDI file provides this information.

W1-I	NCHAN	=	Number of active channels.
W2-I	NINPL	=	Number of planes below the active fuel region.
W3-I	NACTFP	=	Number of planes within the active fuel region.
W4-I	NOUTPL	=	Number of planes above active fuel region.
W5-I	IBYPIN	=	The bypass inlet junction (lower plenum to bypass).
W6-I	ICHNIN	=	The channel inlet junction (lower plenum to channel). Repeated for NCHAN inlet junctions.

31.2 FIBWR Leakage Model Constants Data Card 635010

The data card is used to supplement Data Card 635000 and should be used only when it is used. This card is not used for three-dimensional kinetics models where the CDI file provides this information. The control rod drive flow (FCROD) is an explicit flow definition used that is added to all of the leakage flows after the flow split calculation has determined them. It reduces the active channel flow by the amount of FCROD. It does not affect the total reactor flow specification.

The FIBWR reference density is used in the FIBWR model to scale the flow coefficient equation by a multiplier of SQRT(RHO/RHOREF). If RHOREF is not specified, then scaling does not occur. Negative values of FCROD and RHOREF will result in termination with an error in input processing.

W1-R	FCROD	=	Control rod drive flow (lbm/sec).
W2-R	RHOREF	=	FIBWR reference density (lbm/ft**3).
W3-R	WRXTOT	=	Total core flow (lbm/hr). Optional data. Default = 0.0.

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31.3 FIBWR Lateral Leakage Coefficient Data Cards 6351XX

The FIBWR lateral leakage coefficient data cards are used to define a given leakage model set that defines a leakage flow (lb/hr) given the pressure drop. XX ranges from 1 to 99 and defines unique leakage sets that are referenced via the IPUMP variable on the junction data cards (W3 Card 08XXXY). A leakage set can be used by one or more junctions.

The flow is determined by the following equation

W = (C1 * DP ** 0.5 + C2 * DP ** C4 + C3 * DP ** 2) * SQRT (RHO/RHOREF)

where

DP	=	the junction pressure drop,
RHO	=	the instantaneous density based on donor conditions, and
RHOREF	=	the FIBWR reference density given on Data Record 635010. An optional flow multiplier for the entire flow value is allows allowed.

This input record is not used for three-dimensional kinetics models where the CDI file provides this information.

W1-R	C1	=	Lateral leakage flow equation coefficient.
W2-R	C2	=	Lateral leakage flow equation coefficient.
W3-R	C3	=	Lateral leakage flow equation coefficient.
W4-R	C4	=	Lateral leakage flow equation coefficient.
W5-RC	CMUL	=	Lateral leakage flow multiplier.

31.4 FIBWR Bypass Leakage Coefficient Data Cards 6352XX

The FIBWR bypass leakage coefficient data cards are used to define the bypass leakage flow (lb/hr). XX ranges from 1 to 99 and defines unique leakage paths across the core support plate. The bypass leakage flow will be determined by summing the flows determined for each bypass leakage set defined. The bypass junction is identified via IPUMP = 201 variable on the junction data cards (W3 Card 08XXXY).

The flow is determined by the following equation

W = (C1 * DP ** 0.5 + C2 * DP ** C4 + C3 * DP ** 2) * SQRT (RHO/RHOREF)

where

DP	=	the junction pressure drop,
RHO	=	the instantaneous density based on donor conditions, and
RHOREF	=	the FIBWR reference density given on data record 635010. An optional flow multiplier for the entire flow value is allows allowed.

This card is not used for three-dimensional kinetics models where the CDI file provides this information.

W1-R	C1	=	Bypass leakage flow equation coefficient.
W2-R	C2	=	Bypass leakage flow equation coefficient.
W3-R	C3	=	Bypass leakage flow equation coefficient.
W4-R	C4	=	Bypass leakage flow equation coefficient.
W5-RC	CMUL	=	Bypass leakage flow multiplier.

31.5 Additional Input Considerations for the FIBWR Model

31.5.1 Junction Data Cards 08XXXY

The junction data cards are also used to define the FIBWR leakage flow paths or junctions. However, for these junctions, only the first seven words should be input. The use of the from-to specifications, IW1 and IW2, are unchanged. The value of IPUMP should be 100 plus the particular lateral leakage coefficient set (XXX from Cards 6351XX) that is to define the flow for the lateral leakage junction. For the single bypass inlet junction connecting the lower plenum with the bypass, IPUMP should be 201. All bypass leakage sets (defined on Cards 6352XX) will be summed to determine the total bypass inlet flow. All other input variables can be zero except W7-R, ZJUN, which is the junction elevation.

31.5.2 Junction Initial Condition Data Cards 232XXX

The junction initial condition data cards are used to define the necessary initial conditions. They are used to supply initial estimates of the channel, water rod, leakage, and bypass flows. For these estimates, JESTW = 2 should be used, but the plenum volume number data is not needed. The total core flow can be specified by setting JUN = -1 and JESTW = 0. If this card is not present, the core pressure drop boundary condition is applied.

For the core pressure drop boundary condition, it is assumed that the lower and upper plenum pressures are known either through direct specification or by propagation. The active core and bypass channels are not legitimate paths for the pressure propagation. The core pressure drop boundary condition is not proper boundary condition when a system is modeled, i.e., the excore

components that connect the two plenums are modeled. In these connecting regions, the flows will be specified. They will define the flows out of the upper plenum and into the lower plenum. The core pressure drop will define the flows out of the lower plenum and into the upper plenum. It will be fortuitous if these flows yield mass balances in the plenums. A loss coefficient can be tuned to give a mass balance, but this will require a manual user adjustment (probably an iterative one). The core pressure drop boundary condition was originally intended for application where the plenums are the boundaries of the model.

When the total core flow boundary condition is applied, the upper plenum pressure must be known, either by direct specification or by propagation, but not through the active core or bypass channels. The lower plenum pressure is obtained by propagating the pressure from the upper plenum down through the bypass channel. The active channel (and water rod) pressures are obtained by propagating the lower plenum pressure upward to the upper plenum. The bypass flow is obtained by subtracting the active channel exit flows from the total flow specified on Data Card 232XXX.

32.0 AUTOMATIC SUBNODALIZATION OPTION FOR VOLUMES

RETRAN-3D contains an option to automatically subnodalize a volume into a number of subnodes. The option was originally designed for the pressurizer thermal stratification model but can be used for any normal volume in RETRAN-3D. The following input discussion describes the automatic subnodalization option.

This option creates the number of subnodes specified on 58XXXY cards. The user specifies the base volume (specified on Volume Data Cards 5XXXY) and additional subnode volumes are created automatically with geometry defined per the base volume. Additional junctions are also created automatically to connect the subnode volumes. Some of the junction parameters can be specified on 58XXXY cards.

Normal RETRAN volumes and junctions are numbered from 1 to 999. Subnode volumes are numbered as ‘1000 x Base Volume number + n’; where n is the subnode number. N is sequential from bottom to the top, for vertical volumes and from inlet to the outlet, for horizontal volumes. The last subnode retains the base volume number.

The last subnode volume number remains the same as the parent volume so the associated junctions, trips, control systems, etc. do not get affected by the automatic subnodalization. Any minor edits requested for the parent volume will be edited for the last subnode. If edits are desired for the other subnodes, they must be specified by subnode number through input. The number of junctions created for subnodes will be one less than the number of subnode volumes. The subnode junctions will be numbered the same as the ‘from’ side volume.

All subnode volumes are modeled as homogeneous equilibrium volumes. The choking model is turned off for subnode junctions that are part of the pressurizer stratification model.

Any conductors associated with the subdivided volume will also be subdivided and numbered the same as the associated subnode volume. For a pressurizer, conductors are required to be

stacked using the stack model. When automatic subnodalization is used for the pressurizer, the top subnode conductor is automatically divided into three separate conductors and a stack is created. This allows modeling heat transfer between vapor region and liquid region of the pressurizer and the wall. Also, an additional stack is created to store the remaining subnode conductors. During the transient, conductors move in and out of stacks as mixture level increases or decreases.

If the volume to be subdivided already has a conductor stack associated with it then all conductors in the stack are summed into a single conductor and then subdivided to create a new conductor for each subnode. This ensures that conductors are correctly associated with new subnodes but effectively eliminates the stack model. The automatic subnodalization should not be used in a volume where the stack is needed for local conditions or condensation.

If a steady-state initialization option is used, properties must be specified for only one node; preferably for the volume that is being subdivided. Providing additional properties for subnodes may result in over-specification and steady-state may not converge. If initial conditions are needed for subnode volumes, the fluid properties must be specified using volume initial condition data cards 231XXX.

When automatic subnodalization option is used for pressurizer, it is required that the number of subnodes specified on automatic subnodalization card must match with the number of subnodes specified on two-region nonequilibrium volume data card 610XXX.

32.1 Automatic Subnodalization Option Data Card 58XXXY

W1-I	SVOL	=	The fluid volume number to be subdivided.
W2-I	NSUB	=	Number of subnodes.
W3-I	SPLT	=	Orientation Flag to indicate whether volume is horizontally subdivided or vertically subdivided. = 0, horizontal subdivision (default) = 1, vertical subdivision

Words 4 to 23 can be used to specify the junction data for subnode junctions. Words 4 to 23 are the same as Words 4 to 23 on Junction Data Cards 8XXXY. As on 8XXXY cards, the user can use default options for the junction data and the code will calculate the required values from the subnode volumes.

The subnodalization option assumes that one junction is connected at the inlet and one at the outlet of the parent node. There are situations where more junctions are connected to the subnode volumes besides the inlet and/or outlet. For example, the hot leg and cold leg volumes may connect to the pressurizer in addition to the normal inlet and outlet connections. If desired, additional junction connections are specified using pair of words starting from Word 24. Each pair is the junction number and flow distance from the inlet of the parent volume.

W24	SJUN(1)	=	These are the numbers of junctions connected somewhere between each end of the subnodalized volume.
W25	FLOWD(1)	=	This is the flow distance from the inlet end of the subnodalized volume for sjun.
	.		
	.		
	.		
	SJUN(10)		
	FLOWD(10)		

Up to 10 junctions can be connected as additional junctions to the subnodalized volume.

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RESTRT INPUT DATA SUMMARY

In the following description of the input data cards for the RESTRT program module, the card number is given along with a descriptive title of the data contained on the card. Next is given the order of the data (W1, W2...), the data format (I, R, or A), the variable name, and the input data requirements where applicable. The format of the data field (i.e., integer, real floating point, or alphanumeric) is indicated by I, R, or A, respectively.

The RESTRT program module provides for two types of problem continuation. In the simple restart mode, optional input data may be supplied to modify time-step selection features, edit frequencies, minor edit parameters, and trip-control-system descriptions. In the generalized restart mode, a second set of input is supplied in addition to that for the simple restart. In this second set of input, data cards are supplied which replace and/or augment the original problem input data deck. The generalized restart option allows for great flexibility in modification of the original problem at restart time. Caution is required since modification of some problem parameters at restart time may result in anomalous problem results. All changes are made to the original RETRAN data deck. The restart data must be supplied with each subsequent restart if the modifications are desired.

The RESTRT option can be used to continue a previous solution. This may be to extend the solution in time, or to re-do part of the solution with revised input, e.g., time-step size, trip set points, or constants that can be revised using the generalized restart feature. RESTRT can be used to restart problem solutions that use any of the kinetics models.

The data file information for the file with initial run results and for the restart job must be supplied using command language. Examples of the procedure used to execute a restart job are given in Section III.

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1.0 TITLE CARD

The first 16 columns of the RESTRT problem title must be identical to those of the original problem time.

2.0 PROBLEM CONTROL AND DESCRIPTION DATA CARD 010001

W1-I	LDMP	=	The data record on the original problem data tape at which restart is to be initiated (LDMP $\geq$ 1).
W2-I	NEDI	=	Number of minor edit variables requested. If NEDI is omitted or 0, the minor edit variables specified on the original problem will be edited. If a negative value of NEDI is supplied, printer plots will generated for each of the minor edit variables requested.
W3-I	NTC	=	Number of time-step sets supplied. If NTC is omitted or 0, the time-step sets supplied with the original problem will be used provided the original time-step set covers the desired time frame. If a value of NTC is specified it must be greater than or equal to 0.
W4-I	NTRP	=	Number of trip control cards supplied. If NTRP is omitted, the trip control cards supplied with the original problem will be used. If a value of NTRP is supplied, it must be less than or equal to the number of trip control cards supplied with the original problem.
W5-I	IRTYP	=	1 if the generalized restart option is to be used. If IRTYP = 1, a second set of data cards is expected following the end terminator. If IRTYP is 0 or omitted, then a regular restart is used.
W6-I	ITAP	=	-1 if no restart file is desired for restart run. If ITAP is 0 or omitted, then a new restart tape will be generated.

3.0 MINOR EDIT VARIABLE DATA CARDS 0200YY

Minor Edit Variable Data Card(s) are required only if |NEDI| (Card 010001) is greater than 0. The same requirements apply for minor edit variable requests at restart as for the original problem (see Section IV.4). The quantities edited on a RESTRT problem need not have any relation to those edited on the original problem.

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If the original problem used the option to generate an auxiliary file (Section III.4-1), an auxiliary file will be generated during the restart. The contents of the file will contain information for the time period covered by the restart. If users want to turn the option on or off for a RESTRT job, the necessary input can be supplied with the generalized restart option described above. Remember that a blank card, e.g., a card number only, effectively removes previous nonblank cards. This feature can be used to turn the option off, by using it in a generalized restart input deck.

3.1 Units Selection Card 030000

The units used in output files for restart problems will be either those specified on Card 030000 in the original input deck, or the default British units if no 030000 card was present. The output units can be changed at restart by use of an 030000 card if time-step data cards are also present in the restart deck. When either the SI or British output option is selected, the requested units are used for the major and minor edits and printer plots in the standard output file. The data written to the auxiliary data file (FORTRAN Unit 60) will also be written in the requested units. Card 030000 is used to select the output option as described below. Its use is optional and if it is not present, the output will default to British units.

W1-I	=	1, for British units.
	=	2, for SI units.

4.0 TIME-STEP DATA CARDS 03XXX0 AND 03XXX1

If no time-step control data are provided in the restart input file, the time-step control information provided on time-step data cards (03XXX0) in the original deck will be used. Any associated data that was supplied on every time-step edit cards (030002) or time-step control coefficient data cards (03XXX1) will also be used, or the appropriate default values if no data was supplied.

When time-step data cards (03XXX0) are supplied in a restart deck, any time-step edit (030002) or time-step control coefficient data (03XXX1) provided in the original input deck is voided and default values are used unless new data cards are provided in the restart deck. The input requirements for these data are the same as for the original problem, except NTC is determined by the 010001 card in the restart input file.

5.0 TRIP CONTROL DATA CARDS 04XXX0

If a value of NTRP is supplied on Card 010001, NTRP must be less than or equal to the number of trip control cards specified in the original problem. Additionally, if NTRP is omitted or input as 0, the trips specified with the original problem input will be used. Any or all of the trip signals (IDSIG) specified with the original problem can be reset at restart time provided the trip (IDTRP) has not been actuated (see Section IV.6). If trip replacement data is supplied for a signal or trip already actuated, the conflicting replacement data will be edited and the problem

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terminated. The only exception to this rule is the problem end trip (IDTRP=1), which can always be reset. Trip control cards supplied at restart time must have the same card numbers as those being modified in the original problem. Additionally, the first four data items on each replacement card must match those from the original problem.

6.0 DATA FOR GENERALIZED RESTART OPTION

The generalized restart option is designed to allow more flexibility at restart time primarily for changing tabular data such as area tables, fills, and material properties. However, most data cards can be changed, though caution should be exercised as changing model options can produce anomalous results. The nodalization of the model cannot be changed.

If IRTYP on Card 010001 in the RESTRT data deck is set to 1, the program expects a second set of data following the end terminator. This second set of data may contain any data card which could be included in the original RETRAN data deck. A card with the same card number as a card in the original deck acts as a replacement card, and a card with a card number which does not match any of the original card numbers is added to the deck. The same requirements apply for the replacement data cards as for the original problem. If new cards are supplied in this deck which duplicate cards in the RESTRT data deck, the input for the cards appearing in the second data deck take precedence with the exceptions discussed below. A title card may be included, but the title card supplied in the RESTRT deck will be used on all edits.

The input variables that can be changed are restricted by the input variables saved on a data file. The original problem input is saved on the data file. At restart time the original input is removed from this file and reprocessed along with any change cards as if it were an initial run, with the exception that input edits are not done. Then the variables stored on the data file are moved from the data file to main memory. Consequently, input parameters that are stored on the data file will override any values that come through the input stream.

Not all input or computed variables are stored on the data file. The variables stored fall into two categories. First, variables required to recreate the state of the system at restart time are saved. Second, variables needed for major and minor edits are also saved, primarily for plotting and reediting. As a result, there are some input parameters that may be changed using generalized restart but will be restored to their original values once the variables are moved from the data file to main memory at restart time. Table V-1 lists the input quantities that can be changed at restart time because they are not stored on the data file.

7.0 ONE-DIMENSIONAL AND THREE-DIMENSIONAL KINETICS INPUT

RESTRT problems that use one-dimensional and three-dimensional kinetics must also supply the cross-section files that were used with the original runs. Three-dimensional kinetics problems will also need to supply a CDI file if one was used with the original problem.

Table V-1

Input Quantities

CARD NUMBER	INPUT VARIABLES
05XXXY	W8-FLOWL, W9-FLOWA, W10-DIAMV, W12-EOVRD, W14-IHTLG, W15-IMAP, W16-IVFIT, W17-IFRIC
08XXXY	W11-JVRTL, W12-JCHOKE, W13-JCALCI, W14-MVMIX, W15-DIAMJ, W16-CONCO, W17-IFRQ, W18-JTPMJ, W20-ISP, W21-SLPMUL
11XXX0	For valve data cards, all input data can be modified.
12XXYY	For general data table data cards, all input data can be modified.
13XXYY	For fill system data cards, all input data can be modified.
15XXXY	W5-IMCL, W6-IMCR, W10-HDML, W11-HDMR, W12-DHEL, W13-DHER, W17-ICOND, W18-CNDL, W19-INJL, W20-INJR
18XXYY 19XXYY 20XXYY	For thermal conductivity, volumetric heat capacity, and linear expansion coefficient data cards, all input data can be modified.
21XXYY	For nonconducting heat exchanger data cards all input data can be modified.
60XXXY	For separators, all input data can be modified.
610XXX	W5-CFCV, W6-CTRB, W7-VRAIN
620XXX	W5-CHWALL, W6-CHSURF
6300XX	For MOC data cards all input data can be modified.
701000	W3-DTCMAX, 24-CNTEPS, 25-ITMAX, 26-INIT
702XXX	W1-IDC, W4-CGAIN
703XXX	W1-ITYPE, W2-ITYPE, WE-INC1, W4-INC2, W5-CGAIN, W6-CP1, W7-CP2, W9-CMIN, W10-CMAX

VI

REEDIT INPUT DATA SUMMARY

The REEDIT program module allows editing of data archived on a RETRAN-3D data file. Major edits, minor edits, and printer plots can be obtained. REEDIT also has an option to write any available minor edit variable to an auxiliary file in a user-specified format.

In the following description of the REEDIT input data cards, the card number is given along with a descriptive title of the data contained on the card. Next is given the order of the data (W1, W2,...), the data format (I, R or A), the variable name, and the input data requirements where applicable. The format of the data field (i.e., integer, real floating point, or alphanumeric) is indicated by I, R or A, respectively.

The data file information for RETRAN-3D must be supplied using job control language. Examples of the procedures used to execute a REEDIT job are given in Section III.

1.0 TITLE CARD

A title card is designated by use of an equal sign (=) as the first nonblank character on a card. The first 16 columns of the REEDIT problem title must be identical to those of the original problem title.

2.0 PROBLEM CONTROL AND DESCRIPTION DATA CARD 010001

W1-I	LDMP	=	-2
W2-I	NEDI	=	Number of minor edit variables requested. If NEDI is omitted or 0, no minor edits will be generated. If a negative value of NEDI is supplied, printer plots will be generated for each of the minor edit requests.
W3-I	NEDF	=	Number of edit frequency control cards supplied (NEDF $\geq$ 1).
W4-I	NPLOT	=	Data record number at which editing is to begin; if omitted, 1 is assumed. A consecutive set of RETRAN data must be specified beginning with the tape volume containing data record 1.

3.0 MINOR EDIT VARIABLE DATA CARDS 0200YY

Minor Edit Variable Data Card(s) are required only if |NEDI| (Card 010001) is greater than 0. The same requirements apply for the minor edit variable requests as for the original problem. The quantities being edited on a REEDIT problem need not have any relation to those of the original problem (see Section IV.4).

4.0 AUXILIARY DATA FILE FORMAT DESCRIPTION CARDS 02500Y

The Auxiliary Data File Format Description Cards are optional and should be supplied only when an auxiliary data file is to be written. These cards define the format that is used to write the minor edit variable list to FORTRAN Unit 60. The input requirements are the same as those given in Section III.4.1 for a RETRAN job.

5.0 EDIT FREQUENCY CONTROL DATA CARDS 03XXX0

The Edit Frequency Control Data Cards specify the frequency at which the data records on a RETRAN data tape are to be read and minor and/or major edits produced. NEDF (Card 010001) cards must be entered with XXX = 001, 002, ..., NDEF.

W1-I	NRTG	=	Currently not used, enter NRTG = 0.
W2-I	NMIN	=	Number of data records per minor edit. (0 is interpreted as 1)
W3-I	NMAJ	=	Number of minor edits per major edit. (0 is interpreted as 50)
W4-R	TLAST	=	End of current edit frequency control data ($TLAST_{i-1} < TLAST_i$, (sec))

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VII

RETRAN SAMPLE PROBLEMS

RETRAN-3D sample problems are presented to illustrate the use of various program features and options. The problems in this group include simple models (i.e., a pipe blowdown, ecc injection into a pipe, simple two-dimensional flow field) as well as complete models of a reactor system. The major options used in these sample problems are presented in summary form in Table VII-1. The input data requirements are given in Section IV of this manual. The definitions of most RETRAN-3D output parameters are presented in Appendix A. The individual sample problems are discussed in the following sections.

The input deck and the output listing for each problem are contained on the transmittal for each version of the code. When a new code version is prepared, all the sample problems are executed on each computer system for which the code is supported. The input decks are the same for each system, however, the output on the transmittal media are the actual output files for that system. The input deck listings and the edited output presented in this section are intended to be for general reference purposes only, and should not be associated with a specific code version. The input and complete output files for a particular problem and code version and computing system should be obtained from the transmittal media.

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Table VII-1

Options Exercised by RETRAN-3D Sample Problems

		SAMPLE PROBLEM NUMBER*															
RETRAN OPTIONS		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Field	HEM			X	X		X	X	X		X				X	X	X
Equations	Four Equation (Slip)	3	1			3				1		3	5	1			
	Five Equation		X							X		X	X	X			
	Noncondensable Flow											X	X	X			
	Purdue TH														X		
	Purdue Numerics														X		
Power	Tabulated Values				X									X			
Generated	Point Kinetics					X	X				X						
	One-Dimensional Kinetics									X							
	Direct Moderator Heating					X				X							
	Metal Water										X						
	Three-Dimensional Kinetics														X	X	X
Heat	Forced Convection																
Transfer	Transfer Correlations			X	X	X	X				X					X	X
	Combined Heat																
	Transfer Correlations**	X							X	X				X	X		
	Local Conditions																
	Heat Transfer										X						
Component	Pressurizer						X				X						
Models	Centrifugal Pump			X	X	X	X		X	X	X			X			
	Jet Pump				X	X				X							
	Valves	X	X	X	X	X	X		X	X	X			X			
	Nonconducting																
	Heat Exchanger						X		X		X			X			

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Table VII-1 (Cont'd)

RETRAN OPTIONS		SAMPLE PROBLEM NUMBER* 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Separator					X			X								
	Turbine								X								
	Accumulator		X														
Boundary	Time-Dependent Volume		X					X				X			X	X	X
Condition	Critical Flow	X		X	X	X		X		X	X			X			
Models	Fill Junction		X	X	X	X	X	X	X	X	X	X		X	X	X	
Special	Subcooled Void					X											
Purpose	Bubble Rise Model	X		X	X	X	X		X	X	X			X			
Models	Control System					X	X			X	X	X		X	X	X	X
	Trips	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Transport Delay Model						X										
	Auxiliary DNB						X	X			X						
	General Transport Model															X	
	FIBWR Model									X							
	Fuel Enthalpy					X				X							X
Steady-State Initialization			X	X		X	X	X	X	X	X	X			X	X	X
Steady-State Off-Rated Power Initialization											X						
Steady-State Flow Splits																	X

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Table VII-1 (Cont'd)

RETRAN OPTIONS	SAMPLE PROBLEM NUMBER* 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

* Sample Problem Numbers and Names

No.	Sample Problem
1	Standard Problem One
2	ECC Injection Problem
3	Standard Problem Five
4	Standard Problem Four
5	Turbine Trip Without Bypass With Point Kinetics
6	Uncontrolled Rod Withdrawal
7	Two-Dimensional Flow Field
8	Secondary-Side Sample Problem
9	Turbine Trip Without Bypass With Space-Time Kinetics
10	PWR ATWS Sample Problem
11	Three-Component Flow Test
12	Water Over Air/Steam
13	Loss of Residual Heat Removal
14	Rod Ejection - 3D Kinetics
15	Steam Line Break - 3D Kinetics
16	BWR Sample Problem - 3D Kinetics

** Forced Convection Plus Low Flow Heat Transfer Correlations

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1.0 STANDARD PROBLEM ONE - EDWARDS' PIPE TEST

The Standard Problem One sample problem is a nine volume model of a straight pipe depressurization experiment performed by Edwards and O'Brien.[VII.1-1] This experiment is referred to as Standard Problem One from the NRC's Comparative Analysis of Standard Problems (CASP) series.

The Edwards' experiments consisted of fluid depressurization studies in a straight pipe 13.44 feet long with an inside diameter of 2.88 inches. The pipe was filled with water and brought to initial conditions ranging from 500 psig and 467 F to 2500 psig and 650 F. The particular experiment used for the sample problem was performed at nominal initial conditions of 1000 psig and 448 F.

The reported initial conditions for the nominal 1000 psig tests were 1014.7 psia and 465 F. However, the temperature measurements indicate that the temperature distribution across the pipe may have varied as much as 15 F. The initial conditions used for the sample problem were prescribed by assuming the nominal pressure of 1000 psig and a constant temperature based upon the mean energy content of the fluid in the test section.

A glass disc at one end of the pipe was designed to be broken with a single shot from a pellet gun to initiate depressurization to atmospheric conditions. The break opening time was estimated to be 1 msec. A small amount of glass was observed to remain at the circumference of the opening so that the break flow area was reduced by approximately 13% from the pipe cross-sectional area.

The RETRAN noding is illustrated in Figure VII.1-1 where the eight pipe nodes are equal volume regions and the containment volume (Volume 9) is effectively an infinite volume employed to provide a constant sink pressure. The system conditions are described in Table VII.1-1.

The input listing for the Standard Problem One sample problem and selected output from the RETRAN program module are given.

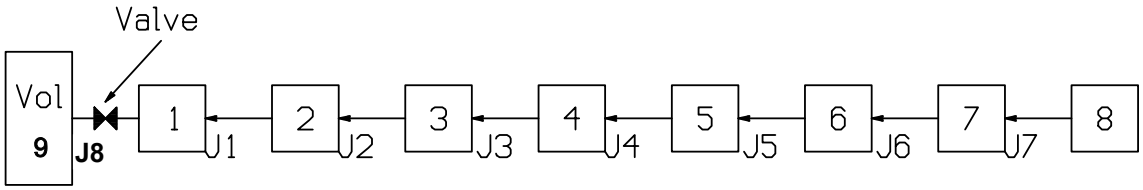


Figure VII.1-1. Schematic Diagram for Standard Problem One

Table VII.1-1

System Conditions Used for RETRAN Standard Problem One Sample Problem

Initial Conditions

1. Pressure = 1014.7 psia
2. Temperature = 448 F
3. Mass Flow Rate = 0.0

Leak Description

1. Break initiated at time zero (i.e., no delay time to break)
2. Break opening time = 0.001 second
3. Break area at end of opening time = 87% of pipe flow area
   = 0.03936 ft^2
   (The leak area is less than the full flow area because a small amount of the glass rupture disk remained in the opening.)
4. Leak Elevation - Use horizontal volume centerline as zero reference. Therefore, leak elevation equals zero.

Transient Initiation and Termination

1. Transient initiation at time zero
2. Transient termination when pressure at closed end of pipe reaches containment pressure (atmospheric = 14.7 psia) or termination on elapsed time at 0.46 msec

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```
LISTING OF INPUT DATA FOR CASE  1

    1    =STANDARD PROBLEM ONE - RETRAN-3D SAMPLE PROBLEM
    2    *
    3    ********************************************************************************
    4    *
    5    *    (S.P-1 / EDWARD'S PIPE TEST)
    6    *
    7    *  PROBLEM DIMENSIONS
    8    *
    9    *        1     2     3     4     5     6     7     8     9    10    11    12
   10    *      TAPE PRNPLT  POW   SS  NVOID GENTRN HTMAP SLIP  5EQ  NCOND  NSOL  PNMTH
   11    010001   0     0     0     1     0     0     0     3     0     0     2     0
   12    *
   13    *
   14    010005     0.0
   15    *
   16    *20000   MINOR EDIT CARDS
   17    020000 TIMX  0 NTTS  0
   18    020001 PRES  4 WP**  4
   19    +      VOIV  2 VOIV  5 VOIV  8
   20    *
   21    *
   22    * FORMAT FOR TAPE60
   23    *
   24    025000 1
   25    025001 '(5(1X,1P,E15.7))'
   26    *
   27    *  TIME STEP DATA
   28    *
   29    *3XXX0  RTG  MIN  RST MAJ NDMP NCHK DELTM    TLST
   30    030010  0.  .005  0.  0.5  .5    0   .001    10.0
   31    *
   32    *  TIME STEP CONSTANTS
   33    *30011    EPSIMP  COURNT  EPSIU  CONDT  EPMDOT PRATE
   34    030011     .001    0.5    0.001  1.1892   1.0   0.25
   35    *
   36    *  TRIP DATA
   37    *4XXX0 IDTRP  IDSIG  IXI  IX2  SETPT  DELAY     DESCRIPTION
   38    040010   1      1     0    0    0.46   0.0     "END OF BLOWDOWN "
   39    040020   1     -4     1    0    4.7    1.E-3   "LIMITING PRESSURE END PRBLM"
   40    040030   2      1     0    0    0.0    0.0     "BROKEN END VALVE DATA   "
   41    *
   42    *  VOLUME DATA
   43    *50001 IB IRED PRESSURE   TEMPERTURE   QLTY      VOLUME     **VOLUME DATA CARD 1
   44    050091  1   0     0.          0.       0.       1E+9     **SINK VOLUME DATA **
   45    050011  0   0     0.          0.       0.       0.07600  **BREAK END VOLUME **
   46    050021  0   0     0.          0.       0.       0.07600
   47    050031  0   0     0.          0.       0.       0.07600
   48    050041  0   0     0.          0.       0.       0.07600
   49    050051  0   0     0.          0.       0.       0.07600
   50    050061  0   0     0.          0.       0.       0.07600
   51    050071  0   0     0.          0.       0.       0.07600
   52    050081  0   0     0.          0.       0.       0.07600  **CLOSED  END VOLUME**
   53    *
   54    *50002   HEIGHT  FLOWL  FLOWA   HYDIAM    ELEV    EOVRD **VOLUME DAT CARD 2 *
   55    050092    1E+4    0     1E+4      1.00  -500.00    0.   **SINK VOLUME DATA **
   56    050012    0.24    0     0.04524   0.24    -0.12    0.   **BREAK END VOLUME **
   57    050022    0.24    0     0.04524   0.24    -0.12    0.
   58    050032    0.24    0     0.04524   0.24    -0.12    0.
   59    050042    0.24    0     0.04524   0.24    -0.12    0.
   60    050052    0.24    0     0.04524   0.24    -0.12    0.
   61    050062    0.24    0     0.04524   0.24    -0.12    0.
   62    050072    0.24    0     0.04524   0.24    -0.12    0.
   63    050082    0.24    0     0.04524   0.24    -0.12    0.  **CLOSED END VOLUME**
   64    *
   65    *  BUBBLE RISE DATA
   66    *060001  ALPH    VBUB     ZM
   67    060011   0.8     1E+3    0.01
   68    *
   69    *  JUNCTION DATA
   70    *8XXX1 IW1 IW1 PMP VLV   FLOWRATE   JUNAREA  JUNELEV  INERTA **JUN DAT CAD 1
   71    080081  1   9   0   1      0.0       .03936    0.0   18.56806 *BRKN END VALV*
   72    080011  2   1   0   0      0.0       .04524    0.0   37.13615
   73    080021  3   2   0   0      0.0       .04524    0.0   37.13615
   74    080031  4   3   0   0      0.0       .04524    0.0   37.13615
   75    080041  5   4   0   0      0.0       .04524    0.0   37.13615
   76    080051  6   5   0   0      0.0       .04524    0.0   37.13615
   77    080061  7   6   0   0      0.0       .04524    0.0   37.13615
   78    080071  8   7   0   0      0.0       .04524    0.0   37.13615  **CLSD END JN*
   79    *
   80    *80002 FJUNF  FJUNR  JVT  JCK  JCL MVMX  HYDIAM   CNC IFRJ JTMJ **JUN DAT CD 2 *
   81    080082 1.02   0.56    0    0    0   0    0.22386  .6   12    0  **BRKN END JNTN*
   82    080012 0.0    0.0     0    0    0   0    0.24    1.0   12    0
   83    080022 0.0    0.0     0    0    0   0    0.24    1.0   12    0
   84    080032 0.0    0.0     0    0    0   0    0.24    1.0   12    0
   85    080042 0.0    0.0     0    0    0   0    0.24    1.0   12    0
   86    080052 0.0    0.0     0    0    0   0    0.24    1.0   12    0
   87    080062 0.0    0.0     0    0    0   0    0.24    1.0   12    0
   88    080072 0.0    0.0     0    0    0   0    0.24    1.0   12    0  **CLSD END-1 JN*
   89    *
   90    *  VALVE DATA CARDS
   91    *11XXX0  ITCV IACV IACV2   PCV  CVI  CV2  CV3
   92    110010    -2   1     0     0.0  0.0  0.0  0.0
   93    *
   94    *  AREA TABLE
   95    *12XXYY NAREA   TAREA---                          ** TIME TO OPEN VALV *
   96    120101   -3     0.0  0.0   1.E-3 1.0   10.0 1.0
   97    *
   98    *
   99    *  VOLUME INITIAL CONDITIONS
  100    *
```


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```
101    *       LVOL   PRES     TEMP    ENTH      X     XNC
102    231001   1    1014.7     0.0    427.1    0.0    0.0
103    231002   2    1014.7     0.0    427.1    0.0    0.0
104    231003   3    1014.7     0.0    427.1    0.0    0.0
105    231004   4    1014.7     0.0    427.1    0.0    0.0
106    231005   5    1014.7     0.0    427.1    0.0    0.0
107    231006   6    1014.7     0.0    427.1    0.0    0.0
108    231007   7    1014.7     0.0    427.1    0.0    0.0
109    231008   8    1014.7     0.0    427.1    0.0    0.0
110    231009   9      14.7     0.0      0.     0.4    0.0
111    *
112    *
113    . END TERMINATOR
```

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```
RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page    1
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:10
 STANDARD PROBLEM ONE - RETRAN-3D SAMPLE PROBLEM                                                                CPU TIME =    0.000
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

RETRAN PROBLEM CONTROL AND DESCRIPTION DATA.

    WORD  DESCRIPTION
    ====  ===================================================================
      1   RESTART FILE OPTION (SAVE=-1 / NO SAVE=0) .................... =    0
      2   PRINTER PLOT OPTION (YES=1 / NO=0) ........................... =    0
      3   POWER OPTION (TAPE OPTNS<0 / NO/TBL=0 / PT KIN=1 / 1D=2 / 3D=3) =    0
      4   USE STEADY-STATE SOLUTION (YES=0 / NO=1) ..................... =    1
      5   USE NEUTRON VOID MODEL (YES=1 / NO=0) ........................ =    0
      6   USE GENERALIZED TRANSPORT MODEL (NO=0 / VAP=1 / LIQ=-1) ....... =    0
      7   HEAT TRANSFER MAP OPTION (FORCED=0 / NAT CONV=1) ............. =    0
      8   SLIP OPTION (DYN=1 / Z-L=2 / C-L=3 / Z-L TAUGL=4 / C-L TAUGL=5) =    3
      9   FIVE-EQUATION OPTION (NO= 0 / YES=1) ......................... =    0
     10   NONCONDENSABLE GAS FLOW OPTION (NO=0 / YES=1) ................ =    0
     11   TH MATRIX DIRECT SOLVER OPTION (4-EQ=2 / 6-EQ=3) ............. =    2
     12   TH MATRIX ITERATIVE SOLVER OPTION (NO<=1 / YES=2) ............ =    0

    (DIMENSIONS AND OPTIONS AUTOMATICALLY DETERMINED BY CONTENT OF INPUT DATA)

          NUMBER OF MINOR EDIT SETS (0200XX DATA )...................... =    7
          NUMBER OF TIME-STEP CONTROL SETS (03XXX0 DATA )............... =    1
          NUMBER OF TRIP CONTROL SETS (04XXX0 DATA )..................... =    3
          NUMBER OF CONTROL VOLUME DESCRIPTIONS (05XXXY DATA )........... =    9
          NUMBER OF BUBBLE RISE DESCRIPTIONS (060XXY DATA) ............. =    1
          NUMBER OF TIME DEPENDENT VOLUMES FORM CARDS (07XXYY DATA) ..... =    0
          NUMBER OF JUNCTION DESCRIPTIONS (08XXXY DATA) ................ =    8
          NUMBER OF CENTRIFUGAL PUMP DESCRIPTIONS (090XXY DATA )......... =    0
          NUMBER OF VALVE DESCRIPTIONS (11XXXY DATA) ................... =    1
          NUMBER OF GENERAL DATA TABLE DESCRIPTIONS (12XXYY DATA) ....... =    1
          NUMBER OF FILL DESCRIPTIONS (13XXYY DATA )..................... =    0
          NUMBER OF HEAT CONDUCTOR DESCRIPTIONS (15XXXY DATA) ........... =    0
          NUMBER OF HEAT CONDUCTOR GEOMETRY DESCRIPTIONS (17XXYY DATA) .. =    0
          NUMBER OF HEAT CONDUCTOR MATERIAL DESCRIPTIONS (18XXYY DATA) .. =    0
          NUMBER OF CORE SECTION DESCRIPTIONS (16XXXY DATA) ............ =    0
          NUMBER OF NON-CONDUCTNG HEAT EXCHNGR DESCRIPTIONS (21XXYY DATA) =    0
          NUMBER OF TIME DEP BCS FROM TAPE (IREAD<0 ON 05XXXY DATA) ..... =    0
          NUMBER OF SPECIFIED HEAT TRAN COEF DESCRIPTIONS (015XXX DATA) . =    0
          TWO-REGION NONEQ VOL DESCRIPTIONS (610XXX OR 611XXX DATA) ..... =    0
          TEMP. TRANSPORT DELAY OPTION (MESH>0 ON 05XXXY DATA) .......... =    0
          AUXILIARY DNB MODEL (8001XX DATA INCLUDED) .................... =    0
          CONTROL SYSTEM MODEL (702XXX OR 702XXXX DATA) ................ =    0
          ACCUMULATOR MODEL DESCRIPTIONS (620XXX OR 621XXX DATA)......... =    0
          DYNAMIC GAP CONDUCTANCE MODEL DESCRIPTIONS (225XX0 DATA) ...... =    0
          NUMBER OF HT CONDUCTOR STACK DESCRIPTIONS (2200XY DATA) ....... =    0
          NUMBER OF TURBINE SHAFT DESCRIPTIONS (500XXY DATA) ........... =    0
          NUMBER OF PROFILE FIT DESCRIPTIONS (061XX1 DATA) ............. =    0
          NUMBER OF STEAM-WATER SEPARATOR DESCRIPTIONS (60XXX0 DATA) .... =    0


                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * *                                                * * *
                   * * *          STEADY-STATE OPTION    =   1          * * *
                   * * *                                                * * *
                   * * *          SLIP OPTION            =   3          * * *
                   * * *                                                * * *
                   * * *          NUMERICS OPTION        =   2          * * *
                   * * *                                                * * *
                   * * *          HEAT TRANSFER OPTION   =   0          * * *
                   * * *                                                * * *
                   * * *          NEW EQUATIONS OPTION   =   0          * * *
                   * * *                                                * * *
                   * * *         USING THE 4-EQ SOLVER - SOLVE3         * * *
                   * * *                                                * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *


INITIAL THERMAL POWER (MEGAWATTS) =  0.00000E+00


AIR IS THE DEFAULT NONCONDENSABLE GAS.
```


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```
RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   15
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis           11:57:10
 STANDARD PROBLEM ONE - RETRAN-3D SAMPLE PROBLEM                                                              CPU TIME =    0.031
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	ENERGY BALANCE (BTU)	TOTAL MASS BALANCE (LBM)	NCG MASS BALANCE (LBM)	AVERAGE TIME STEP (SEC)	CURRENT TIME STEP (SEC)	ELAPSED TIME (SEC)	TIME STEP NUM STANDRD/ACTUL
0.00000E+00	0.00000E+00	0.00000E+00	4.02881E+09	3.73847E+06	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0 0

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	VOID FRAC.	POWR TO H2O (BTU/SEC)
1	1.01470E+03	3.94749E+00	4.27100E+02	5.19406E+01	4.46954E+02	0.00000E+00	0.00000E+00	0.00000E+00
2	1.01470E+03	3.94749E+00	4.27100E+02	5.19406E+01	4.46954E+02	0.00000E+00	0.00000E+00	0.00000E+00
3	1.01470E+03	3.94749E+00	4.27100E+02	5.19406E+01	4.46954E+02	0.00000E+00	0.00000E+00	0.00000E+00
4	1.01470E+03	3.94749E+00	4.27100E+02	5.19406E+01	4.46954E+02	0.00000E+00	0.00000E+00	0.00000E+00
5	1.01470E+03	3.94749E+00	4.27100E+02	5.19406E+01	4.46954E+02	0.00000E+00	0.00000E+00	0.00000E+00
6	1.01470E+03	3.94749E+00	4.27100E+02	5.19406E+01	4.46954E+02	0.00000E+00	0.00000E+00	0.00000E+00
7	1.01470E+03	3.94749E+00	4.27100E+02	5.19406E+01	4.46954E+02	0.00000E+00	0.00000E+00	0.00000E+00
8	1.01470E+03	3.94749E+00	4.27100E+02	5.19406E+01	4.46954E+02	0.00000E+00	0.00000E+00	0.00000E+00
9	1.47000E+01	3.73844E+06	1.15043E+03	3.73844E-02	2.11944E+02	9.99985E-01	1.00000E+00	0.00000E+00

JUNCTION NUMBER	CONNECTS VOLUMES	CHOK/ PATH	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E D I F F E R E N T I A L S VEL. PSI	ELEV. PSI	FRIC. PSI	ACCL. PSI	PUMP PSI
1	2 TO 1		0.00000E+00	4.27100E+02	1.92528E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
2	3 TO 2		0.00000E+00	4.27100E+02	1.92528E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3	4 TO 3		0.00000E+00	4.27100E+02	1.92528E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
4	5 TO 4		0.00000E+00	4.27100E+02	1.92528E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
5	6 TO 5		0.00000E+00	4.27100E+02	1.92528E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
6	7 TO 6		0.00000E+00	4.27100E+02	1.92528E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
7	8 TO 7		0.00000E+00	4.27100E+02	1.92528E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
8	1 TO 9		0.00000E+00	4.27100E+02	1.92528E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

BUBL SET NUMB.	VOL. NUMB.	BUBBLE GRADIENT PARAMETER	BUBBLE VELOCITY (FT/SEC)	MIXTURE LEVEL (FT)	MIXTURE QUALITY	BUBBLE MASS (LB)

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE -- NRC APPROVED VERSION 29/08/14 Page 16
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis 11:57:10
STANDARD PROBLEM ONE - RETRAN-3D SAMPLE PROBLEM CPU TIME = 0.187
* *

SYSTEM ELAPSED TIME (SEC)	SYSTEM ELAPSED TIME (SEC)	TIME STP ACTUAL	VOL 4 AVG. PRESS. (PSIA)	JUN 4 FLOW (LB/SEC)	VOL 2 VOID FRACTN	VOL 5 VOID FRACTN	VOL 8 VOID FRACTN
0.00000E+00	0.00000E+00	0.00000E+00	1.01470E+03	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
5.00000E-03	5.00000E-03	2.00000E+01	4.02812E+02	2.93923E+01	0.00000E+00	1.79653E-03	4.49024E-03
1.00000E-02	1.00000E-02	2.80000E+01	4.03059E+02	2.85988E+01	0.00000E+00	7.58706E-03	2.09928E-02
1.50000E-02	1.50000E-02	3.30000E+01	4.02806E+02	2.81266E+01	2.82387E-03	1.21328E-02	3.40814E-02
2.00000E-02	2.00000E-02	3.90000E+01	4.02722E+02	2.71637E+01	3.60889E-02	1.92647E-02	5.29836E-02
2.50000E-02	2.50000E-02	4.40000E+01	4.02643E+02	2.64039E+01	9.39521E-02	2.40593E-02	6.45590E-02
3.00000E-02	3.00000E-02	4.90000E+01	4.02560E+02	2.55595E+01	1.88616E-01	2.89755E-02	7.54333E-02
3.50000E-02	3.50000E-02	5.40000E+01	4.02466E+02	2.46270E+01	3.16256E-01	3.40390E-02	8.55705E-02
4.00000E-02	4.00000E-02	5.90000E+01	4.02342E+02	2.36093E+01	4.57476E-01	3.92630E-02	9.49511E-02
4.50000E-02	4.50000E-02	6.40000E+01	4.02196E+02	2.25236E+01	5.73974E-01	4.46671E-02	1.03571E-01
5.00000E-02	5.00000E-02	6.90000E+01	4.02071E+02	2.13828E+01	6.19176E-01	5.02753E-02	1.11436E-01
5.50000E-02	5.50000E-02	7.40000E+01	4.02077E+02	2.01761E+01	5.73380E-01	5.60952E-02	1.18564E-01
6.00000E-02	6.00000E-02	7.90000E+01	4.02301E+02	1.87925E+01	4.72077E-01	6.20263E-02	1.24970E-01
6.50000E-02	6.50000E-02	8.40000E+01	4.02382E+02	1.70642E+01	3.89743E-01	6.77357E-02	1.30671E-01
7.00000E-02	7.00000E-02	8.90000E+01	4.00853E+02	1.47114E+01	3.99446E-01	7.26342E-02	1.35674E-01
7.50000E-02	7.50000E-02	9.40000E+01	3.94379E+02	9.83068E+00	5.14074E-01	7.46870E-02	1.39984E-01
8.00000E-02	8.00000E-02	9.90000E+01	3.76598E+02	1.28933E+00	6.61130E-01	6.93143E-02	1.43597E-01
8.50000E-02	8.50000E-02	1.04000E+02	3.36744E+02	-7.41629E-01	7.17741E-01	5.85098E-02	1.46507E-01
9.00000E-02	9.00000E-02	1.09000E+02	2.79856E+02	3.08430E+01	6.20475E-01	7.11020E-02	1.48710E-01
9.50000E-02	9.50000E-02	1.14000E+02	2.75921E+02	1.01351E+02	4.54513E-01	1.63552E-01	1.50205E-01
1.00000E-01	1.00000E-01	1.19000E+02	3.23740E+02	1.50278E+02	3.63735E-01	3.45261E-01	1.50990E-01
1.05000E-01	1.05000E-01	1.24000E+02	3.59044E+02	1.52265E+02	4.53128E-01	5.59785E-01	1.51042E-01
1.10000E-01	1.10000E-01	1.29000E+02	3.69068E+02	9.54236E+01	6.82667E-01	7.06480E-01	1.50281E-01
1.15000E-01	1.15000E-01	1.34000E+02	3.47881E+02	1.01695E+01	8.46739E-01	6.75407E-01	1.48507E-01
1.20000E-01	1.20000E-01	1.39000E+02	2.70511E+02	-2.03021E+01	7.48347E-01	4.92647E-01	1.45349E-01
1.25000E-01	1.25000E-01	1.44000E+02	2.15132E+02	6.22390E+01	4.87791E-01	3.34690E-01	1.40246E-01
1.30000E-01	1.30000E-01	1.49000E+02	2.91531E+02	1.46120E+02	3.26181E-01	3.47976E-01	1.33261E-01
1.35000E-01	1.35000E-01	1.59000E+02	3.47568E+02	1.63102E+02	4.25466E-01	5.06177E-01	1.24529E-01
1.40000E-01	1.40000E-01	1.65000E+02	3.64066E+02	1.18890E+02	7.51586E-01	6.99736E-01	1.13025E-01
1.45000E-01	1.45000E-01	1.71000E+02	3.50268E+02	2.45065E+01	9.40499E-01	7.40422E-01	1.08639E-01
1.50000E-01	1.50000E-01	1.85000E+02	2.79848E+02	-3.05297E+01	7.76468E-01	5.81780E-01	1.41983E-01
1.55000E-01	1.55000E-01	1.91000E+02	2.16175E+02	4.15707E+01	4.84815E-01	3.89733E-01	2.55835E-01
1.60000E-01	1.60000E-01	2.00000E+02	2.87083E+02	1.36247E+02	3.75407E-01	3.44630E-01	4.29946E-01
1.65000E-01	1.65000E-01	2.05000E+02	3.45638E+02	1.62299E+02	5.66839E-01	4.72161E-01	6.09793E-01
1.70000E-01	1.70000E-01	2.12000E+02	3.64602E+02	1.27385E+02	8.76397E-01	6.76986E-01	7.30461E-01
1.75000E-01	1.75000E-01	2.28000E+02	3.52695E+02	3.25239E+01	9.50042E-01	7.76406E-01	7.44174E-01
1.80000E-01	1.80000E-01	2.36000E+02	2.83052E+02	-3.51223E+01	7.02475E-01	6.39183E-01	6.62667E-01
1.85000E-01	1.85000E-01	2.41000E+02	2.09029E+02	3.06863E+01	4.73478E-01	4.29247E-01	6.15323E-01
1.90000E-01	1.90000E-01	2.48000E+02	2.75769E+02	1.39372E+02	4.72488E-01	3.54079E-01	6.55198E-01
1.95000E-01	1.95000E-01	2.53000E+02	3.37605E+02	1.81707E+02	7.00748E-01	4.98919E-01	6.91032E-01
2.00000E-01	2.00000E-01	2.59000E+02	3.61181E+02	1.38791E+02	9.44994E-01	7.60729E-01	7.16286E-01
2.05000E-01	2.05000E-01	2.71000E+02	3.39103E+02	-5.47871E+00	8.70799E-01	8.90478E-01	7.56534E-01
2.10000E-01	2.10000E-01	2.77000E+02	1.97265E+02	-1.01531E+02	5.70550E-01	7.33193E-01	8.21368E-01
2.15000E-01	2.15000E-01	2.92000E+02	9.12033E+01	4.16662E+01	3.97609E-01	6.21531E-01	8.46409E-01
2.20000E-01	2.20000E-01	3.01000E+02	2.46750E+02	8.47617E+01	5.11159E-01	6.89864E-01	7.89299E-01
2.25000E-01	2.25000E-01	3.14000E+02	2.77031E+02	6.01746E+01	8.14683E-01	8.28759E-01	6.93507E-01
2.30000E-01	2.30000E-01	3.24000E+02	2.46770E+02	-1.30997E+01	9.70826E-01	8.64265E-01	6.46664E-01
2.35000E-01	2.35000E-01	3.50000E+02	1.84515E+02	-2.59755E+01	8.21021E-01	7.80108E-01	6.90090E-01
2.40000E-01	2.40000E-01	3.55000E+02	1.94687E+02	1.06410E+01	6.80910E-01	7.50617E-01	7.62887E-01
2.45000E-01	2.45000E-01	3.62000E+02	2.30205E+02	2.39617E+01	7.66028E-01	8.07039E-01	8.01678E-01

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   17
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:11
 STANDARD PROBLEM ONE - RETRAN-3D SAMPLE PROBLEM                                                               CPU TIME =    0.312
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NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	ENERGY BALANCE (BTU)	TOTAL MASS BALANCE (LBM)	NCG MASS BALANCE (LBM)	AVERAGE TIME STEP (SEC)	CURRENT TIME STEP (SEC)	ELAPSED TIME (SEC)	TIME STEP NUM STANDRD/ACTUL
0.00000E+00	0.00000E+00	0.00000E+00	4.02881E+09	3.73847E+06	0.00000E+00	8.33333E-04	6.46485E-04	4.60000E-01	460 715

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	VOID FRAC.	POWR TO H2O (BTU/SEC)
1	1.53750E+01	7.38469E-02	2.20738E+02	9.71670E-01	2.14225E+02	3.94995E-02	9.84380E-01	0.00000E+00
2	1.70239E+01	1.33659E-01	2.10603E+02	1.75867E+00	2.19468E+02	2.36874E-02	9.71195E-01	0.00000E+00
3	8.47436E+00	8.51731E-02	1.72819E+02	1.12070E+00	1.85330E+02	1.95474E-02	9.81830E-01	0.00000E+00
4	2.37257E+00	3.37695E-02	1.15765E+02	4.44336E-01	1.32178E+02	1.50939E-02	9.92887E-01	0.00000E+00
5	6.43542E+00	6.47192E-02	1.60968E+02	8.51569E-01	1.72916E+02	1.99640E-02	9.86263E-01	0.00000E+00
6	7.81013E+00	7.32416E-02	1.70672E+02	9.63705E-01	1.81590E+02	2.11130E-02	9.84423E-01	0.00000E+00
7	5.87484E+00	6.54451E-02	1.55191E+02	8.61119E-01	1.68925E+02	1.81222E-02	9.86102E-01	0.00000E+00
8	6.39260E+00	9.11667E-02	1.54748E+02	1.19956E+00	1.72622E+02	1.40022E-02	9.80534E-01	0.00000E+00
9	1.47000E+01	3.73847E+06	1.15043E+03	3.73847E-02	2.11944E+02	9.99979E-01	1.00000E+00	0.00000E+00

JUNCTION NUMBER	CONNECTS VOLUMES	CHOK/ PATH	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E VEL. PSI	P R E S S U R E ELEV. PSI	D I F F E R E N T I A L S FRIC. PSI	D I F F E R E N T I A L S ACCL. PSI	D I F F E R E N T I A L S PUMP PSI
1	2 TO 1		-3.58799E-01	2.23146E+02	9.92995E-01	-9.20268E-02	0.00000E+00	1.54962E-03	1.52767E+00	0.00000E+00
2	3 TO 2		-1.46848E+00	1.99565E+02	5.78162E-01	1.12492E-01	0.00000E+00	1.36466E-03	-8.45360E+00	0.00000E+00
3	4 TO 3		-1.34861E+00	1.59019E+02	9.15676E-01	-5.15779E-02	0.00000E+00	9.47874E-04	-6.19043E+00	0.00000E+00
4	5 TO 4		1.52853E-01	1.37016E+02	2.25229E+00	7.03121E-01	0.00000E+00	5.00086E-04	4.48269E+00	0.00000E+00
5	6 TO 5		3.59688E+00	1.71757E+02	1.02059E+00	3.49416E-01	0.00000E+00	-2.95291E-02	2.22862E+00	0.00000E+00
6	7 TO 6		1.70235E+00	1.56581E+02	1.13139E+00	-7.63510E-01	0.00000E+00	-9.66989E-03	-2.69859E+00	0.00000E+00
7	8 TO 7		-9.72342E-01	1.57536E+02	1.12459E+00	-3.78487E-01	0.00000E+00	3.16474E-03	8.10335E-04	0.00000E+00
8	1 TO 9		1.88139E+00	2.20057E+02	1.00936E+00	1.84393E-02	0.00000E+00	-2.43027E-01	4.62571E-01	0.00000E+00

JUNCTION NUMBER	FLOW REG.	SLIP VEL. (FT/SEC)	VOID FRACTION	LIQUID FLOW (LB/SEC)	GAS FLOW (LB/SEC)	SLIP CNVCTN (BTU/SEC)	GAS VEL. (FT/SEC)	LIQ. VEL. (FT/SEC)	VG/VL	SLIP ACCEL. (FT/SEC**2)
1	12	-4.58707E+01	9.83851E-01	-4.27335E-01	6.85358E-02	7.91943E+01	3.59349E+01	-9.93589E+00	-3.61667E+00	-3.25331E+02
2	12	-1.11847E+02	9.71347E-01	-1.55812E+00	8.96376E-02	1.37984E+02	9.17925E+01	-2.00549E+01	-4.57706E+00	8.88135E+04
3	12	-3.24762E+02	9.82049E-01	-1.43474E+00	8.61311E-02	1.05874E+02	2.95743E+02	-2.90194E+01	-1.01912E+01	1.55645E+05
4	12	-1.23542E+02	9.93049E-01	5.99683E-02	9.28844E-02	8.74569E+01	1.26563E+02	3.02018E+00	4.19057E+01	1.70886E+04
5	12	-3.34155E+02	9.84158E-01	3.21330E+00	3.83575E-01	2.73850E+02	4.08216E+02	7.40606E+01	5.51191E+00	-9.00081E+04
6	12	-2.93944E+02	9.85729E-01	1.46171E+00	2.40637E-01	2.16613E+02	3.31176E+02	3.72319E+01	8.89494E+00	9.57111E+03
7	12	-9.74658E+01	9.85656E-01	-1.02716E+00	5.48194E-02	7.27409E+01	7.13076E+01	-2.61583E+01	-2.72600E+00	-3.43693E+02

BUBL SET NUMB.	VOL. NUMB.	BUBBLE GRADIENT PARAMETER	BUBBLE VELOCITY (FT/SEC)	MIXTURE LEVEL (FT)	MIXTURE QUALITY	BUBBLE MASS (LB)
1	9	8.00000E-01	1.00000E+02	1.31345E-05	9.92308E-12	7.79551E-10

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   18
 LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis             11:57:11
  STANDARD PROBLEM ONE - RETRAN-3D SAMPLE PROBLEM                                                                 CPU TIME =     0.312
 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *
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SYSTEM ELAPSED TIME (SEC)	SYSTEM ELAPSED TIME (SEC)	TIME STP ACTUAL	VOL 4 AVG. PRESS. (PSIA)	JUN 4 FLOW (LB/SEC)	VOL 2 VOID FRACTN	VOL 5 VOID FRACTN	VOL 8 VOID FRACTN
2.50000E-01	2.50000E-01	3.70000E+02	2.42033E+02	3.35500E+00	9.65684E-01	8.32316E-01	7.90737E-01
2.55000E-01	2.55000E-01	3.98000E+02	2.37671E+02	-8.28386E+00	9.53510E-01	7.71204E-01	7.80177E-01
2.60000E-01	2.60000E-01	4.11000E+02	2.31058E+02	1.74957E+01	8.76457E-01	7.00365E-01	8.06050E-01
2.65000E-01	2.65000E-01	4.16000E+02	2.21839E+02	4.17185E+01	9.17369E-01	7.25555E-01	8.13494E-01
2.70000E-01	2.70000E-01	4.21000E+02	1.88098E+02	4.22819E+01	9.31618E-01	8.40904E-01	7.85771E-01
2.75000E-01	2.75000E-01	4.26000E+02	1.40566E+02	1.77590E+01	8.81250E-01	9.15930E-01	7.55847E-01
2.80000E-01	2.80000E-01	4.32000E+02	1.25798E+02	1.37037E+01	8.82456E-01	8.81976E-01	7.61414E-01
2.85000E-01	2.85000E-01	4.37000E+02	1.43996E+02	5.01660E+01	9.46634E-01	8.37831E-01	7.86139E-01
2.90000E-01	2.90000E-01	4.47000E+02	1.43963E+02	5.27284E+01	9.46294E-01	8.73273E-01	8.00524E-01
2.95000E-01	2.95000E-01	4.52000E+02	1.22128E+02	3.43495E+01	8.89494E-01	9.00660E-01	7.96637E-01
3.00000E-01	3.00000E-01	4.57000E+02	1.23904E+02	4.83418E+01	9.02554E-01	8.74774E-01	8.22686E-01
3.05000E-01	3.05000E-01	4.62000E+02	1.35436E+02	6.25442E+01	9.40328E-01	8.76252E-01	8.96332E-01
3.10000E-01	3.10000E-01	4.67000E+02	1.24879E+02	4.45006E+01	9.22385E-01	9.09324E-01	9.39436E-01
3.15000E-01	3.15000E-01	4.72000E+02	1.13103E+02	3.11173E+01	8.99608E-01	9.14765E-01	9.19304E-01
3.20000E-01	3.20000E-01	4.85000E+02	1.14683E+02	3.49464E+01	9.24465E-01	8.99867E-01	8.99206E-01
3.25000E-01	3.25000E-01	4.91000E+02	1.01877E+02	2.89098E+01	9.42469E-01	9.11477E-01	9.19184E-01
3.30000E-01	3.30000E-01	5.06000E+02	7.68130E+01	1.35383E+01	9.25050E-01	9.50837E-01	9.41203E-01
3.35000E-01	3.35000E-01	5.19000E+02	5.87735E+01	-6.13046E+00	9.29317E-01	9.63054E-01	9.41740E-01
3.40000E-01	3.40000E-01	5.25000E+02	4.22918E+01	6.64522E+00	9.58462E-01	9.25598E-01	9.34100E-01
3.45000E-01	3.45000E-01	5.31000E+02	6.37417E+01	3.17090E+01	9.67395E-01	9.34641E-01	9.33047E-01
3.50000E-01	3.50000E-01	5.42000E+02	6.80824E+01	1.49641E+01	9.56424E-01	9.78468E-01	9.36639E-01
3.55000E-01	3.55000E-01	5.56000E+02	3.74968E+01	-1.37553E+01	9.52666E-01	9.74995E-01	9.44525E-01
3.60000E-01	3.60000E-01	5.68000E+02	1.57427E+01	5.33857E+00	9.60991E-01	9.46351E-01	9.52732E-01
3.65000E-01	3.65000E-01	5.76000E+02	4.70913E+01	2.37453E+01	9.71352E-01	9.60377E-01	9.53279E-01
3.70000E-01	3.70000E-01	5.81000E+02	4.62619E+01	6.67849E+00	9.73836E-01	9.75397E-01	9.50328E-01
3.75000E-01	3.75000E-01	5.86000E+02	2.31242E+01	1.28357E+00	9.65656E-01	9.61216E-01	9.55256E-01
3.80000E-01	3.80000E-01	5.91000E+02	2.60454E+01	1.36852E+01	9.69133E-01	9.59826E-01	9.61810E-01
3.85000E-01	3.85000E-01	6.21000E+02	3.37682E+01	9.77510E+00	9.78309E-01	9.74707E-01	9.61721E-01
3.90000E-01	3.90000E-01	6.28000E+02	2.02753E+01	1.36281E+00	9.78105E-01	9.71168E-01	9.59645E-01
3.95000E-01	3.95000E-01	6.34000E+02	1.70627E+01	1.00469E+01	9.76663E-01	9.63278E-01	9.65670E-01
4.00000E-01	4.00000E-01	6.39000E+02	2.44609E+01	1.27070E+01	9.80498E-01	9.73452E-01	9.72743E-01
4.05000E-01	4.05000E-01	6.44000E+02	2.01587E+01	4.61420E+00	9.82250E-01	9.82914E-01	9.72819E-01
4.10000E-01	4.10000E-01	6.49000E+02	1.25213E+01	1.70128E+00	9.81173E-01	9.76517E-01	9.69536E-01
4.15000E-01	4.15000E-01	6.54000E+02	1.26615E+01	8.33424E+00	9.81697E-01	9.71407E-01	9.70918E-01
4.20000E-01	4.20000E-01	6.59000E+02	1.65309E+01	9.35889E+00	9.83654E-01	9.78891E-01	9.75469E-01
4.25000E-01	4.25000E-01	6.64000E+02	1.36045E+01	3.70822E+00	9.84121E-01	9.88466E-01	9.78142E-01
4.30000E-01	4.30000E-01	6.75000E+02	7.77993E+00	-1.19208E+00	9.83263E-01	9.87761E-01	9.77602E-01
4.35000E-01	4.35000E-01	6.80000E+02	5.44834E+00	2.51699E+00	9.83214E-01	9.80795E-01	9.77023E-01
4.40000E-01	4.40000E-01	6.85000E+02	9.63997E+00	7.36145E+00	9.83799E-01	9.81454E-01	9.78419E-01
4.45000E-01	4.45000E-01	6.90000E+02	1.13951E+01	5.24074E+00	9.83164E-01	9.88222E-01	9.80437E-01
4.50000E-01	4.50000E-01	6.95000E+02	7.41187E+00	4.33254E-01	9.78687E-01	9.92104E-01	9.81675E-01
4.55000E-01	4.55000E-01	7.09000E+02	3.35621E+00	-1.79212E+00	9.72723E-01	9.90390E-01	9.81540E-01
4.60000E-01	4.60000E-01	7.15000E+02	2.37257E+00	1.52853E-01	9.71195E-01	9.86263E-01	9.80534E-01

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2.0 ECC INJECTION SAMPLE PROBLEM

The ECC Injection Sample Problem is presented to illustrate some of the input data requirements for using the five-equation option of RETRAN-3D. This problem is comprised of an accumulator with water at 90F and a simple pipe with a high quality two-phase fluid flowing through the pipe. At one second, a valve is opened between the line and the accumulator and the cold water is injected into the two-phase mixture. A noding diagram for this problem is given in Figure VII.2-1.

A listing of the input deck, and selected output are given in this section.

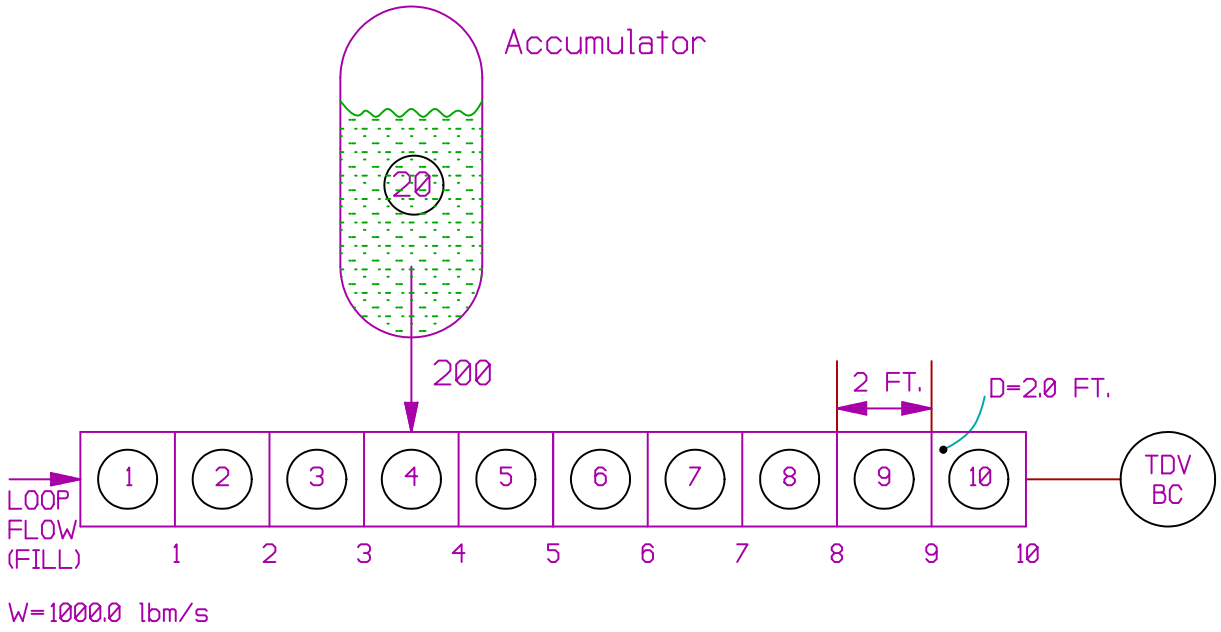


Figure VII.2-1. ECC Injection Sample Problem

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```
LISTING OF INPUT DATA FOR CASE  1

    1    = ECC INJECTION DECK - RETRAN-3D SAMPLE PROBLEM
    2    *
    3    ********************************************************************************
    4    *
    5    *  PROBLEM DIMENSIONS
    6    *
    7    *        1     2     3     4     5     6     7     8     9    10    11    12
    8    *      TAPE PRNPLT  POW    SS  NVOID GENTRN HTMAP SLIP  5EQ  NCOND  NSOL  PNMTH
    9    010001   0     0     0     0     0     0     1     1     1     0     3     0
   10    *
   11    *
   12    *       EDIT VARIABLES
   13    *
   14    020000 TIMX  0 NTTS  0
   15    020001 PRES  4 PRES 20
   16    020002 WP**  4 WP** 200
   17    020003 WGJ*  3 WLJ*  3
   18    020004 WGJ*  4 WLJ*  4
   19    020005 AVEX  3 AVEX  4
   20    020006 TEML  3 TEML  4
   21    020007 TEMV  4 TEML 10
   22    020009 TAIR 20 TLIQ 20
   23    020010 TWAL 20 EXPC 20
   24    *
   25    *
   26    * FORMAT FOR TAPE60
   27    *
   28    025000 1
   29    025001 '(5(1X,1P,E15.7))'
   30    *
   31    *
   32    *       TIME STEP CARDS
   33    *
   34    *30000 RTG  MIN  RST  MMJ  NDMP  NCHK   DTMAX   TLAST
   35    030010 0.   0.2  0.   2.   2.      0    0.1     1.
   36    030020 0.   0.1  0.   2.   2.      0    0.025   5.
   37    030030 0.   0.2  0.   4.   4.      0    0.025 100.
   38    *
   39    *
   40    *        CONV    COUR    FLOREV    CONDT
   41    030011   0.005    2.0    0.005      0.0
   42    030021   0.005    2.0    0.005      0.0
   43    030031   0.005    2.0    0.005      0.0
   44    *
   45    *       TRIP INFORMATION
   46    *
   47    *40000  ID SIG IX1 IX2  SETPT   DELY
   48    040010   1  1   0   0     5.0    0.   "STOP THE PROBLEM"
   49    040020   2  1   0   0     0.0    0.   "LOOP FILL"
   50    040030   3  1   0   0     1.0    0.   "ISOLATION VALVE OPENS"
   51    *
   52    *       VOLUME DATA CARDS
   53    *
   54    *50000 BUB IRD  PRESS   TEMP   QUAL    VOL   ZVOL   FLOWL
   55    050011  0   0     0.    0.     0.    6.282  2.0     2.0    *COND
   56    050021  0   0     0.    0.     0.    6.282  2.0     2.0    *COND
   57    050031  0   0     0.    0.     0.    6.282  2.0     2.0    *COND
   58    050041  0   0     0.    0.     0.    6.282  2.0     2.0    *COND
   59    050051  0   0     0.    0.     0.    6.282  2.0     2.0    *COND
   60    050061  0   0     0.    0.     0.    6.282  2.0     2.0    *COND
   61    050071  0   0     0.    0.     0.    6.282  2.0     2.0    *COND
   62    050081  0   0     0.    0.     0.    6.282  2.0     2.0    *COND
   63    050091  0   0     0.    0.     0.    6.282  2.0     2.0    *COND
   64    050101  0   0     0.    0.     0.    6.282  2.0     2.0    *COND
   65    050201  0   0     0.    0.     1.    1380.   18.    0.0    *ACCUMULATOR
   66    059991  0   1     0.    0.     0.    6.282  2.0     2.0    *TDV BC
   67    *
   68    *
   69    *50000   FLOWA  DIAV   ELEV  EOVRD  MESH  IHTLG   IMAP
   70    050012   3.141  2.0    0.0    0.0    0      0      1   *COND
   71    050022   3.141  2.0    0.0    0.0    0      0      1   *COND
   72    050032   3.141  2.0    0.0    0.0    0      0      1   *COND
   73    050042   3.141  2.0    0.0    0.0    0      0      1   *COND
   74    050052   3.141  2.0    0.0    0.0    0      0      1   *COND
   75    050062   3.141  2.0    0.0    0.0    0      0      1   *COND
   76    050072   3.141  2.0    0.0    0.0    0      0      1   *COND
   77    050082   3.141  2.0    0.0    0.0    0      0      1   *COND
   78    050092   3.141  2.0    0.0    0.0    0      0      1   *COND
   79    050102   3.141  2.0    0.0    0.0    0      0      1   *COND
   80    050202  97.7   11.15   2.0    0.0    0      1          *ACCUMULATOR
   81    059992   3.141  2.0    0.0    0.                       *TDV BC
   82    *
   83    *
   84    *     TIME DEPENDENT VOLUME CARDS
   85    *
   86    *70000 NDAT  TIME    PRESS    TEMP    QUAL     ZMIX
   87    070101   2   0.       585.0     0.    0.50     2.0  * DOWNCOMER
   88    070102       1.+9     585.0     0.    0.50     2.0  * DOWNCOMER
   89    *
   90    *     JUNCTION DATA CARDS
   91    *
   92    *80000 VIN VOUT FIL VAL FLOW  AJUN   ZJUN    INERT  FLOS  RLOS
   93    081001   0   1   1   0    0.  1.00    0.0     0.64    0.      0. * IN FLOW
   94    082001  20   4   0   1    0.  0.418   2.0   100.00    0.4     0. * ACCUM
   95    080011   1   2   0   0    0.  3.141   0.0     0.64    0.      0. * COND
   96    080021   2   3   0   0    0.  3.141   0.0     0.64    0.      0. * COND
   97    080031   3   4   0   0    0.  3.141   0.0     0.64    0.      0. * COND
   98    080041   4   5   0   0    0.  3.141   0.0     0.64    0.      0. * COND
   99    080051   5   6   0   0    0.  3.141   0.0     0.64    0.      0. * COND
  100    080061   6   7   0   0    0.  3.141   0.0     0.64    0.      0. * COND
```


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```
080071   7   8   0   0    0.  3.141   0.0     0.64    0.      0. * COND
080081   8   9   0   0    0.  3.141   0.0     0.64    0.      0. * COND
080091   9  10   0   0    0.  3.141   0.0     0.64    0.      0. * COND
080101  10 999   0   0    0.  3.141   0.0     0.64    0.      0. * OUTLET
*
*     JUNCTION DATA CARDS CONTINUED
*
*80000 JVERT JCHK JCAL MVMX  DIAJ  CONJ  IFRJ JTPM  IHQC  ISPY  ANGL1  ANGL2
081002   0   -1    0     3    1.00  0.0   10    0     0     0     0      0   *IN
082002   0   -1    0     3    0.00  0.0   00    0     0     0     0      0   *ACC
080012   0   -1    0     3    2.00  0.0   10    0     0     0     0      0   *CON
080022   0   -1    0     3    2.00  0.0   10    0     0     0     0      0   *CON
080032   0   -1    0     3    2.00  0.0   10    0     0     0     0      0   *CON
080042   0   -1    0     3    2.00  0.0   10    0     0     0     0      0   *CON
080052   0   -1    0     3    2.00  0.0   10    0     0     0     0      0   *CON
080062   0   -1    0     3    2.00  0.0   10    0     0     0     0      0   *CON
080072   0   -1    0     3    2.00  0.0   10    0     0     0     0      0   *CON
080082   0   -1    0     3    2.00  0.0   10    0     0     0     0      0   *CON
080092   0   -1    0     3    2.00  0.0   10    0     0     0     0      0   *CON
080102   0   -1    0     3    2.00  0.0   10    0     0     0     0      0   *OUT
*
*     LOOP FILL CARDS
*
*13000 NDAT ID JX JY  TIME    FLUX       ENTH     PRESS
130100  2   2   0  0   0.     1000.0    725.0     590.0  * LOOP FILL
130101                 1.+6   1000.0    725.0     590.0  * LOOP FILL
*
*   VALVE DATA
*
110010 -3  1  1  0.0  0.0  0.0  0.0    *ISOLATION VALVE
*
*   AREA VS. TIME TABLE DATA
*
120101 -13  0.0  0.0     1.0  0.1157   2.0  0.2302   3.0  0.3428
120102      4.0  0.4526  5.0  0.5582   6.0  0.6583   7.0  0.7516
120103      8.0  0.8361  9.0  0.9094  10.0  0.9676  11.0  1.0
120104    150.   1.
*
*
*     STEADY STATE INITALIZATION DATA
*
*23000  ITMAX    ACCER    ENTHL     MASS
230000   25
*
*
*  VOLUME INITIAL CONDITIONS
*
*       LVOL   PRES    TEMP    ENTH     X   XNC
231020   20     615.    90.      0.     0.   0.
*
*
*  ACCUMULATOR DATA
*
*        VOL    LEVEL    WTHICK   VHTCAP     CSURF  CWALL   VESGEOM
621001   20     11.7381  0.02083   186.0      1.0    1.0      1
*
. END
```

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```
RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page    1
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:12
  ECC INJECTION DECK - RETRAN-3D SAMPLE PROBLEM                                                                  CPU TIME =    0.000
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

RETRAN PROBLEM CONTROL AND DESCRIPTION DATA.

    WORD  DESCRIPTION
    ====  ===================================================================
      1   RESTART FILE OPTION (SAVE=-1 / NO SAVE=0) .................... =    0
      2   PRINTER PLOT OPTION (YES=1 / NO=0) ........................... =    0
      3   POWER OPTION (TAPE OPTNS<0 / NO/TBL=0 / PT KIN=1 / 1D=2 / 3D=3) =    0
      4   USE STEADY-STATE SOLUTION (YES=0 / NO=1) ..................... =    0
      5   USE NEUTRON VOID MODEL (YES=1 / NO=0) ........................ =    0
      6   USE GENERALIZED TRANSPORT MODEL (NO=0 / VAP=1 / LIQ=-1) ....... =    0
      7   HEAT TRANSFER MAP OPTION (FORCED=0 / NAT CONV=1) ............. =    1
      8   SLIP OPTION (DYN=1 / Z-L=2 / C-L=3 / Z-L TAUGL=4 / C-L TAUGL=5) =    1
      9   FIVE-EQUATION OPTION (NO= 0 / YES=1) ......................... =    1
     10   NONCONDENSABLE GAS FLOW OPTION (NO=0 / YES=1) ................ =    0
     11   TH MATRIX DIRECT SOLVER OPTION (4-EQ=2 / 6-EQ=3) ............. =    3
     12   TH MATRIX ITERATIVE SOLVER OPTION (NO<=1 / YES=2) ............ =    0

    (DIMENSIONS AND OPTIONS AUTOMATICALLY DETERMINED BY CONTENT OF INPUT DATA)

          NUMBER OF MINOR EDIT SETS (0200XX DATA )...................... =   20
          NUMBER OF TIME-STEP CONTROL SETS (03XXX0 DATA )............... =    3
          NUMBER OF TRIP CONTROL SETS (04XXX0 DATA )..................... =    3
          NUMBER OF CONTROL VOLUME DESCRIPTIONS (05XXXY DATA )........... =   12
          NUMBER OF BUBBLE RISE DESCRIPTIONS (060XXY DATA) ............. =    0
          NUMBER OF TIME DEPENDENT VOLUMES FORM CARDS (07XXYY DATA) ..... =    1
          NUMBER OF JUNCTION DESCRIPTIONS (08XXXY DATA) ................ =   12
          NUMBER OF CENTRIFUGAL PUMP DESCRIPTIONS (090XXY DATA )......... =    0
          NUMBER OF VALVE DESCRIPTIONS (11XXXY DATA) ................... =    1
          NUMBER OF GENERAL DATA TABLE DESCRIPTIONS (12XXYY DATA) ....... =    1
          NUMBER OF FILL DESCRIPTIONS (13XXYY DATA )..................... =    1
          NUMBER OF HEAT CONDUCTOR DESCRIPTIONS (15XXXY DATA) ........... =    0
          NUMBER OF HEAT CONDUCTOR GEOMETRY DESCRIPTIONS (17XXYY DATA) .. =    0
          NUMBER OF HEAT CONDUCTOR MATERIAL DESCRIPTIONS (18XXYY DATA) .. =    0
          NUMBER OF CORE SECTION DESCRIPTIONS (16XXXY DATA) ............ =    0
          NUMBER OF NON-CONDUCTNG HEAT EXCHNGR DESCRIPTIONS (21XXYY DATA) =    0
          NUMBER OF TIME DEP BCS FROM TAPE (IREAD<0 ON 05XXXY DATA) ..... =    0
          NUMBER OF SPECIFIED HEAT TRAN COEF DESCRIPTIONS (015XXX DATA) . =    0
          TWO-REGION NONEQ VOL DESCRIPTIONS (610XXX OR 611XXX DATA) ..... =    0
          TEMP. TRANSPORT DELAY OPTION (MESH>0 ON 05XXXY DATA) .......... =    0
          AUXILIARY DNB MODEL (8001XX DATA INCLUDED) ................... =    0
          CONTROL SYSTEM MODEL (702XXX OR 702XXXX DATA) ................ =    0
          ACCUMULATOR MODEL DESCRIPTIONS (620XXX OR 621XXX DATA)......... =    1
          DYNAMIC GAP CONDUCTANCE MODEL DESCRIPTIONS (225XX0 DATA) ...... =    0
          NUMBER OF HT CONDUCTOR STACK DESCRIPTIONS (2200XY DATA) ....... =    0
          NUMBER OF TURBINE SHAFT DESCRIPTIONS (500XXY DATA) ........... =    0
          NUMBER OF PROFILE FIT DESCRIPTIONS (061XX1 DATA) ............. =    0
          NUMBER OF STEAM-WATER SEPARATOR DESCRIPTIONS (60XXX0 DATA) .... =    0


                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * *                                                * * *
                   * * *          STEADY-STATE OPTION    =   0          * * *
                   * * *                                                * * *
                   * * *          SLIP OPTION            =   1          * * *
                   * * *                                                * * *
                   * * *          NUMERICS OPTION        =   3          * * *
                   * * *                                                * * *
                   * * *          HEAT TRANSFER OPTION   =   1          * * *
                   * * *                                                * * *
                   * * *          NEW EQUATIONS OPTION   =   1          * * *
                   * * *                                                * * *
                   * * *         USING THE 6-EQ SOLVER - SOLVE4         * * *
                   * * *                                                * * *
                   * * *     USING STANDARD STEADY-STATE SOLUTION       * * *
                   * * *                                                * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *


INITIAL THERMAL POWER (MEGAWATTS) =  0.00000E+00


AIR IS THE DEFAULT NONCONDENSABLE GAS.
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PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   16
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:13
  ECC INJECTION DECK - RETRAN-3D SAMPLE PROBLEM                                                               CPU TIME =    0.031
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	ENERGY BALANCE (BTU)	TOTAL MASS BALANCE (LBM)	NCG MASS BALANCE (LBM)	AVERAGE TIME STEP (SEC)	CURRENT TIME STEP (SEC)	ELAPSED TIME (SEC)	TIME STEP NUM STANDRD/ACTUL
0.00000E+00	0.00000E+00	0.00000E+00	3.51800E+06	6.03005E+04	1.29934E+03	0.00000E+00	0.00000E+00	0.00000E+00	0 0

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	VOID FRAC.	POWR TO H2O (BTU/SEC)
1	5.85281E+02	2.18350E+01	7.24463E+02	3.47581E+00	4.83774E+02	3.47123E-01	9.54576E-01	0.00000E+00
2	5.85253E+02	2.18340E+01	7.24463E+02	3.47564E+00	4.83772E+02	3.47123E-01	9.54578E-01	0.00000E+00
3	5.85224E+02	2.18329E+01	7.24463E+02	3.47547E+00	4.83770E+02	3.47123E-01	9.54580E-01	0.00000E+00
4	5.85195E+02	2.18319E+01	7.24463E+02	3.47531E+00	4.83769E+02	3.47123E-01	9.54582E-01	0.00000E+00
5	5.85166E+02	2.18308E+01	7.24463E+02	3.47514E+00	4.83767E+02	3.47123E-01	9.54584E-01	0.00000E+00
6	5.85137E+02	2.18298E+01	7.24463E+02	3.47497E+00	4.83765E+02	3.47123E-01	9.54586E-01	0.00000E+00
7	5.85108E+02	2.18287E+01	7.24463E+02	3.47480E+00	4.83764E+02	3.47123E-01	9.54589E-01	0.00000E+00
8	5.85080E+02	2.18277E+01	7.24463E+02	3.47464E+00	4.83762E+02	3.47123E-01	9.54591E-01	0.00000E+00
9	5.85051E+02	2.18266E+01	7.24463E+02	3.47447E+00	4.83760E+02	3.47123E-01	9.54593E-01	0.00000E+00
10	5.85022E+02	2.18198E+01	7.24535E+02	3.47339E+00	4.83758E+02	3.47221E-01	9.54614E-01	0.00000E+00
20	6.15000E+02	6.00667E+04	5.76731E+01	6.22324E+01	9.00000E+01	0.00000E+00	0.00000E+00	0.00000E+00
999	5.85000E+02	1.54813E+01	8.36212E+02	2.46439E+00	4.83146E+02	5.00000E-01	9.75358E-01	0.00000E+00

JUNCTION NUMBER	CONNECTS VOLUMES	CHOK/ PATH	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E VEL. PSI	ELEV. PSI	D I F F E R E N T I A L S FRIC. PSI	ACCL. PSI	PUMP PSI
1	1 TO 2		1.00000E+03	7.24463E+02	2.87703E-01	0.00000E+00	1.16239E-06	-2.88407E-02	7.87455E-11	0.00000E+00
2	2 TO 3		1.00000E+03	7.24463E+02	2.87717E-01	0.00000E+00	1.16245E-06	-2.88421E-02	7.82528E-11	0.00000E+00
3	3 TO 4		1.00000E+03	7.24463E+02	2.87731E-01	0.00000E+00	1.16251E-06	-2.88436E-02	7.77402E-11	0.00000E+00
4	4 TO 5		1.00000E+03	7.24463E+02	2.87744E-01	0.00000E+00	1.16257E-06	-2.88450E-02	7.73172E-11	0.00000E+00
5	5 TO 6		1.00000E+03	7.24463E+02	2.87758E-01	0.00000E+00	1.16263E-06	-2.88464E-02	7.67521E-11	0.00000E+00
6	6 TO 7		1.00000E+03	7.24463E+02	2.87772E-01	0.00000E+00	1.16269E-06	-2.88479E-02	7.62712E-11	0.00000E+00
7	7 TO 8		1.00000E+03	7.24463E+02	2.87786E-01	0.00000E+00	1.16276E-06	-2.88493E-02	7.58426E-11	0.00000E+00
8	8 TO 9		1.00000E+03	7.24463E+02	2.87800E-01	0.00000E+00	1.16810E-06	-2.88508E-02	7.02364E-11	0.00000E+00
9	9 TO 10		1.00000E+03	7.24463E+02	2.87814E-01	0.00000E+00	7.49633E-06	-2.88522E-02	2.02186E-10	0.00000E+00
10	10 TO 999		1.00000E+03	7.24535E+02	2.87903E-01	0.00000E+00	7.00696E-03	-2.88577E-02	-5.47016E-12	0.00000E+00
200	20 TO 4		0.00000E+00	5.76731E+01	1.60688E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
100	0 TO 1		1.00000E+03	7.25000E+02	2.86016E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

VOLUME NUMBER	FLOW REG.	LIQ. ENTH. (BTU/LB)	GAS ENTH. (BTU/LB)	LIQ. TEMP. (DEG. F)	GAS TEMP. (DEG. F)	IF AREA DEN (FT2/FT3)	IF HT COEFF (B/H-FT2-F)	IF MASS TRN (LB/SEC)	TOT MAS TRN (LB/SEC)	LIQ. HT RT (BTU/SEC)
1	19	4.69564E+02	1.20388E+03	4.84021E+02	4.83197E+02	5.49721E-01	5.54899E+00	5.97666E-06	5.97666E-06	-7.19521E-03
2	19	4.69564E+02	1.20388E+03	4.84021E+02	4.83192E+02	5.49713E-01	9.65457E+00	1.04622E-05	1.04622E-05	-1.25952E-02
3	19	4.69564E+02	1.20389E+03	4.84021E+02	4.83186E+02	5.49704E-01	9.65441E+00	1.05255E-05	1.05255E-05	-1.26715E-02
4	19	4.69563E+02	1.20389E+03	4.84021E+02	4.83181E+02	5.49696E-01	9.65424E+00	1.05888E-05	1.05888E-05	-1.27477E-02
5	19	4.69563E+02	1.20389E+03	4.84021E+02	4.83176E+02	5.49688E-01	9.65407E+00	1.06521E-05	1.06521E-05	-1.28240E-02
6	19	4.69563E+02	1.20389E+03	4.84020E+02	4.83171E+02	5.49680E-01	9.65390E+00	1.07155E-05	1.07155E-05	-1.29002E-02
7	19	4.69563E+02	1.20389E+03	4.84020E+02	4.83165E+02	5.49672E-01	9.65374E+00	1.07788E-05	1.07788E-05	-1.29764E-02
8	19	4.69563E+02	1.20389E+03	4.84020E+02	4.83160E+02	5.49664E-01	9.65357E+00	1.08421E-05	1.08421E-05	-1.30527E-02
9	19	4.69562E+02	1.20389E+03	4.84020E+02	4.83155E+02	5.49656E-01	9.65297E+00	1.09050E-05	1.09050E-05	-1.31283E-02
10	19	4.69562E+02	1.20389E+03	4.84020E+02	4.83150E+02	5.49578E-01	9.12878E+00	1.03715E-05	1.03715E-05	-1.24862E-02

JUNCTION NUMBER	FLOW REG.	SLIP VEL. (FT/SEC)	VOID FRACTION	LIQUID FLOW (LB/SEC)	GAS FLOW (LB/SEC)	SLIP CNVCTN (BTU/SEC)	GAS VEL. (FT/SEC)	LIQ. VEL. (FT/SEC)	VG/VL	SLIP ACCEL. (FT/SEC**2)
1	12	-2.95394E-01	9.54576E-01	6.52146E+02	3.47854E+02	5.36692E+02	9.17888E+01	9.14934E+01	1.00323E+00	1.20132E-05
2	12	-2.95401E-01	9.54578E-01	6.52146E+02	3.47854E+02	5.36680E+02	9.17932E+01	9.14978E+01	1.00323E+00	1.19314E-05
3	12	-2.95408E-01	9.54580E-01	6.52146E+02	3.47854E+02	5.36667E+02	9.17976E+01	9.15022E+01	1.00323E+00	1.18487E-05
4	12	-2.95415E-01	9.54582E-01	6.52146E+02	3.47854E+02	5.36655E+02	9.18021E+01	9.15066E+01	1.00323E+00	1.17650E-05
5	12	-2.95422E-01	9.54584E-01	6.52146E+02	3.47854E+02	5.36642E+02	9.18065E+01	9.15110E+01	1.00323E+00	1.16806E-05
6	12	-2.95429E-01	9.54586E-01	6.52146E+02	3.47854E+02	5.36630E+02	9.18109E+01	9.15155E+01	1.00323E+00	1.15951E-05
7	12	-2.95436E-01	9.54589E-01	6.52146E+02	3.47854E+02	5.36617E+02	9.18153E+01	9.15199E+01	1.00323E+00	1.15086E-05
8	12	-2.95443E-01	9.54591E-01	6.52146E+02	3.47854E+02	5.36605E+02	9.18197E+01	9.15243E+01	1.00323E+00	1.14169E-05
9	12	-2.95418E-01	9.54593E-01	6.52146E+02	3.47854E+02	5.36532E+02	9.18241E+01	9.15287E+01	1.00323E+00	1.18029E-05
10	12	-2.55848E-01	9.54614E-01	6.52146E+02	3.47854E+02	4.64583E+02	9.18268E+01	9.15709E+01	1.00279E+00	-3.22689E-07

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   21
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis           11:57:13
  ECC INJECTION DECK - RETRAN-3D SAMPLE PROBLEM                                                               CPU TIME =    0.062
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	ENERGY BALANCE (BTU)	TOTAL MASS BALANCE (LBM)	NCG MASS BALANCE (LBM)	AVERAGE TIME STEP (SEC)	CURRENT TIME STEP (SEC)	ELAPSED TIME (SEC)	TIME STEP NUM STANDRD/ACTUL
0.00000E+00	0.00000E+00	0.00000E+00	3.44685E+06	5.90100E+04	1.29934E+03	2.50000E-02	2.50000E-02	5.00000E+00	170 184

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	VOID FRAC.	POWR TO H2O (BTU/SEC)
1	5.85025E+02	2.18257E+01	7.24463E+02	3.47432E+00	4.83759E+02	3.47123E-01	9.54595E-01	0.00000E+00
2	5.84996E+02	2.18246E+01	7.24463E+02	3.47416E+00	4.83757E+02	3.47123E-01	9.54597E-01	0.00000E+00
3	5.84968E+02	2.18271E+01	7.24419E+02	3.47455E+00	4.83755E+02	3.47063E-01	9.54588E-01	0.00000E+00
4	5.84934E+02	2.61097E+01	6.07694E+02	4.15627E+00	4.16381E+02	2.87250E-01	9.45145E-01	0.00000E+00
5	5.84943E+02	2.62486E+01	6.04706E+02	4.17839E+00	4.14692E+02	2.85633E-01	9.44811E-01	0.00000E+00
6	5.84952E+02	2.63865E+01	6.01780E+02	4.20033E+00	4.13041E+02	2.84045E-01	9.44479E-01	0.00000E+00
7	5.84960E+02	2.65232E+01	5.98915E+02	4.22210E+00	4.11425E+02	2.82486E-01	9.44149E-01	0.00000E+00
8	5.84967E+02	2.66587E+01	5.96109E+02	4.24367E+00	4.09844E+02	2.80956E-01	9.43821E-01	0.00000E+00
9	5.84975E+02	2.67930E+01	5.93359E+02	4.26504E+00	4.08295E+02	2.79455E-01	9.43495E-01	0.00000E+00
10	5.84981E+02	2.69061E+01	5.90862E+02	4.28305E+00	4.06807E+02	2.78206E-01	9.43231E-01	0.00000E+00
20	5.75109E+02	5.87435E+04	5.75934E+01	6.22246E+01	8.98967E+01	0.00000E+00	0.00000E+00	3.64316E+02
999	5.85000E+02	1.54813E+01	8.36212E+02	2.46439E+00	4.83146E+02	5.00000E-01	9.75358E-01	0.00000E+00

JUNCTION NUMBER	CONNECTS VOLUMES	CHOK/ PATH	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E VEL. PSI	ELEV. PSI	D I F F E R E N T I A L S FRIC. PSI	ACCL. PSI	PUMP PSI
1	1 TO 2		1.00001E+03	7.24463E+02	2.87824E-01	0.00000E+00	1.16099E-06	-2.88535E-02	2.20420E-06	0.00000E+00
2	2 TO 3		1.00001E+03	7.24463E+02	2.87838E-01	0.00000E+00	-2.86249E-06	-2.88552E-02	4.45066E-06	0.00000E+00
3	3 TO 4		1.00002E+03	7.24417E+02	2.87804E-01	0.00000E+00	-4.90635E-03	-2.88545E-02	-2.03772E-04	0.00000E+00
4	4 TO 5		1.21214E+03	6.04217E+02	2.39171E-01	0.00000E+00	-1.51996E-04	-3.35140E-02	-4.21284E-02	0.00000E+00
5	5 TO 6		1.21832E+03	6.01302E+02	2.37926E-01	0.00000E+00	-1.50744E-04	-3.36021E-02	-4.17083E-02	0.00000E+00
6	6 TO 7		1.22444E+03	5.98447E+02	2.36703E-01	0.00000E+00	-1.49420E-04	-3.36895E-02	-4.12818E-02	0.00000E+00
7	7 TO 8		1.23051E+03	5.95651E+02	2.35504E-01	0.00000E+00	-1.48066E-04	-3.37761E-02	-4.08620E-02	0.00000E+00
8	8 TO 9		1.23650E+03	5.92912E+02	2.34327E-01	0.00000E+00	-1.46820E-04	-3.38621E-02	-4.04872E-02	0.00000E+00
9	9 TO 10		1.24244E+03	5.90225E+02	2.33172E-01	0.00000E+00	-1.23048E-04	-3.39478E-02	-4.02079E-02	0.00000E+00
10	10 TO 999		1.24831E+03	5.87795E+02	2.32213E-01	0.00000E+00	1.27917E-02	-3.40530E-02	-3.98450E-02	0.00000E+00
200	20 TO 4		2.05875E+02	5.75936E+01	1.60708E-02	0.00000E+00	3.91807E+00	-8.84479E-01	-6.64687E+00	0.00000E+00
100	0 TO 1		1.00000E+03	7.25000E+02	2.86016E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

VOLUME NUMBER	FLOW REG.	LIQ. ENTH. (BTU/LB)	GAS ENTH. (BTU/LB)	LIQ. TEMP. (DEG. F)	GAS TEMP. (DEG. F)	IF AREA DEN (FT2/FT3)	IF HT COEFF (B/H-FT2-F)	IF MASS TRN (LB/SEC)	TOT MAS TRN (LB/SEC)	LIQ. HT RT (BTU/SEC)
1	19	4.69562E+02	1.20389E+03	4.84019E+02	4.83150E+02	5.49650E-01	5.54853E+00	6.29432E-06	6.29432E-06	-7.57765E-03
2	19	4.69562E+02	1.20389E+03	4.84019E+02	4.83145E+02	5.49642E-01	9.65384E+00	1.10120E-05	1.10120E-05	-1.32572E-02
3	19	4.69561E+02	1.20389E+03	4.84019E+02	4.83140E+02	5.49678E-01	9.97451E+00	1.14410E-05	1.14410E-05	-1.37737E-02
4	19	3.67417E+02	1.20389E+03	3.92639E+02	4.83134E+02	5.83314E-01	5.73062E+02	-6.46773E-02	-6.46773E-02	7.78643E+01
5	19	3.65128E+02	1.20389E+03	3.90503E+02	4.83135E+02	5.84365E-01	5.73723E+02	-6.61396E-02	-6.61396E-02	7.96247E+01
6	19	3.62902E+02	1.20389E+03	3.88424E+02	4.83137E+02	5.85406E-01	5.74174E+02	-6.75445E-02	-6.75445E-02	8.13160E+01
7	19	3.60736E+02	1.20389E+03	3.86397E+02	4.83138E+02	5.86436E-01	5.74613E+02	-6.89158E-02	-6.89158E-02	8.29669E+01
8	19	3.58628E+02	1.20389E+03	3.84422E+02	4.83140E+02	5.87454E-01	5.75042E+02	-7.02557E-02	-7.02557E-02	8.45801E+01
9	19	3.56572E+02	1.20389E+03	3.82494E+02	4.83141E+02	5.88460E-01	5.75462E+02	-7.15667E-02	-7.15667E-02	8.61583E+01
10	19	3.54580E+02	1.20389E+03	3.80623E+02	4.83142E+02	5.89268E-01	5.76085E+02	-7.28438E-02	-7.28438E-02	8.76958E+01

JUNCTION NUMBER	FLOW REG.	SLIP VEL. (FT/SEC)	VOID FRACTION	LIQUID FLOW (LB/SEC)	GAS FLOW (LB/SEC)	SLIP CNVCTN (BTU/SEC)	GAS VEL. (FT/SEC)	LIQ. VEL. (FT/SEC)	VG/VL	SLIP ACCEL. (FT/SEC**2)
1	12	-2.95469E-01	9.54595E-01	6.52150E+02	3.47856E+02	5.36604E+02	9.18279E+01	9.15325E+01	1.00323E+00	-2.74138E-04
2	12	-2.95511E-01	9.54597E-01	6.52154E+02	3.47858E+02	5.36651E+02	9.18329E+01	9.15374E+01	1.00323E+00	-5.56207E-04
3	12	-3.19168E-01	9.54587E-01	6.52164E+02	3.47858E+02	5.81119E+02	9.18384E+01	9.15193E+01	1.00349E+00	3.56480E-01
4	12	1.89703E-01	9.44776E-01	8.66661E+02	3.45477E+02	-4.14036E+02	9.21626E+01	9.23523E+01	9.97946E-01	4.33561E-01
5	12	1.85137E-01	9.44445E-01	8.72995E+02	3.45327E+02	-4.05081E+02	9.21533E+01	9.23384E+01	9.97995E-01	4.40743E-01
6	12	1.80358E-01	9.44116E-01	8.79270E+02	3.45175E+02	-3.95547E+02	9.21437E+01	9.23241E+01	9.98046E-01	4.45187E-01
7	12	1.75413E-01	9.43788E-01	8.85483E+02	3.45023E+02	-3.85827E+02	9.21339E+01	9.23093E+01	9.98100E-01	4.38087E-01
8	12	1.70542E-01	9.43464E-01	8.91634E+02	3.44870E+02	-3.76981E+02	9.21237E+01	9.22942E+01	9.98152E-01	4.10494E-01
9	12	1.66442E-01	9.43141E-01	8.97730E+02	3.44715E+02	-3.70902E+02	9.21126E+01	9.22790E+01	9.98196E-01	3.64725E-01
10	12	2.63874E-01	9.42881E-01	9.03750E+02	3.44562E+02	-6.04728E+02	9.20962E+01	9.23600E+01	9.97143E-01	3.64507E-02

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   22
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:13
  ECC INJECTION DECK - RETRAN-3D SAMPLE PROBLEM                                                                 CPU TIME =     0.062
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *
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SYSTEM ELAPSED TIME (SEC)	SYSTEM ELAPSED TIME (SEC)	TIME STP ACTUAL	VOL 4 AVG. PRESS. (PSIA)	VOL 20 AVG. PRESS. (PSIA)	JUN 4 FLOW (LB/SEC)	JUN 200 FLOW (LB/SEC)	JUN 3 GAS FLOW (LB/SEC)	JUN 3 LIQ FLOW (LB/SEC)
0.00000E+00	0.00000E+00	0.00000E+00	5.85195E+02	6.15000E+02	1.00000E+03	0.00000E+00	3.47854E+02	6.52146E+02
2.00000E-01	2.00000E-01	4.00000E+00	5.85195E+02	6.15000E+02	1.00000E+03	0.00000E+00	3.47854E+02	6.52146E+02
4.00000E-01	4.00000E-01	9.00000E+00	5.85195E+02	6.15000E+02	1.00000E+03	0.00000E+00	3.47854E+02	6.52146E+02
6.00000E-01	6.00000E-01	1.40000E+01	5.85195E+02	6.15000E+02	1.00000E+03	0.00000E+00	3.47854E+02	6.52146E+02
8.00000E-01	8.00000E-01	1.90000E+01	5.85195E+02	6.15000E+02	1.00000E+03	0.00000E+00	3.47854E+02	6.52146E+02
1.00000E+00	1.00000E+00	2.40000E+01	5.85195E+02	6.15000E+02	1.00000E+03	0.00000E+00	3.47854E+02	6.52146E+02
1.10000E+00	1.10000E+00	2.80000E+01	5.85351E+02	6.14912E+02	1.02821E+03	3.13739E+01	3.47841E+02	6.52160E+02
1.20000E+00	1.20000E+00	3.20000E+01	5.85436E+02	6.14760E+02	1.05451E+03	6.06547E+01	3.47831E+02	6.52088E+02
1.30000E+00	1.30000E+00	3.60000E+01	5.85479E+02	6.14514E+02	1.08402E+03	9.01753E+01	3.47845E+02	6.52118E+02
1.40000E+00	1.40000E+00	4.00000E+01	5.85492E+02	6.14174E+02	1.11339E+03	1.19437E+02	3.47853E+02	6.52135E+02
1.50000E+00	1.50000E+00	4.40000E+01	5.85494E+02	6.13743E+02	1.14236E+03	1.48275E+02	3.47855E+02	6.52139E+02
1.60000E+00	1.60000E+00	4.80000E+01	5.85494E+02	6.13221E+02	1.17078E+03	1.76553E+02	3.47856E+02	6.52140E+02
1.70000E+00	1.70000E+00	5.20000E+01	5.85491E+02	6.12611E+02	1.19854E+03	2.04148E+02	3.47857E+02	6.52142E+02
1.80000E+00	1.80000E+00	5.60000E+01	5.85486E+02	6.11917E+02	1.22553E+03	2.30946E+02	3.47857E+02	6.52144E+02
1.90000E+00	1.90000E+00	6.00000E+01	5.85480E+02	6.11140E+02	1.25162E+03	2.56835E+02	3.47858E+02	6.52145E+02
2.00000E+00	2.00000E+00	6.40000E+01	5.85473E+02	6.10285E+02	1.27672E+03	2.81707E+02	3.47858E+02	6.52146E+02
2.10000E+00	2.10000E+00	6.80000E+01	5.85464E+02	6.09356E+02	1.30065E+03	3.05364E+02	3.47859E+02	6.52148E+02
2.20000E+00	2.20000E+00	7.20000E+01	5.85454E+02	6.08358E+02	1.32329E+03	3.27723E+02	3.47859E+02	6.52149E+02
2.30000E+00	2.30000E+00	7.60000E+01	5.85443E+02	6.07294E+02	1.34459E+03	3.48734E+02	3.47859E+02	6.52149E+02
2.40000E+00	2.40000E+00	8.00000E+01	5.85432E+02	6.06171E+02	1.36448E+03	3.68325E+02	3.47859E+02	6.52150E+02
2.50000E+00	2.50000E+00	8.40000E+01	5.85419E+02	6.04993E+02	1.38288E+03	3.86416E+02	3.47859E+02	6.52151E+02
2.60000E+00	2.60000E+00	8.80000E+01	5.85406E+02	6.03766E+02	1.39972E+03	4.02927E+02	3.47860E+02	6.52152E+02
2.70000E+00	2.70000E+00	9.20000E+01	5.85392E+02	6.02494E+02	1.41492E+03	4.17781E+02	3.47860E+02	6.52154E+02
2.80000E+00	2.80000E+00	9.60000E+01	5.85376E+02	6.01185E+02	1.42839E+03	4.30902E+02	3.47860E+02	6.52155E+02
2.90000E+00	2.90000E+00	1.00000E+02	5.85360E+02	5.99843E+02	1.44008E+03	4.42220E+02	3.47860E+02	6.52156E+02
3.00000E+00	3.00000E+00	1.04000E+02	5.85344E+02	5.98475E+02	1.44991E+03	4.51671E+02	3.47861E+02	6.52157E+02
3.10000E+00	3.10000E+00	1.08000E+02	5.85326E+02	5.97087E+02	1.45777E+03	4.59135E+02	3.47861E+02	6.52158E+02
3.20000E+00	3.20000E+00	1.12000E+02	5.85307E+02	5.95685E+02	1.46360E+03	4.64556E+02	3.47861E+02	6.52159E+02
3.30000E+00	3.30000E+00	1.16000E+02	5.85287E+02	5.94276E+02	1.46737E+03	4.67912E+02	3.47861E+02	6.52160E+02
3.40000E+00	3.40000E+00	1.20000E+02	5.85267E+02	5.92866E+02	1.46906E+03	4.69179E+02	3.47861E+02	6.52160E+02
3.50000E+00	3.50000E+00	1.24000E+02	5.85247E+02	5.91461E+02	1.46863E+03	4.68330E+02	3.47861E+02	6.52161E+02
3.60000E+00	3.60000E+00	1.28000E+02	5.85226E+02	5.90069E+02	1.46608E+03	4.65353E+02	3.47861E+02	6.52162E+02
3.70000E+00	3.70000E+00	1.32000E+02	5.85205E+02	5.88694E+02	1.46138E+03	4.60229E+02	3.47861E+02	6.52163E+02
3.80000E+00	3.80000E+00	1.36000E+02	5.85184E+02	5.87343E+02	1.45453E+03	4.52948E+02	3.47861E+02	6.52163E+02
3.90000E+00	3.90000E+00	1.40000E+02	5.85162E+02	5.86022E+02	1.44552E+03	4.43507E+02	3.47861E+02	6.52164E+02
4.00000E+00	4.00000E+00	1.44000E+02	5.85140E+02	5.84738E+02	1.43436E+03	4.31914E+02	3.47861E+02	6.52165E+02
4.10000E+00	4.10000E+00	1.48000E+02	5.85118E+02	5.83496E+02	1.42104E+03	4.18158E+02	3.47861E+02	6.52165E+02
4.20000E+00	4.20000E+00	1.52000E+02	5.85096E+02	5.82302E+02	1.40558E+03	4.02261E+02	3.47861E+02	6.52166E+02
4.30000E+00	4.30000E+00	1.56000E+02	5.85074E+02	5.81161E+02	1.38802E+03	3.84272E+02	3.47862E+02	6.52168E+02
4.40000E+00	4.40000E+00	1.60000E+02	5.85052E+02	5.80080E+02	1.36841E+03	3.64248E+02	3.47860E+02	6.52166E+02
4.50000E+00	4.50000E+00	1.64000E+02	5.85031E+02	5.79063E+02	1.34683E+03	3.42252E+02	3.47860E+02	6.52166E+02
4.60000E+00	4.60000E+00	1.68000E+02	5.85011E+02	5.78116E+02	1.32337E+03	3.18360E+02	3.47860E+02	6.52166E+02
4.70000E+00	4.70000E+00	1.72000E+02	5.84993E+02	5.77242E+02	1.29816E+03	2.92655E+02	3.47859E+02	6.52166E+02
4.80000E+00	4.80000E+00	1.76000E+02	5.84970E+02	5.76447E+02	1.27094E+03	2.65253E+02	3.47862E+02	6.52172E+02
4.90000E+00	4.90000E+00	1.80000E+02	5.84948E+02	5.75735E+02	1.24226E+03	2.36296E+02	3.47857E+02	6.52164E+02
5.00000E+00	5.00000E+00	1.84000E+02	5.84934E+02	5.75109E+02	1.21214E+03	2.05875E+02	3.47858E+02	6.52164E+02

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   23
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:13
  ECC INJECTION DECK - RETRAN-3D SAMPLE PROBLEM                                                                 CPU TIME =     0.062
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *
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SYSTEM ELAPSED TIME (SEC)	JUN 4 GAS FLOW (LB/SEC)	JUN 4 LIQ FLOW (LB/SEC)	VOL 3 AVG. QUALITY	VOL 4 AVG. QUALITY	VOL 3 LIQUID TEMP. (DEG F)	VOL 4 LIQUID TEMP. (DEG F)	VOL 4 VAPOR TEMP. (DEG F)	VOL 10 LIQUID TEMP. (DEG F)
0.00000E+00	3.47854E+02	6.52146E+02	3.47123E-01	3.47123E-01	4.84021E+02	4.84021E+02	4.83181E+02	4.84020E+02
2.00000E-01	3.47854E+02	6.52146E+02	3.47123E-01	3.47123E-01	4.84021E+02	4.84021E+02	4.83181E+02	4.84020E+02
4.00000E-01	3.47854E+02	6.52146E+02	3.47123E-01	3.47123E-01	4.84021E+02	4.84021E+02	4.83181E+02	4.84020E+02
6.00000E-01	3.47854E+02	6.52146E+02	3.47123E-01	3.47123E-01	4.84021E+02	4.84021E+02	4.83181E+02	4.84020E+02
8.00000E-01	3.47854E+02	6.52146E+02	3.47123E-01	3.47123E-01	4.84021E+02	4.84021E+02	4.83181E+02	4.84020E+02
1.00000E+00	3.47854E+02	6.52146E+02	3.47123E-01	3.47123E-01	4.84021E+02	4.84021E+02	4.83181E+02	4.84020E+02
1.10000E+00	3.49167E+02	6.79044E+02	3.47111E-01	3.37401E-01	4.84024E+02	4.69548E+02	4.83210E+02	4.80117E+02
1.20000E+00	3.50325E+02	7.04185E+02	3.47108E-01	3.28827E-01	4.84026E+02	4.56772E+02	4.83225E+02	4.71384E+02
1.30000E+00	3.50309E+02	7.33710E+02	3.47099E-01	3.19863E-01	4.84025E+02	4.43450E+02	4.83233E+02	4.59953E+02
1.40000E+00	3.50227E+02	7.63168E+02	3.47091E-01	3.11410E-01	4.84024E+02	4.31009E+02	4.83235E+02	4.47219E+02
1.50000E+00	3.50127E+02	7.92229E+02	3.47083E-01	3.03496E-01	4.84023E+02	4.19498E+02	4.83235E+02	4.34725E+02
1.60000E+00	3.50021E+02	8.20758E+02	3.47076E-01	2.96110E-01	4.84023E+02	4.08879E+02	4.83235E+02	4.23018E+02
1.70000E+00	3.49912E+02	8.48630E+02	3.47068E-01	2.89236E-01	4.84023E+02	3.99103E+02	4.83235E+02	4.12188E+02
1.80000E+00	3.49800E+02	8.75728E+02	3.47061E-01	2.82855E-01	4.84023E+02	3.90119E+02	4.83234E+02	4.02209E+02
1.90000E+00	3.49686E+02	9.01939E+02	3.47054E-01	2.76947E-01	4.84023E+02	3.81881E+02	4.83233E+02	3.93036E+02
2.00000E+00	3.49569E+02	9.27154E+02	3.47047E-01	2.71493E-01	4.84022E+02	3.74343E+02	4.83232E+02	3.84620E+02
2.10000E+00	3.49444E+02	9.51208E+02	3.47041E-01	2.66493E-01	4.84022E+02	3.67481E+02	4.83230E+02	3.76919E+02
2.20000E+00	3.49321E+02	9.73967E+02	3.47035E-01	2.61930E-01	4.84022E+02	3.61261E+02	4.83228E+02	3.69901E+02
2.30000E+00	3.49199E+02	9.95387E+02	3.47030E-01	2.57779E-01	4.84022E+02	3.55635E+02	4.83226E+02	3.63528E+02
2.40000E+00	3.49078E+02	1.01540E+03	3.47025E-01	2.54020E-01	4.84022E+02	3.50565E+02	4.83224E+02	3.57759E+02
2.50000E+00	3.48956E+02	1.03393E+03	3.47020E-01	2.50641E-01	4.84022E+02	3.46022E+02	4.83222E+02	3.52558E+02
2.60000E+00	3.48833E+02	1.05089E+03	3.47016E-01	2.47628E-01	4.84022E+02	3.41980E+02	4.83219E+02	3.47890E+02
2.70000E+00	3.48710E+02	1.06621E+03	3.47012E-01	2.44974E-01	4.84022E+02	3.38420E+02	4.83217E+02	3.43730E+02
2.80000E+00	3.48585E+02	1.07981E+03	3.47009E-01	2.42669E-01	4.84021E+02	3.35324E+02	4.83214E+02	3.40056E+02
2.90000E+00	3.48459E+02	1.09162E+03	3.47006E-01	2.40709E-01	4.84021E+02	3.32678E+02	4.83211E+02	3.36849E+02
3.00000E+00	3.48332E+02	1.10157E+03	3.47004E-01	2.39087E-01	4.84021E+02	3.30472E+02	4.83208E+02	3.34094E+02
3.10000E+00	3.48200E+02	1.10957E+03	3.47002E-01	2.37809E-01	4.84021E+02	3.28705E+02	4.83205E+02	3.31783E+02
3.20000E+00	3.48067E+02	1.11554E+03	3.47000E-01	2.36877E-01	4.84021E+02	3.27379E+02	4.83201E+02	3.29910E+02
3.30000E+00	3.47934E+02	1.11944E+03	3.46999E-01	2.36285E-01	4.84021E+02	3.26488E+02	4.83198E+02	3.28473E+02
3.40000E+00	3.47801E+02	1.12125E+03	3.46999E-01	2.36033E-01	4.84021E+02	3.26030E+02	4.83194E+02	3.27467E+02
3.50000E+00	3.47667E+02	1.12096E+03	3.46999E-01	2.36122E-01	4.84020E+02	3.26007E+02	4.83191E+02	3.26893E+02
3.60000E+00	3.47532E+02	1.11854E+03	3.47000E-01	2.36557E-01	4.84020E+02	3.26424E+02	4.83187E+02	3.26751E+02
3.70000E+00	3.47395E+02	1.11399E+03	3.47001E-01	2.37342E-01	4.84020E+02	3.27292E+02	4.83183E+02	3.27045E+02
3.80000E+00	3.47256E+02	1.10727E+03	3.47002E-01	2.38489E-01	4.84020E+02	3.28625E+02	4.83179E+02	3.27783E+02
3.90000E+00	3.47116E+02	1.09841E+03	3.47004E-01	2.40007E-01	4.84020E+02	3.30441E+02	4.83175E+02	3.28979E+02
4.00000E+00	3.46974E+02	1.08739E+03	3.47007E-01	2.41911E-01	4.84020E+02	3.32762E+02	4.83171E+02	3.30648E+02
4.10000E+00	3.46827E+02	1.07421E+03	3.47010E-01	2.44219E-01	4.84019E+02	3.35620E+02	4.83167E+02	3.32811E+02
4.20000E+00	3.46679E+02	1.05890E+03	3.47014E-01	2.46953E-01	4.84019E+02	3.39048E+02	4.83163E+02	3.35491E+02
4.30000E+00	3.46530E+02	1.04149E+03	3.47018E-01	2.50132E-01	4.84019E+02	3.43084E+02	4.83159E+02	3.38705E+02
4.40000E+00	3.46376E+02	1.02203E+03	3.47023E-01	2.53781E-01	4.84019E+02	3.47767E+02	4.83155E+02	3.42585E+02
4.50000E+00	3.46219E+02	1.00061E+03	3.47028E-01	2.57930E-01	4.84019E+02	3.53144E+02	4.83151E+02	3.47061E+02
4.60000E+00	3.46051E+02	9.77318E+02	3.47034E-01	2.62626E-01	4.84019E+02	3.59268E+02	4.83148E+02	3.52207E+02
4.70000E+00	3.45850E+02	9.52313E+02	3.47040E-01	2.68014E-01	4.84019E+02	3.66186E+02	4.83144E+02	3.58082E+02
4.80000E+00	3.45770E+02	9.25165E+02	3.47047E-01	2.73853E-01	4.84018E+02	3.74044E+02	4.83140E+02	3.64797E+02
4.90000E+00	3.45623E+02	8.96638E+02	3.47055E-01	2.80234E-01	4.84018E+02	3.82825E+02	4.83136E+02	3.72177E+02
5.00000E+00	3.45477E+02	8.66661E+02	3.47063E-01	2.87250E-01	4.84019E+02	3.92639E+02	4.83134E+02	3.80623E+02

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   24
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:13
  ECC INJECTION DECK - RETRAN-3D SAMPLE PROBLEM                                                                 CPU TIME =    0.062
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *
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SYSTEM ELAPSED TIME (SEC)	ACCM 20 AIR TEMP (DEG F)	ACCM 20 LIQUID TEMP (DEG F)	ACCM 20 WALL TEMP (DEG F)	ACCM 20 EXP COEF
0.00000E+00	9.00000E+01	9.00000E+01	9.00000E+01	1.40049E+00
2.00000E-01	9.00000E+01	9.00000E+01	9.00000E+01	1.40049E+00
4.00000E-01	9.00000E+01	9.00000E+01	9.00000E+01	1.40049E+00
6.00000E-01	9.00000E+01	9.00000E+01	9.00000E+01	1.40049E+00
8.00000E-01	9.00000E+01	9.00000E+01	9.00000E+01	1.40049E+00
1.00000E+00	9.00000E+01	9.00000E+01	9.00000E+01	1.40049E+00
1.10000E+00	8.99820E+01	8.99997E+01	9.00000E+01	1.40049E+00
1.20000E+00	8.99476E+01	8.99993E+01	9.00000E+01	1.40049E+00
1.30000E+00	8.98891E+01	8.99986E+01	9.00000E+01	1.40049E+00
1.40000E+00	8.98067E+01	8.99976E+01	9.00000E+01	1.40049E+00
1.50000E+00	8.97006E+01	8.99965E+01	9.00000E+01	1.40048E+00
1.60000E+00	8.95713E+01	8.99950E+01	9.00000E+01	1.40048E+00
1.70000E+00	8.94194E+01	8.99934E+01	9.00000E+01	1.40048E+00
1.80000E+00	8.92454E+01	8.99915E+01	9.00000E+01	1.40048E+00
1.90000E+00	8.90502E+01	8.99895E+01	9.00000E+01	1.40048E+00
2.00000E+00	8.88345E+01	8.99872E+01	9.00000E+01	1.40048E+00
2.10000E+00	8.85995E+01	8.99847E+01	9.00000E+01	1.40047E+00
2.20000E+00	8.83460E+01	8.99821E+01	8.99999E+01	1.40047E+00
2.30000E+00	8.80754E+01	8.99793E+01	8.99999E+01	1.40047E+00
2.40000E+00	8.77888E+01	8.99763E+01	8.99999E+01	1.40047E+00
2.50000E+00	8.74875E+01	8.99732E+01	8.99999E+01	1.40047E+00
2.60000E+00	8.71727E+01	8.99700E+01	8.99998E+01	1.40047E+00
2.70000E+00	8.68459E+01	8.99667E+01	8.99998E+01	1.40047E+00
2.80000E+00	8.65084E+01	8.99633E+01	8.99998E+01	1.40047E+00
2.90000E+00	8.61618E+01	8.99598E+01	8.99997E+01	1.40046E+00
3.00000E+00	8.58075E+01	8.99562E+01	8.99997E+01	1.40046E+00
3.10000E+00	8.54471E+01	8.99526E+01	8.99996E+01	1.40046E+00
3.20000E+00	8.50823E+01	8.99490E+01	8.99996E+01	1.40046E+00
3.30000E+00	8.47146E+01	8.99453E+01	8.99995E+01	1.40046E+00
3.40000E+00	8.43459E+01	8.99417E+01	8.99994E+01	1.40046E+00
3.50000E+00	8.39776E+01	8.99381E+01	8.99993E+01	1.40046E+00
3.60000E+00	8.36116E+01	8.99345E+01	8.99992E+01	1.40046E+00
3.70000E+00	8.32493E+01	8.99310E+01	8.99992E+01	1.40046E+00
3.80000E+00	8.28925E+01	8.99275E+01	8.99991E+01	1.40046E+00
3.90000E+00	8.25429E+01	8.99241E+01	8.99989E+01	1.40046E+00
4.00000E+00	8.22020E+01	8.99209E+01	8.99988E+01	1.40046E+00
4.10000E+00	8.18715E+01	8.99177E+01	8.99987E+01	1.40046E+00
4.20000E+00	8.15529E+01	8.99147E+01	8.99986E+01	1.40046E+00
4.30000E+00	8.12479E+01	8.99118E+01	8.99985E+01	1.40046E+00
4.40000E+00	8.09579E+01	8.99091E+01	8.99983E+01	1.40046E+00
4.50000E+00	8.06845E+01	8.99065E+01	8.99982E+01	1.40047E+00
4.60000E+00	8.04290E+01	8.99041E+01	8.99981E+01	1.40047E+00
4.70000E+00	8.01928E+01	8.99019E+01	8.99979E+01	1.40047E+00
4.80000E+00	7.99771E+01	8.99000E+01	8.99978E+01	1.40047E+00
4.90000E+00	7.97831E+01	8.98982E+01	8.99976E+01	1.40047E+00
5.00000E+00	7.96119E+01	8.98967E+01	8.99974E+01	1.40047E+00

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

3.0 STANDARD PROBLEM FIVE

Standard Problem Five from the NRC's CASP series was the prediction of test S-02-8 in the Semiscale Mod-1 experimental program. This system was a scale model PWR with an electrically heated core of 40 rods. Test S-02-8 was a 200% double-ended break with the heated core at full power (1.6 MW). Nominal initial conditions prior to the break were 2200 psia, 600 F, and a flow of 17 lbm/sec through the operating loop. There was no ECC injection.

The Standard Problem Five sample problem is a 10-volume model. The schematic diagram of the model is given in Figure VII.3-1. The input listing and selected output are given.

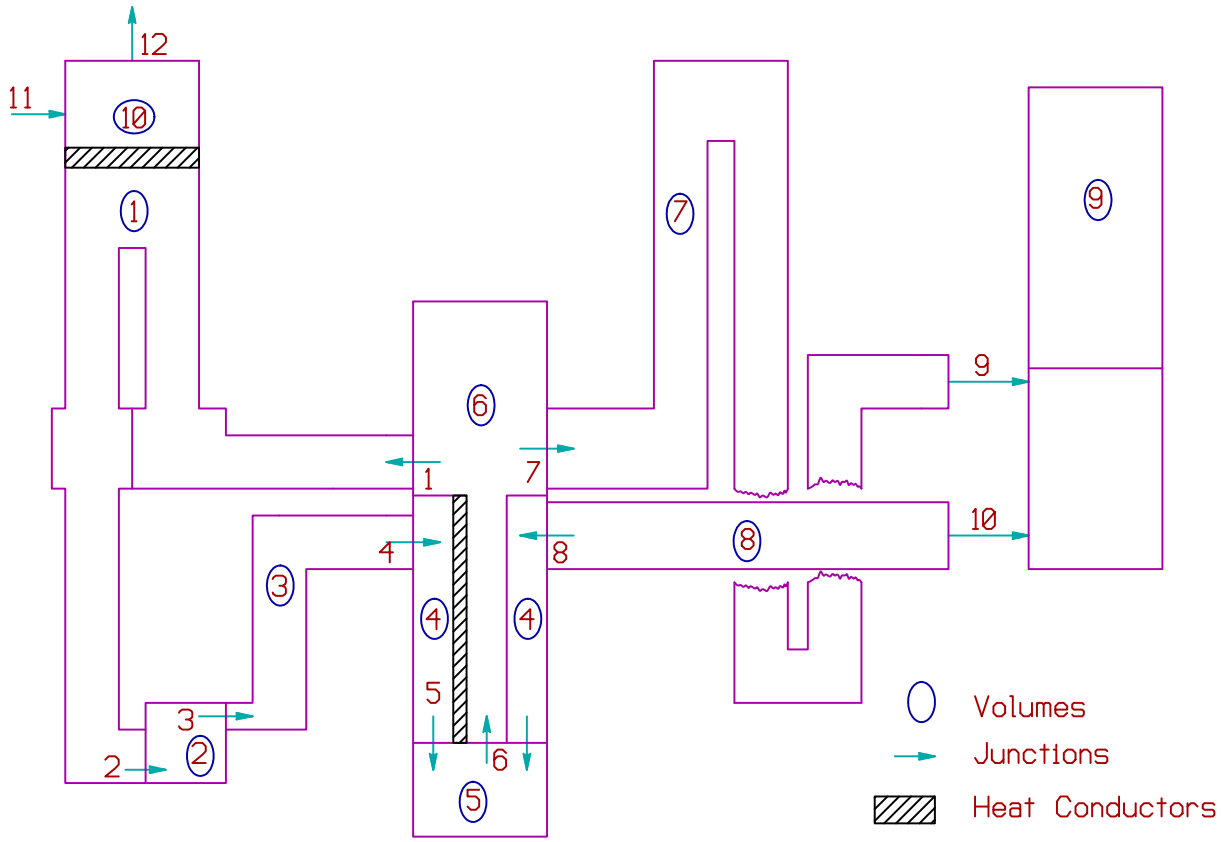


Figure VII.3-1. Schematic Diagram for Standard Problem Five

```
LISTING OF INPUT DATA FOR CASE  1

    1    =STANDARD PROBLEM FIVE - RETRAN-3D SAMPLE PROBLEM
    2    *
    3    ********************************************************************************
    4    *
    5    *  PROBLEM DIMENSIONS
    6    *
    7    *        1     2     3     4     5     6     7     8     9    10    11    12
    8    *      TAPE PRNPLT  POW    SS  NVOID GENTRN HTMAP SLIP  5EQ  NCOND  NSOL  PNMTH
    9    010001   0     0     0     0     0     0     0     0     0     0     2     0
   10    *
   11    *
   12    *10005    INITIAL POWER
   13    010005        1.5747                     * FULL POWER
   14    *
   15    *
   16    020000 TIMX  0 NTTS  0
   17    020001 PRES  6 AVED  6 WP**  8 WP**  9
   18    *
   19    *
   20    * FORMAT FOR TAPE60
   21    *
   22    025000 1
   23    025001 '(5(1X,1P,E15.7))'
   24    *
   25    *
   26    *  TIME STEP DATA
   27    *3XXX0  RTG  MIN    RST  MAJ    DMP    NCHK  DELTM   TLAST
   28    030010  0.   0.001  0.   0.005  0.005    0   0.001   0.01   *  TIME STEP 1
   29    030020  0.   0.01   0.   0.09   0.09     0   0.002   0.1    *  TIME STEP 2
   30    030030  0.   0.1    0.   0.9    0.9      0   0.01    1.0    *  TIME STEP 3
   31    030040  0.   0.2    0.   2.0    2.0      0   0.02   25.0    *  TIME STEP 4
   32    *
   33    *  TRIP CONTROL DATA
   34    *4XXX0   ID  SIG  IX1  IX2    SETPT   DELAY   DESCRIPTION
   35    040010   1    1    0    0      5.0       0.  "END TRIP, TRANSIENT          "
   36    040020   2    1    0    0      0.00005   0.  "BREAK OPENING PUMP SIDE BREAK"
   37    040030   3    1    0    0      0.0       0.  "POWER TRIP                    "
   38    040040   4   -4    8    0   1000.0       0.  "VESSEL SIDE BREAK VALVE      "
   39    040050   5    1    0    0    500.0       0.  "PUMP TRIP (NO TRIP)          "
   40    *
   41    *
   42    *  VOLUME DATA
   43    *5XXX1 BR IR  PRES  TEMP  X   VOL      ZVOL   FLWL FLOWA    DIAMV   ELEV
   44    050011 0  0    0.    0.   0.  2.262   15.281    0  .05116  .25522  -3.50764
   45    050021 0  0    0.    0.   0.   .1603   1.1616   0  .037611 .21883  -3.50764
   46    050031 0  0    0.    0.   0.   .53953  3.7925   0  .037611 .22245  -3.08607
   47    050041 0  0    0.    0.   0.   .9047  13.886    0  .058738 .07352 -13.6063
   48    050051 0  0    0.    0.   0.   .59184  2.3885   0  .56275  .33396 -15.9948
   49    050061 0  0    0.    0.   0.  1.0165  18.013    0  .052986 .0358  -13.6063
   50    050071 0  0    0.    0.   0.   .87619 13.869    0  .0376   .1824   -4.0885
   51    050081 0  0    0.    0.   0.   .28365   .21883  0  .037611 .1927   -0.10942
   52    050091 1  0    0.    0.   0. 90.      11.5      0 8.727   2.9435   -0.10942
   53    050101 2  0    0.    0.   0.  6.8717  12.12     0  .567    .0316    3.45
   54    *
   55    *
   56    *  BUBBLE DATA
   57    *60011
   58    060011   .8    3.   2.0
   59    060021   .8    3.   9.6667
   60    *
   61    *
   62    *  JUNCTION DATA
   63    * 1ST JUNCTION DATA CARDS (WORDS 1 - 10)
   64    *8XXX1  IW1  IW2  IPMP IVLV    WP     AJUN       ZJUN   INERTA   FJUNF   FJUNR
   65    080011   6    1    0    0     0.     .01969    .70833   318.3     0.     9.997
   66    080021   1    2   -1    0     0.     .03761   -3.4741   404.      0.    34.42
   67    080031   2    3    1    0     0.     .03761   -2.9432   444.      0.     8.536
   68    080041   3    4    0    0     0.     .01969     0.      160.8     0.     1.998
   69    080051   4    5    0    0     0.     .05874   -13.6063  150.      1.843  1.34
   70    080061   5    6    0    0     0.     .04912   -13.6063  266.      0.    13.25
   71    080071   6    7    0    0     0.     .03761     .70833  777.   417.5  417.5
   72    080081   4    8    0    0     0.     .03761     0.      254.      3.929  3.213
   73    080091   7    9    0    2     0.     .00262     .70833 1300.      6.463  6.563
   74    080101   8    9    0    1     0.     .00262     0.      506.6     2.19   2.19
   75    080111   0   10    1    0     0.     .02321    12.3025    0.      1.      .45
   76    080121   0   10    2    0     0.     .02321    15.56      0.      0.45   1.
   77    *
   78    * 2ND JUNCTION DATA CARDS (WORDS 11 - 22)
   79    *8XXX1 JVTL JCK  JCLC  MVX DIAMJ CONCO IFRJ JTPMJ IHQCOR ISP   ANGL1 ANGL2
   80    080012  0    0     0    0    0.    1.    0    0      1    0       0.    0.
   81    080022  0    0     0    0    0.    1.    0    0      0    0       0.    0.
   82    080032  0    0     0    0    0.    1.    0    0      0    0       0.    0.
   83    080042  0    0     0    0    0.    1.    0    0      0    0       0.    0.
   84    080052  0   -1     0    0    0.    1.    0    0      0    0       0.    0.
   85    080062  0    0     0    0    0.    1.    0    0      1    0       0.    0.
   86    080072  0    0     0    0    0.    1.    0    0      1    0       0.    0.
   87    080082  0    0     0    0    0.    1.    0    0      0    0       0.    0.
   88    080092  0    0     0    0    0.     .6   0    0      0    0       0.    0.
   89    080102  0    0     0    0    0.    1.    0    0      0    0       0.    0.
   90    080112  1    0     2    0    0.    1.    0    0      0    0       0.    0.
   91    080122  1    0     2    0    0.    1.    0    0      0    0       0.  180.
   92    *
   93    *
   94    *  PUMP DATA
   95    *90XXY IPC ITP IRP IPM IMT RPM SRATIO FLOW  HEAD PTORK PINRTA VRHOI MTRK
   96    090011  1   3   0   2   0  3560. .8605 180. 192. 34.80  38.3  62.30  0.
   97    *
   98    *  FRICTION COEFFICIENTS
   99    090012   0.0   6.7    0.     0.             * COEFFIENTS FOR FRICTIONAL TORQUE
  100    *
```

```
*910XXY  REF  ANC WRS RES RPT  MAR 74  PG17
*910XXY PTS   VF MULTI    VF MULTI                          HEAD MULTIPLIER
091021   -11   0. 0.   .1 0.   .15 .05   .24 .8   .3 .96   .4 .98
091022         .6 .97   .8 .9   .9 .8   .96 .5   1. 0.
*
*9200X  TORQUE MULTIPLIER,  REF. STND PROB 5 SUPPL INFO, SRB-4-75
092021   9   0.  -.17    .0001   -.17   .006  0.    .1  0.  .15   .05
092022        .24 .56    .86      .56   .96    .45 1.   0.
*
*10XYYZ NC1 NC2 NC3 NC4   PUMP CURVE INDIC
100000   0  16   3  -8
*
* SEMISCALE MOD-1 PUMP CURVE,SINGLE PHASE,   REF. ANCR-1165, PP.12 - 13
*     H/T TYP PTS     X    Y    /    X    Y    /    X    Y    /    X    Y
101011        10     0.   1.22       .1  1.2        .2   1.15      .3  1.18
101012                .4  1.16       .5  1.15       .6  1.13       .7  1.1
101013                .9  1.04      1.   1.
101021         7     0.   -.37       .1  -.32       .2  -.275      .3  -.2
101022                .50  0.        .8     .545
101023                             1.   1.
101031         9    -1.    1.5      -.96 1.5       -.86 1.33      -.81 1.28
101032               -.75  1.32     -.57 1.37      -.37 1.37      -.2  1.3
101033               0.    1.22
101041         9    -1.    1.5      -.87 1.36      -.75  1.1      -.6   .96
101042               -.46   .87     -.3   .8       -.2    .76     -.1   .74
101043               0.     .73
101051         9     0.     .96      .06 1.          .2  1.1        .3  1.18
101052                .5   1.35      .6  1.46       .9  1.81       .96 1.9
101053               1.    1.95
101061        10     0.     .73                                    .1   .725
101062                .26   .75      .34  .78        .4   .8       .5   .9
101063               .56  1.      .6  1.06       .83  1.5       1.   1.95
101071        10    -1.   .17     -.92   .29     -.74   .48     -.6   .59
101072              -.5   .67     -.41   .76     -.31   .81     -.2   .87
101073              -.08   .92     0.   .96
101081        10     -1.    .17                  -.8  -.1       -.69 -.2
101082               -.58  -.28     -.5  -.34      -.39 -.4       -.3  -.42
101083               -.2   -.42     -.1  -.41      0.   -.37
*
101091        10     0.     .71      .1   .75       .2   .81       .3   .86
101092                .53  1.03      .6  1.05       .7  1.07       .8  1.08
101093                .9   1.07     1.   1.02
101101          8    0.   -.08     0.07  0.     .16   .1     .3   .23
101102              .51   .45     .68   .64     .81   .78     1.   1.02
101111        10    -1.    1.13     -.8   .92      -.7   .983     -.6   .76
101112               -.5    .71     -.4   .68      -.3   .66      -.2   .665
101113               -.1    .68     0.    .71
101121        10    -1.    1.13                    -.91  .87      -.84  .74
101122               -.8    .69     -.7   .59      -.6    .54     -.5   .5
101123               -.35   .48     -.2   .43      0.    .32
101131         4     0.   -.74     .16   -.65     .4    -.55     1.   -.29
101141         9     0.     .32      .18  .2        .3   .14       .4   .1
101142                .6    .06      .7   .01       .76 -.03       .93 -.2
101143               1.    -.29
101151         7    -1.   -1.69     -.94   -1.6     -.7   -1.34
101152               -.5   -1.13     -.3   -.96     -.17   -.86     0.   -.74
101161         7    -1.   -1.69     -.88 -1.4      -.74 -1.17     -.57 -.9
101162               -.2   -.33     -.1  -.2       0.   -.08
*
102091        10     0.     .71      .1   .75       .2   .81       .3   .86
102092                .53  1.03      .6  1.05       .7  1.07       .8  1.08
102093                .9   1.07     1.   1.02
102101          8    0.   -.08     0.07  0.     .16   .1     .3   .23
102102              .51   .45     .68   .64     .81   .78     1.   1.02
102111        10    -1.    1.13     -.8   .92      -.7   .983     -.6   .76
102112               -.5    .71     -.4   .68      -.3   .66      -.2   .665
102113               -.1    .68     0.    .71
102121        10    -1.    1.13                    -.91  .87      -.84  .74
102122               -.8    .69     -.7   .59      -.6    .54     -.5   .5
102123               -.35   .48     -.2   .43      0.    .32
102131         4     0.   -.74     .16   -.65     .4    -.55     1.   -.29
102141         9     0.     .32      .18  .2        .3   .14       .4   .1
102142                .6    .06      .7   .01       .76 -.03       .93 -.2
102143               1.    -.29
102151         7    -1.   -1.69     -.94   -1.6     -.7   -1.34
102152               -.5   -1.13     -.3   -.96     -.17   -.86     0.   -.74
102161         7    -1.   -1.69     -.88 -1.4      -.74 -1.17     -.57 -.9
102162               -.2   -.33     -.1  -.2       0.   -.08
*
*
*  VALVE DATA
*11XX0 ITCC IACV IACV2 PCV CV1 CV2 CV3
110010 -2    1     0   0.  0.  0.  0.    * RUPTURE DISC - 1. BD COLD LEG
110020 -2    0     0   0   0.  0.  0.    * RUPTURE DISC - 2. BD HOT LEG
*
*
*  LEAK TABLE DATA
*12XYY PTS TRP SINK    T   A        T   A       T   A
120101  4   0.  1.   4.45   1.   4.55  .6   60.  .6      * VESSEL SIDE BREAK LEA
*
*
*  FILL DATA
*      NFLL ITFLL JX JY   TABLE-----
130101  4     3   0  0    0.  95.64 419. 381.54   1. 95.64 419. 381.54
130102                    1.75 0.   419. 381.54 500.  0.   419. 381.54
130201  4     3   0  0    0.   -95.64   1199.4  798.55
130202                    1.   -95.64   1199.4  798.55
130203                    1.75   0.     1199.4  798.55
130204                  500.     0.     1199.4  798.55
*
*
*  POWER GENERATION DATA
```

```
*
* SCRAM TABLE DATA (POWER CURVE) TEST S-02-8.
* POWER CURVE REF. FROM LETTER OF TRANSMITTAL OF INITIAL CONDITIONS, SEPT 26.
141001  -7    3   0    * MOD-1, 100% INITIAL POWER
141002    0.  1.   .63 .7  1.9 .67  8.1 .254  20. .051  30. .051  30.1 0.
*
*
*  HEAT CONDUCTOR DATA
*15XXY IVSL IVSR IGOM CELEV IMCL IMCR   ASUL     ASUR     VOLS   HDML
150011   0    6   1    0.0   2    2      0.0    23.698  .208344   0.
150021   1   10   2    0.0   2    2    104.313 129.717  .43888    0.
*
*        HDMR  DHEL   DHER   CHNL   CHNR   IXHQF
150012  .0358   0.   .04453   0.    5.5      0
150022  .03158  0.   .06178   0.    0.0      1
*
*
*  CORE CONDUCTOR DATA
*16XXY   ISLB   CLTI   QFRAC
160010    1      0.0    1.0
*
*
*  SLAB GEOMETRY DATA
*17X0Y GOM REG MAT STP  RADIST  REGIONWIDTH POWRFRAC * MATERIAL AND GEOMETRY ***
170101  2   4   1   1    0.       .0029167     0.    * BN AT CENTER OF ROD
170102  0       2   2             .0071633     1.    * HEATER ELEMENT
170103  0       1   2             .00425       0.    * BN BETWN. HEATER AND TUBE
170104  0       3   3             .00325       0.    * 316L SST. CLADDING
170201  2   1   4   3     .01675  .004083      0.
*
*
*  **  MATERIAL PROPERTY DATA  **
*
*  THERMAL CONDUCTIVITY DATA *****
180101   -2   500.  14.21   1500.  13.42   * BN
*
180201  -3        68.   13.    212.  12.8   392.  15.      * CONSTANTAN
*
180301   -2   500.  9.56  1500.  13.82  * SS
*
180401 -3 212. 10. 752. 11. 1832. 18.
*
*
*  VOLUMETRIC HEAT CAPACITY DATA ****
190101   -10   400.  40.31  500.  43.63  625.  47.75             * BN
190102         750.  50.75  875.  53.   1000.  55.17             * BN
190103        1250.  58.25 1500.  60.89 1875.  63.6 2000. 64.344 * BN
*
190201  -7     212.  56.    572.  61.    932.  67.  1472. 73.    * CONSTANTIN-1
190202        2192.  78.   2552.  84.   3000.  90.               * CONSTANTIN-2
*
190301  -6     500.  61.25 1000.  66.11 1500.  70.79            * SS
190302        2000.  75.29 2375.  78.75 2500.  79.61            * SS
*
190401 1        68.  57.23
*
*
*  STEADY STATE CONVERGENCE CARD
*      LCOUNT
230000   -35
*
*
*  STEADY STATE POWER REMOVAL SYSTEM DATA
*       ISGNUM   JBIAS   JBAL   POWF
230011     1       11     12    1.0
*
*
*  INITIAL CONDITIONS
*
*       LVOL   PRES    TEMP    ENTH       X   XNC
231001    1   2255.     0.     583.788    0.   0.
231002    2   2263.877  0.       0.       0.   0.
231003    3   2281.4    0.       0.       0.   0.
231004    4   2280.618  0.       0.       0.   0.
231006    6   2275.3    0.       0.       0.   0.
231009    9     39.856 70.       0.       0.   1.
231010   10    872.     0.     529.06    -1.   0.
*
*
* JUNCTION INITIAL CONDITIONS
*
*       JUN  JESTW    WP    SPLTV1    SPLTV2
232001   1     0     16.402
232002   2     0     16.402
232003   3     0     16.402
232004   4     0     16.402
232005   5     0     16.402
232006   6     1     16.402
232011  11     0      2.22
232012  12     0     -2.22
*
*
*********************************************************************************
* CHANGES MADE TO FIX ERROR IN INPUT
* IMPLICIT CALCULATION OF LOSSES IN A JUNCTION IS NOT ALLOWED
* WHEN PRESSURE IN UPSTREAM AND DOWNSTREAM VOLUME IS SPECIFIED AND FLOW IS NON-Z
* MAKE FJUNF OR FJUNR = -1 DEPENDING ON FLOW
*
* HJK - 6/1/2011
*
* JUNCTION INITIAL CONDITIONS
*
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PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


```
   305    *       JUN  JESTW    WP
   306    232001   1     1     16.402
+                                                    *** THIS CARD IS A REPLACEMENT CARD. ***
   307    232002   2     1     16.402
+                                                    *** THIS CARD IS A REPLACEMENT CARD. ***
   308    232003   3     1     16.402
+                                                    *** THIS CARD IS A REPLACEMENT CARD. ***
   309    232004   4     1     16.402
+                                                    *** THIS CARD IS A REPLACEMENT CARD. ***
   310
   311    *
   312    . END TERMINATOR
```


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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page    1
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:14
 STANDARD PROBLEM FIVE - RETRAN-3D SAMPLE PROBLEM                                                               CPU TIME =    0.016
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

RETRAN PROBLEM CONTROL AND DESCRIPTION DATA.

    WORD  DESCRIPTION
    ====  ===================================================================
      1   RESTART FILE OPTION (SAVE=-1 / NO SAVE=0) .................... =    0
      2   PRINTER PLOT OPTION (YES=1 / NO=0) ........................... =    0
      3   POWER OPTION (TAPE OPTNS<0 / NO/TBL=0 / PT KIN=1 / 1D=2 / 3D=3) =    0
      4   USE STEADY-STATE SOLUTION (YES=0 / NO=1) ..................... =    0
      5   USE NEUTRON VOID MODEL (YES=1 / NO=0) ........................ =    0
      6   USE GENERALIZED TRANSPORT MODEL (NO=0 / VAP=1 / LIQ=-1) ....... =    0
      7   HEAT TRANSFER MAP OPTION (FORCED=0 / NAT CONV=1) ............. =    0
      8   SLIP OPTION (DYN=1 / Z-L=2 / C-L=3 / Z-L TAUGL=4 / C-L TAUGL=5) =    0
      9   FIVE-EQUATION OPTION (NO= 0 / YES=1) ......................... =    0
     10   NONCONDENSABLE GAS FLOW OPTION (NO=0 / YES=1) ................ =    0
     11   TH MATRIX DIRECT SOLVER OPTION (4-EQ=2 / 6-EQ=3) ............. =    2
     12   TH MATRIX ITERATIVE SOLVER OPTION (NO<=1 / YES=2) ............ =    0

    (DIMENSIONS AND OPTIONS AUTOMATICALLY DETERMINED BY CONTENT OF INPUT DATA)

          NUMBER OF MINOR EDIT SETS (0200XX DATA )...................... =    6
          NUMBER OF TIME-STEP CONTROL SETS (03XXX0 DATA )............... =    4
          NUMBER OF TRIP CONTROL SETS (04XXX0 DATA )..................... =    5
          NUMBER OF CONTROL VOLUME DESCRIPTIONS (05XXXY DATA )........... =   10
          NUMBER OF BUBBLE RISE DESCRIPTIONS (060XXY DATA) ............. =    2
          NUMBER OF TIME DEPENDENT VOLUMES FORM CARDS (07XXYY DATA) ..... =    0
          NUMBER OF JUNCTION DESCRIPTIONS (08XXXY DATA) ................ =   12
          NUMBER OF CENTRIFUGAL PUMP DESCRIPTIONS (090XXY DATA )......... =    1
          NUMBER OF VALVE DESCRIPTIONS (11XXXY DATA) ................... =    2
          NUMBER OF GENERAL DATA TABLE DESCRIPTIONS (12XXYY DATA) ....... =    1
          NUMBER OF FILL DESCRIPTIONS (13XXYY DATA )..................... =    2
          NUMBER OF HEAT CONDUCTOR DESCRIPTIONS (15XXXY DATA) .......... =    2
          NUMBER OF HEAT CONDUCTOR GEOMETRY DESCRIPTIONS (17XXYY DATA) .. =    2
          NUMBER OF HEAT CONDUCTOR MATERIAL DESCRIPTIONS (18XXYY DATA) .. =    4
          NUMBER OF CORE SECTION DESCRIPTIONS (16XXXY DATA) ............ =    1
          NUMBER OF NON-CONDUCTNG HEAT EXCHNGR DESCRIPTIONS (21XXYY DATA) =    0
          NUMBER OF TIME DEP BCS FROM TAPE (IREAD<0 ON 05XXXY DATA) ..... =    0
          NUMBER OF SPECIFIED HEAT TRAN COEF DESCRIPTIONS (015XXX DATA) . =    0
          TWO-REGION NONEQ VOL DESCRIPTIONS (610XXX OR 611XXX DATA) ..... =    0
          TEMP. TRANSPORT DELAY OPTION (MESH>0 ON 05XXXY DATA) ......... =    0
          AUXILIARY DNB MODEL (8001XX DATA INCLUDED) ................... =    0
          CONTROL SYSTEM MODEL (702XXX OR 702XXXX DATA) ................ =    0
          ACCUMULATOR MODEL DESCRIPTIONS (620XXX OR 621XXX DATA)......... =    0
          DYNAMIC GAP CONDUCTANCE MODEL DESCRIPTIONS (225XX0 DATA) ...... =    0
          NUMBER OF HT CONDUCTOR STACK DESCRIPTIONS (2200XY DATA) ....... =    0
          NUMBER OF TURBINE SHAFT DESCRIPTIONS (500XXY DATA) ........... =    0
          NUMBER OF PROFILE FIT DESCRIPTIONS (061XX1 DATA) ............. =    0
          NUMBER OF STEAM-WATER SEPARATOR DESCRIPTIONS (60XXX0 DATA) .... =    0


                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * *                                                 * * *
                   * * *          STEADY-STATE OPTION    =   0           * * *
                   * * *                                                 * * *
                   * * *          SLIP OPTION            =   0           * * *
                   * * *                                                 * * *
                   * * *          NUMERICS OPTION        =   2           * * *
                   * * *                                                 * * *
                   * * *          HEAT TRANSFER OPTION   =   0           * * *
                   * * *                                                 * * *
                   * * *          NEW EQUATIONS OPTION   =   0           * * *
                   * * *                                                 * * *
                   * * *         USING THE 4-EQ SOLVER - SOLVE3          * * *
                   * * *                                                 * * *
                   * * *     USING STANDARD STEADY-STATE SOLUTION        * * *
                   * * *                                                 * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *


INITIAL THERMAL POWER (MEGAWATTS) =  1.57470E+00


AIR IS THE DEFAULT NONCONDENSABLE GAS.
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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   34
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:14
 STANDARD PROBLEM FIVE - RETRAN-3D SAMPLE PROBLEM                                                               CPU TIME =     0.031
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *
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NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	ENERGY BALANCE (BTU)	TOTAL MASS BALANCE (LBM)	NCG MASS BALANCE (LBM)	AVERAGE TIME STEP (SEC)	CURRENT TIME STEP (SEC)	ELAPSED TIME (SEC)	TIME STEP NUM STANDRD/ACTUL
									0
1.00000E+00	1.57470E+00	5.40381E+06	3.46494E+05	1.53007E+03	1.03932E-01	0.00000E+00	0.00000E+00	0.00000E+00	0

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	VOID FRAC.	POWR TO H2O (BTU/SEC)
1	2.25500E+03	1.01697E+02	5.83788E+02	4.49591E+01	5.78243E+02	0.00000E+00	0.00000E+00	-1.50106E+03
2	2.26388E+03	7.20327E+00	5.84285E+02	4.49362E+01	5.78633E+02	0.00000E+00	0.00000E+00	8.15427E+00
3	2.28140E+03	2.42515E+01	5.84285E+02	4.49494E+01	5.78675E+02	0.00000E+00	0.00000E+00	0.00000E+00
4	2.28062E+03	4.06652E+01	5.84285E+02	4.49488E+01	5.78673E+02	0.00000E+00	0.00000E+00	0.00000E+00
5	2.28272E+03	2.66034E+01	5.84285E+02	4.49503E+01	5.78678E+02	0.00000E+00	0.00000E+00	0.00000E+00
6	2.27530E+03	4.27418E+01	6.29795E+02	4.20480E+01	6.10824E+02	0.00000E+00	0.00000E+00	1.49290E+03
7	2.27338E+03	3.68403E+01	6.29795E+02	4.20460E+01	6.10819E+02	0.00000E+00	0.00000E+00	0.00000E+00
8	2.27873E+03	1.27493E+01	5.84285E+02	4.49473E+01	5.78668E+02	0.00000E+00	0.00000E+00	0.00000E+00
9	3.98560E+01	9.75105E+02	3.79832E+01	1.08357E+01	7.00000E+01	8.72542E-05	8.26087E-01	0.00000E+00
10	8.72000E+02	2.62214E+02	5.29060E+02	3.81585E+01	5.27775E+02	1.03319E-02	2.05501E-01	1.50106E+03

JUNCTION NUMBER	CONNECTS VOLUMES	CHOK/ PATH	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E VEL. PSI	ELEV. PSI	D I F F E R E N T I A L S FRIC. PSI	ACCL. PSI	PUMP PSI
1	6 TO 1		1.64020E+01	6.75305E+02	2.58094E-02	-1.66678E-02	-2.61917E+00	-1.76642E+01	-1.27515E-08	0.00000E+00
2	1 TO 2		1.64020E+01	5.83788E+02	2.22425E-02	-1.70447E-01	2.20424E+00	-1.48930E+01	2.30389E-09	2.17362E+01
3	2 TO 3		1.64020E+01	5.84285E+02	2.22538E-02	-9.85176E-05	-5.42209E-01	-3.67091E+00	4.97169E-08	2.17362E+01
4	3 TO 4		1.64020E+01	5.84285E+02	2.22473E-02	2.69526E-01	1.70851E+00	-2.76004E+00	-5.96080E-08	0.00000E+00
5	4 TO 5		1.64020E+01	5.84285E+02	2.22475E-02	1.85173E-01	2.54001E+00	-6.25568E-01	-3.94812E-08	0.00000E+00
6	5 TO 6		1.64020E+01	5.84285E+02	2.22468E-02	-2.64862E-01	-3.00269E+00	-4.15006E+00	7.27361E-08	0.00000E+00
7	6 TO 7		0.00000E+00	6.29795E+02	2.37834E-02	2.51010E-01	-2.17414E+00	0.00000E+00	-6.34998E-08	0.00000E+00
8	4 TO 8		0.00000E+00	5.84285E+02	2.22483E-02	1.87206E-01	-2.07991E+00	0.00000E+00	-4.04962E-08	0.00000E+00
9	7 TO 9		0.00000E+00	6.29795E+02	2.37834E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
10	8 TO 9		0.00000E+00	5.84285E+02	2.22483E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
12	0 TO 10		-2.21980E+00	1.19729E+03	5.21244E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
11	0 TO 10		2.21980E+00	5.21077E+02	1.92330E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

BUBL SET NUMB.	VOL. NUMB.	BUBBLE GRADIENT PARAMETER	BUBBLE VELOCITY (FT/SEC)	MIXTURE LEVEL (FT)	MIXTURE QUALITY	BUBBLE MASS (LB)
1	9	8.00000E-01	3.00000E+00	2.00000E+00	0.00000E+00	0.00000E+00
2	10	8.00000E-01	2.93250E+02	9.66670E+00	1.56628E-04	4.06520E-02

PUMP NUMB.	VOL. NUMB.	PUMP SPEED (RPM)	NORM. PUMP TORQUE	NORM. FRIC. TORQUE	NORM. MOT. TORQUE	POWER TO H2O (BTU/HR)
1	2	3.06338E+03	5.68271E-01	8.60500E-01	1.00000E+00	2.93554E+04

HEAT COND. NUMBER	VOL. NUM.	HT TRAN MODE-COR	SURF. FLUX (BTU/HR-FT2)	CRIT. FLUX (BTU/HR-FT2)	H.T. COEF. (BTU/H-F2-F)	SURF. TEMP. (DEG. F)	MASS FLUX (LBM/HR-FT2)	STORD ENRGY (BTU)	POWR TO H20 (BTU/HR)	DRYOUT PNT ()
1 RGHT	6	2-THOM	2.26747E+05	7.90728E+05	4.48426E+03	6.61389E+02	1.11439E+06	9.82248E+03	5.37445E+06	
2 LEFT	1	1-DB-L	-5.46547E+04	9.00000E+04	2.26682E+03	5.54132E+02	1.15417E+06		-5.40381E+06	
RGHT	10	2-THOM	4.39430E+04	9.36794E+04	5.81664E+03	5.35330E+02	1.40940E+04	1.36655E+04	5.40381E+06	

CORE NUMB.	COND. NUMB.	DEPTH REAC. EXT. ZR-H2O (FT)	DEPTH REAC. INT. ZR-H2O (FT)	HEAT GEN. ZR-H2O (BTU/HR)	COND. HEAT-ING RATE (BTU/HR)	DIR. MODER-ATOR HT RT (BTU/HR)	AVG. METAL TEMPERATURE (DEG. F)	CENTERLINE TEMPERATURE (DEG. F)	FUEL ENTHALPY (CAL/GM)
1	1	0.00000E+00	0.00000E+00	0.00000E+00	5.37445E+06	0.00000E+00	8.77338E+02	9.14119E+02	0.00000E+00

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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   45
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:15
 STANDARD PROBLEM FIVE - RETRAN-3D SAMPLE PROBLEM                                                              CPU TIME =    0.172
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *

  NORMALIZED      CORE          THERMAL       ENERGY        TOTAL MASS    NCG MASS      AVERAGE       CURRENT       ELAPSED       TIME STEP NUM
  CORE            POWER         POWER         BALANCE       BALANCE       BALANCE       TIME STEP     TIME STEP     TIME          STANDRD/ACTUL
  POWER           (MW)          (BTU/HR)      (BTU)         (LBM)         (LBM)         (SEC)         (SEC)         (SEC)                   345
  4.62000E-01     7.27511E-01   2.48643E+06   3.49846E+05   1.53007E+03   1.03932E-01   1.66667E-02   7.88156E-03   5.00000E+00             406

VOLUME          AVG. PRES.    TOT. MASS     AVG. ENTH.    AVG. DEN.     AVG. TEMP.    AVG. QUAL.    VOID FRAC.    POWR TO H2O
NUMBER          (PSIA)        (LB)          (BTU/LB)      (LB/FT3)      (DEG. F)                                  (BTU/SEC)
     1          1.00459E+03   5.52563E+01   5.72902E+02   2.44281E+01   5.44732E+02   4.56431E-02   4.98083E-01 -2.53501E+01
     2          1.00379E+03   3.85431E+00   5.73759E+02   2.40444E+01   5.44634E+02   4.71426E-02   5.06813E-01   9.53628E-01
     3          1.00325E+03   1.24959E+01   5.76085E+02   2.31608E+01   5.44568E+02   5.08433E-02   5.26826E-01   0.00000E+00
     4          1.00263E+03   2.00291E+01   5.79014E+02   2.21390E+01   5.44492E+02   5.54883E-02   5.49964E-01   0.00000E+00
     5          1.00393E+03   1.06982E+01   5.94747E+02   1.80761E+01   5.44650E+02   7.94193E-02   6.41781E-01   0.00000E+00
     6          1.00251E+03   1.17158E+01   6.42413E+02   1.15256E+01   5.44477E+02   1.53068E-01   7.89919E-01   1.53010E+02
     7          8.38988E+02   7.76375E+00   6.36539E+02   8.86081E+00   5.23274E+02   1.76005E-01   8.47270E-01   0.00000E+00
     8          9.99431E+02   6.18143E+00   5.79529E+02   2.17924E+01   5.44100E+02   5.69888E-02   5.57960E-01   0.00000E+00
     9          5.12858E+01   1.13986E+03   1.20032E+02   1.26663E+01   1.51147E+02   6.66499E-04   7.93165E-01   0.00000E+00
    10          9.09837E+02   2.62214E+02   5.35306E+02   3.81585E+01   5.32764E+02   1.05523E-02   2.00472E-01   4.50768E+01

JUNCTION    CONNECTS     CHOK/ JUN. FLOW     JUN. ENTH.    JUN. SPVL.    P  R  E  S  S  U  R  E    D  I  F  F  E  R  E  N  T  I  A  L  S
NUMBER      VOLUMES       PATH  (LB/SEC)      (BTU/LB)      (FT3/LB)      VEL. PSI      ELEV. PSI     FRIC. PSI     ACCL. PSI     PUMP PSI
     1        6 TO      1      -4.86913E+00   5.74077E+02   4.16410E-02 -9.44777E-02 -1.00695E+00   3.15954E+00 -2.54526E-02   0.00000E+00
     2        1 TO      2       5.26375E+00   5.72910E+02   4.08774E-02 -7.20048E-02   1.20079E+00 -2.86741E+00 -5.36364E-02   9.02754E-01
     3        2 TO      3       5.96764E+00   5.73771E+02   4.15300E-02 -1.29821E-01 -2.79656E-01 -9.44408E-01   1.02588E-01   9.02754E-01
     4        3 TO      4       8.10141E+00   5.76098E+02   4.31184E-02 -3.29482E-02   8.34128E-01 -1.45012E+00 -2.49210E-02   0.00000E+00
     5        4 TO      5       1.31063E+00   5.79028E+02   4.51111E-02   5.09505E-02   1.21888E+00 -1.56845E-02 -4.27147E-02   0.00000E+00
     6        5 TO      6       2.74891E+00   5.94747E+02   5.52631E-02 -2.32608E-01 -8.71481E-01 -3.98716E-01 -8.23496E-02   0.00000E+00
     7        6 TO      7       8.72851E+00   6.11266E+02   6.62592E-02 -7.39642E-01 -5.56581E-01 -1.63231E+02 -7.24654E-01   0.00000E+00
     8        4 TO      8       1.00677E+01   5.79028E+02   4.51111E-02 -3.80180E-01 -1.02575E+00 -1.82758E+00 -3.39405E-02   0.00000E+00
     9        7 TO      9 MDY   7.74321E+00   6.36769E+02   1.12970E-01   5.85965E-01   1.31406E-01 -6.07714E-01   1.54977E-06   0.00000E+00
    10        8 TO      9 MDY   1.11007E+01   5.79541E+02   4.58271E-02   3.92054E-01 -7.57679E-07 -1.31365E-01   5.54903E-08   0.00000E+00
    12        0 TO     10       0.00000E+00   1.19608E+03   4.97873E-01   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
    11        0 TO     10       0.00000E+00   5.28258E+02   2.11764E-02   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00

  BUBL              BUBBLE        BUBBLE        MIXTURE       MIXTURE       BUBBLE
  SET     VOL.      GRADIENT      VELOCITY      LEVEL         QUALITY       MASS
  NUMB.   NUMB.     PARAMETER     (FT/SEC)      (FT)                        (LB)
     1       9      8.00000E-01   3.00000E+00   3.85763E+00   1.08133E-04   1.23187E-01
     2      10      8.00000E-01   2.93250E+02   9.69031E+00   1.13377E-07   2.94152E-05

  PUMP    VOL.      PUMP SPEED    NORM. PUMP    NORM. FRIC.   NORM. MOT.    POWER TO H2O
  NUMB.   NUMB.     (RPM)         TORQUE        TORQUE        TORQUE        (BTU/HR)
     1       2      2.41679E+03   8.42387E-02   6.79007E-01   0.00000E+00   3.43306E+03

 HEAT COND.     VOL. HT TRAN    SURF. FLUX    CRIT. FLUX    H.T. COEF.    SURF. TEMP.   MASS FLUX     STORD ENRGY   POWR TO H20   DRYOUT PNT
 NUMBER         NUM. MODE-COR   (BTU/HR-FT2)  (BTU/HR-FT2)  (BTU/H-F2-F)  (DEG. F)      (LBM/HR-FT2)  (BTU)         (BTU/HR)      ()
     1 RGHT        6    9-DO-R  2.32397E+04   1.85977E+05   1.29632E+02   7.23821E+02   2.25534E+05   9.29578E+03   5.50835E+05
     2 LEFT        1    1-DB-L -9.23016E+02   1.03330E+05   8.95276E+01   5.34491E+02   1.39754E+04                -9.12603E+04
       RGHT       10    2-THOM  1.31961E+03   9.00000E+04   1.03872E+03   5.34033E+02   0.00000E+00   1.34192E+04   1.62276E+05

  CORE    COND.     DEPTH REAC.   DEPTH REAC.   HEAT GEN.     COND. HEAT-   DIR. MODER-   AVG. METAL    CENTERLINE    FUEL
  NUMB.   NUMB.     EXT. ZR-H2O   INT. ZR-H2O   ZR-H2O        ING RATE      ATOR HT RT    TEMPERATURE   TEMPERATURE   ENTHALPY
                    (FT)          (FT)          (BTU/HR)      (BTU/HR)      (BTU/HR)      (DEG. F)      (DEG. F)      (CAL/GM)
     1       1      0.00000E+00   0.00000E+00   0.00000E+00   2.48300E+06   0.00000E+00   7.81289E+02   7.93005E+02   0.00000E+00
```


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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   46
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis             11:57:15
 STANDARD PROBLEM FIVE - RETRAN-3D SAMPLE PROBLEM                                                               CPU TIME =     0.172
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
```

SYSTEM ELAPSED TIME (SEC)	SYSTEM ELAPSED TIME (SEC)	TIME STP ACTUAL	VOL 6 AVG. PRESS. (PSIA)	VOL 6 AVG. DENSITY (LB/FT3)	JUN 8 FLOW (LB/SEC)	JUN 9 FLOW (LB/SEC)
0.00000E+00	0.00000E+00	0.00000E+00	2.27530E+03	4.20480E+01	0.00000E+00	0.00000E+00
1.00000E-03	1.00000E-03	5.00000E+00	2.27529E+03	4.20480E+01	7.54116E-01	7.73729E+00
2.00000E-03	2.00000E-03	1.10000E+01	2.27518E+03	4.20479E+01	3.92681E+00	1.44230E+01
3.00000E-03	3.00000E-03	1.80000E+01	2.27484E+03	4.20476E+01	1.04005E+01	1.95791E+01
4.00000E-03	4.00000E-03	2.50000E+01	2.27402E+03	4.20470E+01	1.98810E+01	2.31840E+01
5.00000E-03	5.00000E-03	2.90000E+01	2.27234E+03	4.20458E+01	3.06705E+01	2.54743E+01
6.00000E-03	6.00000E-03	3.10000E+01	2.26914E+03	4.20434E+01	4.03882E+01	2.59398E+01
7.00000E-03	7.00000E-03	3.40000E+01	2.26420E+03	4.20396E+01	4.82329E+01	2.53184E+01
8.00000E-03	8.00000E-03	3.70000E+01	2.25681E+03	4.20339E+01	5.38091E+01	2.43784E+01
9.00000E-03	9.00000E-03	4.10000E+01	2.24632E+03	4.20257E+01	5.70515E+01	2.33837E+01
1.00000E-02	1.00000E-02	4.40000E+01	2.23186E+03	4.20142E+01	5.80982E+01	2.27373E+01
2.00000E-02	2.00000E-02	5.90000E+01	1.91971E+03	4.17540E+01	4.23072E+01	1.89369E+01
3.00000E-02	3.00000E-02	7.10000E+01	1.80224E+03	4.16117E+01	4.76383E+01	1.68913E+01
4.00000E-02	4.00000E-02	8.00000E+01	1.68765E+03	4.14749E+01	3.92376E+01	1.55622E+01
5.00000E-02	5.00000E-02	8.90000E+01	1.64379E+03	4.12257E+01	3.28728E+01	1.53996E+01
6.00000E-02	6.00000E-02	9.40000E+01	1.64418E+03	4.07964E+01	3.25186E+01	1.53890E+01
7.00000E-02	7.00000E-02	9.90000E+01	1.64306E+03	4.02828E+01	3.68200E+01	1.53780E+01
8.00000E-02	8.00000E-02	1.04000E+02	1.64205E+03	3.98022E+01	3.92031E+01	1.53665E+01
9.00000E-02	9.00000E-02	1.09000E+02	1.64166E+03	3.93856E+01	3.86532E+01	1.53546E+01
1.00000E-01	1.00000E-01	1.14000E+02	1.64147E+03	3.89990E+01	3.75895E+01	1.53427E+01
2.00000E-01	2.00000E-01	1.24000E+02	1.62815E+03	3.49308E+01	3.69696E+01	1.52211E+01
3.00000E-01	3.00000E-01	1.34000E+02	1.60613E+03	3.10587E+01	3.57919E+01	1.50890E+01
4.00000E-01	4.00000E-01	1.44000E+02	1.57837E+03	2.74798E+01	3.43056E+01	1.49343E+01
5.00000E-01	5.00000E-01	1.54000E+02	1.54716E+03	2.42629E+01	3.26809E+01	1.47420E+01
6.00000E-01	6.00000E-01	1.64000E+02	1.48765E+03	2.16762E+01	3.01348E+01	1.44736E+01
7.00000E-01	7.00000E-01	1.74000E+02	1.42107E+03	1.98204E+01	2.74380E+01	1.41204E+01
8.00000E-01	8.00000E-01	1.84000E+02	1.42990E+03	1.84367E+01	2.72591E+01	1.37544E+01
9.00000E-01	9.00000E-01	1.94000E+02	1.43227E+03	1.67421E+01	2.71202E+01	1.34574E+01
1.00000E+00	1.00000E+00	2.04000E+02	1.41363E+03	1.47859E+01	2.68145E+01	1.32550E+01
1.20000E+00	1.20000E+00	2.14000E+02	1.36521E+03	1.17712E+01	2.52028E+01	1.28378E+01
1.40000E+00	1.40000E+00	2.24000E+02	1.30253E+03	9.51943E+00	2.34562E+01	1.23120E+01
1.60000E+00	1.60000E+00	2.34000E+02	1.27805E+03	9.06368E+00	1.53306E+01	1.17707E+01
1.80000E+00	1.80000E+00	2.44000E+02	1.26135E+03	8.91061E+00	2.06187E+01	1.13003E+01
2.00000E+00	2.00000E+00	2.54000E+02	1.24641E+03	8.61345E+00	2.09283E+01	1.08262E+01
2.20000E+00	2.20000E+00	2.64000E+02	1.23345E+03	8.68508E+00	2.03583E+01	1.03373E+01
2.40000E+00	2.40000E+00	2.74000E+02	1.21945E+03	8.82198E+00	2.03776E+01	9.82680E+00
2.60000E+00	2.60000E+00	2.84000E+02	1.20497E+03	8.89959E+00	2.01641E+01	9.29842E+00
2.80000E+00	2.80000E+00	2.94000E+02	1.19037E+03	8.86435E+00	1.99446E+01	8.76565E+00
3.00000E+00	3.00000E+00	3.04000E+02	1.17532E+03	8.63116E+00	1.97506E+01	8.24239E+00
3.20000E+00	3.20000E+00	3.14000E+02	1.15975E+03	8.21879E+00	1.95098E+01	7.73994E+00
3.40000E+00	3.40000E+00	3.24000E+02	1.13740E+03	8.87208E+00	1.81359E+01	7.26467E+00
3.60000E+00	3.60000E+00	3.34000E+02	1.12026E+03	1.03861E+01	1.88576E+01	6.95994E+00
3.80000E+00	3.80000E+00	3.44000E+02	1.10161E+03	1.14040E+01	1.85341E+01	6.87610E+00
4.00000E+00	4.00000E+00	3.54000E+02	1.08333E+03	1.19754E+01	1.82132E+01	6.96657E+00
4.20000E+00	4.20000E+00	3.64000E+02	1.06468E+03	1.22059E+01	1.79337E+01	7.13878E+00
4.40000E+00	4.40000E+00	3.74000E+02	1.04601E+03	1.21697E+01	1.76732E+01	7.32882E+00
4.60000E+00	4.60000E+00	3.84000E+02	1.02974E+03	1.19991E+01	9.33700E+00	7.50331E+00
4.80000E+00	4.80000E+00	3.94000E+02	1.01721E+03	1.17823E+01	1.01277E+01	7.65093E+00
5.00000E+00	5.00000E+00	4.06000E+02	1.00251E+03	1.15256E+01	1.00677E+01	7.74321E+00

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4.0 STANDARD PROBLEM FOUR

Standard Problem Four from the NRC's CASP series was the prediction of test number 4906 in the General Electric Boiling Water Reactor Blowdown Heat Transfer Program. The Two-Loop Test Apparatus (TLTA) is a scaled simulation of a two-loop boiling water reactor with an electrically heated 7x7 core bundle. The test conditions for test number 4906 include a break size of 1.20 times the nominal area of the suction line of one of the recirculation loops and nominal bundle power and flow conditions.[VII.4-1]

The RETRAN model used to analyze Standard Problem Four is depicted schematically in Figure VII.4-1. Twenty-nine volumes are used in the model. This model is discussed in greater detail in EPRI NP-169.[VII.4-2] The input listing and selected output are given in this section.

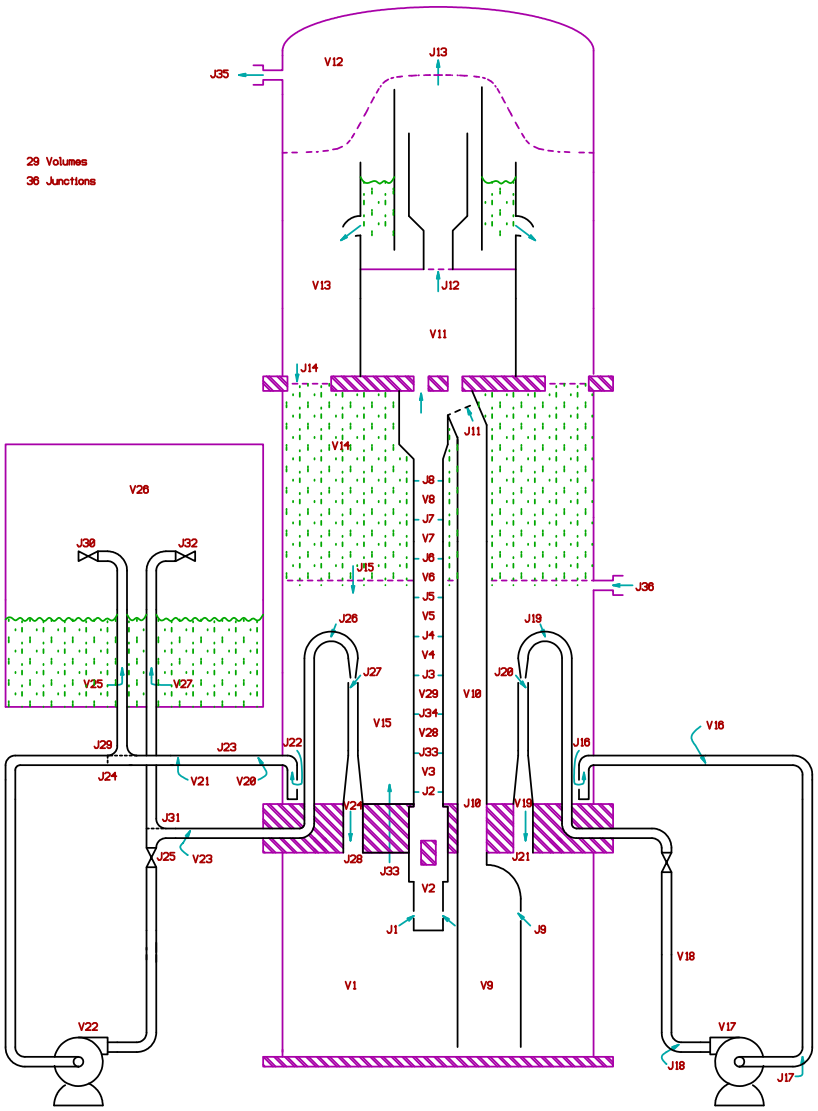


Figure VII.4-1. Schematic Diagram for Standard Problem Four

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LISTING OF INPUT DATA FOR CASE  1

    1    =STANDARD PROBLEM FOUR (TLTA) - RETRAN-3D SAMPLE PROBLEM
    2    *
    3    ********************************************************************************
    4    *
    5    *  PROBLEM DIMENSIONS
    6    *
    7    *        1     2     3     4     5     6     7     8     9    10    11    12
    8    *      TAPE PRNPLT  POW    SS  NVOID GENTRN HTMAP SLIP  5EQ  NCOND  NSOL  PNMTH
    9    010001   0     0     0     1     0     0     0     0     0     0     2     0
   10    *
   11    *
   12    *10005 POWER
   13    010005  4.56
   14    *
   15    *20000  MINOR EDIT VARIABLES
   16    020000 TIMX  0 NTTS  0
   17    020001 PRES  1 TEMP 11 WP**  1 WP** 21 WP** 28 WP** 32
   18    *
   19    *
   20    * FORMAT FOR TAPE60
   21    *
   22    025000 1
   23    025001 '(5(1X,1P,E15.7))'
   24    *
   25    *
   26    *  TIME STEPS
   27    *3XXX0  RTG  MIN  RST  MAJ  DMP  NCHK  DELTM  TLAST
   28    030010  0.   0.02 0.   0.1  0.1    0   0.01     0.3
   29    030020  0.   0.05 0.   0.5  0.5    0   0.05     0.75
   30    030030  0.   0.05 0.   0.5  0.5    0   0.0025   2.5
   31    *
   32    *
   33    * TRIPS
   34    *4XXX0 IDTRP IDSIG IX1 IX2  SETPOINT  DELAY    DESCRIPTION
   35    040010   1     1    0   0     1.0      0.     "PROBLEM END                    "
   36    040020   2     1    0   0     0.0      0.     "TRIP 2 STEAM LINE              "
   37    040030   3     1    0   0     0.0      0.     "TRIP 3 FEEDWATER               "
   38    040040   4     1    0   0     0.0      0.     "TRIP 4 RECIRC. PUMP ISOLATION  "
   39    040050   5     1    0   0     0.0      0.     "TRIP 5 SUCTION BLOWDOWN VALVE  "
   40    040060   6     1    0   0     0.0      0.     "TRIP 6 DISCHARGE BLOWDOWN VALVE"
   41    040070   7     1    0   0     0.0      0.     "TRIP 7 POWER                   "
   42    040080   8     1    0   0     0.001    0.     "TRIP 8 PUMP-UNBROKEN           "
   43    040090   9     1    0   0     0.294    0.     "TRIP 9 PUMP-BROKEN LOOP        "
   44    040100   1    -4   12   0    40.0      0.     "TRIP 10 PROBLEM END UP.PL.P    "
   45    040110  11     1    0   0     0.001    0.     "TRIP 11 COEF. J-23             "
   46    *
   47    *
   48    *  VOLUME  DATA
   49    *5XXX1 BB IR  PRESSURE  ENTHALPY   X  VOLUME   HEIGHT
   50    050011 0  0      0.          0.     0.  2.495    3.513          *LOWER PLENUM
   51    050021 0  0      0.          0.     0.  0.2721   2.203          *FLOW TUBE
   52    050031 0  0      0.          0.     0.  0.2425   2.25001        *1ST CORE VOL.
   53    050041 0  0      0.          0.     0.  0.1257   1.1668         *2ND CORE VOL.
   54    050051 0  0      0.          0.     0.  0.1257   1.1668         *3RD CORE VOL.
   55    050061 0  0      0.          0.     0.  0.1078   1.0001         *4TH CORE VOL.
   56    050071 0  0      0.          0.     0.  0.2515   2.3334         *5TH CORE VOL.
   57    050081 0  0      0.          0.     0.  0.1078   1.0001         *6TH CORE VOL.
   58    050091 0  0      0.          0.     0.  1.922    3.265          *GUIDE TUBES
   59    050101 0  0      0.          0.     0.  1.031   13.136          *BYPASS TUBES
   60    050111 0  0      0.          0.     0.  2.323    4.781          *UPPER PLENUM
   61    050121 0  0      0.          0.     0.  3.440    3.354          *STEAM DOME
   62    050131 1  0      0.          0.     0.  5.49     7.376          *MIXING PLENUM
   63    050141 0  0      0.          0.     0.  7.724    8.73           *UPPER DOWNCOM.
   64    050151 0  0      0.          0.     0.  4.220    5.0            *LOWER DOWNCOM.
   65    050161 0  0      0.          0.     0.  1.9976  23.034          *RECIR.SCTN-UNB
   66    050171 0  0      0.          0.     0.  0.267    1.184          *RECIR.PUMP-UNB
   67    050181 0  0      0.          0.     0.  0.571   23.422          *RECIR.DSCH-UNB
   68    050191 0  0      0.          0.     0.  0.0536   3.275          *JET PUMP-UNB
   69    050201 0  0      0.          0.     0.  0.063    1.246          *RECIR.SCTN-BRK
   70    050211 0  0      0.          0.     0.  0.19385  0.242          *SUCTION BRKN T
   71    050221 0  0      0.          0.     0.  1.876   13.537          *RECIR.PUMP-BRK
   72    050231 0  0      0.          0.     0.  0.1194   3.057          *RECIR.DSCH-BRK
   73    050241 0  0      0.          0.     0.  0.0536   4.655          *JET PUMP-BRK
   74    050251 0  0      0.          0.     0.  0.5841   4.044          *RECIR.BLDN-LN
   75    050261 2  0      0.          0.     0.  2000.  100.0            *DISCHARGE TANK
   76    050271 0  0      0.          0.     0.  0.2119   5.524          *RECIR.BLDN-LN
   77    050281 0  0      0.          0.     0.  0.1796   1.66667
   78    050291 0  0      0.          0.     0.  0.1527   1.41667
   79    *
   80    *5XXX2   FLOWL   FLOWA   DIAMV     ELEV                        VOL
   81    050012     0.     .74      .194      .521                     * LOWER PLENUM
   82    050022     0.     .1104    .005     2.578                     * FLOW TUBE
   83    050032     0.     .1078    .0351    4.781                     * 1ST CORE VOLUME
   84    050042     0.     .1078    .0351    10.1143                   * 2ND CORE VOLUME
   85    050052     0.     .1078    .0351    11.2810                   * 3RD CORE VOLUME
   86    050062     0.     .1078    .0351   12.4477                    * 4TH CORE VOLUME
   87    050072     0.     .1078    .0351   13.4477                    * 5TH CORE VOLUME
   88    050082     0.     .1078    .0351   15.7810                    * 6TH CORE VOLUME
   89    050092     0.     .612     .441      .573                     * GUIDE TUBES
   90    050102     0.     .0985    .1771    3.812                     * BYPASS TUBES
   91    050112     0.     .592     .8683   16.781                     * UPPER PLENUM
   92    050122     0.    1.030     .160    22.234                     * STEAM DOME
   93    050132     0.     .788     .448    17.645                     * MIXING PLENUM
   94    050142     0.     .9603    .429     9.417                     * UPPER DOWNCOMER
   95    050152     0.     .9603    .429     4.721
   96    050162     0.     .04587   .242   -16.913                     * RECIRC SCTN-UNB.
   97    050172     0.     .04587   .242   -16.913                     * RECIRC PUMP-UNB.
   98    050182     0.     .0048    .456   -15.855                     * RECIRC DSCH-UNB.
   99    050192     0.     .0246    .02075   4.028                     * JET PUMP-UNB.
  100    050202     0.     .03322   .0288    4.875                     * RECIRC SCTN-BRK.
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050212     0.    .04587   .242     5.879                     * SUCTION BRKN T
050222     0.    .04587   .242    -7.416                     * RECIRC PUMP-BRK.
050232     0.    .0048    .1265    4.510                     * RECIRC DSCH-BRK.
050242     0.    .0246    .02075   2.648                     * JET PUMP-BRK.
050252     0.    10000.   .242     5.99                      * RECIRC BLDN LINE
050262     0.  19.6      5.0       0.0                       * DISCHARGE TANK
050272     0.    10000.   .1616    4.51                      * RECIRC BLDN LINE
050282     0.    .1078    .0351    7.031
050292     0.    .1078    .0351    8.69766
*
*
*  BUBBLE SETS
*6XXX1  ALPH  VBUB   ZMIX
060011  0.8   3.     0.47                * BUBBLE - SEPARATION WITH GRADIENT
060021  0.    1.E10  5.0
*
*
*  JUNCTION DATA
*8XXX1 IN OT PP IV     FLOW      AJUN       ZJUN   INERTA       JUN
080011  1  2  0  0      0.      .02793    2.857   17.06 *    LOWER PLN.-FLOW TUBE
080021  2  3  0  0      0.      .0891     4.781   35.16 *    FLOW TUBE-CORE
080031 29  4  0  0      0.      .0891    10.1143   0.   *
080041  4  5  0  0      0.      .0891    11.2810   0.   *    2ND JUNCTION IN CORE
080051  5  6  0  0      0.      .1078    12.4477   0.   *    3RD JUNCTION IN CORE
080061  6  7  0  0      0.      .0891    13.4477   0.   *    4TH JUNCTION IN CORE
080071  7  8  0  0      0.      .0891    15.7810   0.   *    5TH JUNCTION IN CORE
080081  8 11  0  0      0.      .0891    16.781   12.92 *    CORE-UPPER PLENUM
080091  1  9  0  0      0.      .00212    3.063    8.79 *    LOWER PLN.-GUIDE TUBE
080101  9 10  0  0      0.      .02405    3.823   82.3  *    GUIDE TUBE-BYPASS
080111 10 11  0  0      0.      .07977   16.948   84.6  *    BYPASS-UPPER PLENUM
080121 11 13  0  0      0.      .07928   21.478   26.22 *    STANDPIPE-STEAM-SEP.
080131 13 12  0  0      0.      .788     24.979   11.49 *    STEAM SEP.-STEAM DOME
080141 13 14  0  0      0.      .5573    17.896   15.24 *    MIX.PLN.-UP.DOWNCOM.
080151 14 15  0  0      0.      .9603     9.438    0.   *    UP.DOWNC.-LOW DOWNC.
080161 15 16  0  0      0.      .03325    5.146    0.   *    UNBROKEN DOWNC-RECIRC
080171 16 17 -1  0      0.      .04587 -16.792     0.   *    UNBROKEN PUMP INLET
080181 17 18  1  0      0.      .0048  -15.792     0.   *    UNBROKEN PUMP OUTLET
080191 18 19  0  0      0.      .001119  7.291 2445.0  *    UNBROKEN JET DRIVE
080201 15 19  0  0      0.      .00343   7.291  172.2  *    UNBROKEN JET SUCTION
080211 19  1  0  0      0.      .0246    4.031  172.2  *    UNBROKEN JET DSCH.
080221 15 20  0  0      0.      .03322   5.146   30.8  *    BROKEN DOWNC-RECIRC
080231 20 21  0  4      0.      .008427  6.000   74.6  *    BL SCTN LINE
080241 21 22 -2  0      0.      .04587   6.00     0.   *    PUMP SUCTION-BLOWDOWN
080251 22 23  2  3      0.      .0048    4.51     0.   *    BRK PUMP 150. VALVE
080261 23 24  0  0      0.      .001119  7.291  918.9  *    BROKEN  JET DRIVE
080271 15 24  0  0      0.      .00343   7.291  172.2  *    BROKEN JET SUCTION
080281 24  1  0  0      0.      .0246    3.341  172.2  *    BROKEN  JET DSCH
080291 21 25  0  0      0.      .04587   6.0    197.9  *    SCTN BLOWNDOWN VALVE
080301 25 26  0  1      0.      .037439  9.882  290.6  *    BD VALVE - SCTN
080311 27 23  0  0      0.      .0048    4.51   749.0  *    DSCH BLOWNDOWN VALVE
080321 27 26  0  2      0.      .014314  9.882  482.2  *    BD VALVE - DSCHRG
080331  3 28  0  0      0.      .0891    7.0310   0.   *
080341 28 29  0  0      0.      .0891    8.69766  0.   *
080351  0 12  2  0      0.      .04587  24.906    0.   *    STEAMLINE OUTLET
080361  0 15  1  0      0.      .00545   9.437    0.   *    FEEDWATER INLET
*
*8XXX2    FJUNF   FJUNR  JV JC JC MV   DIAMJ  CONCO IF JTPMJ IHQCOR ISP ANG1 ANG
080012    .9237  1.2751  1  0  0  0    0.418   .7    0   0    0
080022       0.      0.  0  0  1  0    0.      .7    0   0    1
080032       0.      0.  0  0  3  0    0.      .7    0   0    1
080042       0.      0.  0  0  3  0    0.      .7    0   0    1
080052       0.      0.  0  0  3  0    0.      .7    0   0    1
080062       0.      0.  0  0  3  0    0.      .7    0   0    1
080072       0.      0.  0  0  3  0    0.      .7    0   0    1
080082       0.      0.  0  0  1  0    0.      .7    0   0    1
080092       0.      0.  1  0  1  0    0.03125 .7    0   0    0
080102       0.      0.  1  0  3  0    0.0208  .7    0   0    0
080112       0.      0.  0  0  3  0    0.125   .7    0   0    0
080122       0.      0.  1  0  3  0    0.166   .7    0   0    0
080132       0.      0.  1  0  3  0     .083   .7    0   0    0
080142       0.      0.  1  0  3  0     .5     .7    0   0    0
080152       0.      0.  1  0  3  0    0.0417  .7    0   0    0
080162      .71  1.2567  1  0  2  0    0.      .7    0   0    0
080172       0.      0.  0  0  3  0    0.      .7    0   0    0
080182      0.32  0.436 0  0  2  0    0.    1.02    0   0    0
080192       .01   1.17 1  0  0  2    0.0225 1.0    0   0    0
080202       .9    3.   2  0  0  2    0.0225  .7    0   0    0
080212       .926 .828  1  0  0  0     .005   .7    0   0    0
080222      .784  1.28   1  0  0  0    0.      .7    0   0    0
080232       .3      .3  0  0  0  0    0.0    1.0    0   0    0
080242       0.      0.  0  0  3  0    0.0208  .7    0   0    0
080252       .32  .436  0  0  2  0    0.     1.02   0   0    0
080262       .01   1.17 1  0  0  2    0.0225  .7    0   0    0
080272       .9    1.0  2  0  0  2    0.0225  .7    0   0    0
080282      .926  32.0  1 -1  0  0    1.386  1.0    0   0    0
080292      .4      .9  0  0  0  0    0.0208 1.0    0   0    0
080302      .166  .166  0  0  0  0    0.      .7    0   0    0
080312     .0612  .138  0  0  0  0    0.0208 1.00   0   0    0
080322      .277  .277  0  0  0  0    0.      .7    0   0    0
080332       0.    0.    0  0  3  0    0.      .7    0   0    1
080342       0.    0.    0  0  3  0    0.      .7    0   0    1
080352       0.    0.    0  0  3  0    0.      .7    0   0    0      0  0. 180.
080362       0.    0.    0  0  1  0    0.0417  .7    0   0    0
*
*
*  PUMP DATA
*90XXY IPC TRP REV 2PH MT RPM R/R FLOW HEAD TORQUE INERTIA DENST MTQRQ FRIC
090011  1   8   0   2  0 3550. 1. 145. 690.   70.    30.1  47.2   0.  3.
090021  1   9   0   2  0 3550. 1. 120. 710.  111.    3.23  47.2   0.  4.
*910YY                                  PUMP HEAD MULTIPLIER CARDS
*910YY NPTS   PHDM-----
091021  -11   0.  0.   .1  0.   .15 .05   .24  .8   .3  .96   .4  .98
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091022         .6  .97 .8   .9  .9  .8    .96  .5  1.  0.
*920YY                                 PUMP TORQUE MULTIPLIER CARDS
*920YY NPTS    PHDM-----
092021  -6    0.  0.   .17 .08  .3  .56   .65 .62  .8  .62    1.  .5
*
*  PUMP CURVE SET INPUT
100000  0  16  3   -8
*  PUMP HEAD AND TORQUE DATA
*        NPTS      PHEAD OR PTORK-------
101011     3       0.    1.12     .5      1.10     1.      1.    * PUMP HEAD 1
101021     3       0.    -.56     .79     0.       1.      1.    * PUMP HEAD 2
101031     3      -1.    1.58    -.5      1.19     0.      1.12  * PUMP HEAD 3
101041     3      -1.    1.58    -.5       .94     0.       .71  * PUMP HEAD 4
101051     3       0.     .65     .5       .73     1.      1.    * PUMP HEAD 5
101061     3       0.     .71     .5       .73     1.      1.    * PUMP HEAD 6
101071     3      -.94  -.39    -.51     0.       0.       .65  * PUMP HEAD 7
101081     3      -.94  -.39    -.5      -.54     0.      -.56  * PUMP HEAD 8
*
101091     3       0.     .56     .5       .83     1.      1.03  * PUMP TORQUE 1
101101     3       0.    -.42     .36     0.       1.      1.03  * PUMP TORQUE 2
101111     3      -1.     .98    -.5       .47     0.       .60  * PUMP TORQUE 3
101121     3      -1.     .98    -.5       .92     0.       .83  * PUMP TORQUE 4
101131     3       0.    -.62     .54     0.       1.       .5   * PUMP TORQUE 5
101141     3       0.     .83     .5       .67     1.       .5   * PUMP TORQUE 6
101151     3      -1.   -2.48    -.5     -1.84     0.      -.62  * PUMP TORQUE 7
101161     3      -1.   -2.48    -.5     -1.47     0.      -.42  * PUMP TORQUE 8
*
102091     3       0.     .56     .5       .83     1.      1.03  * PUMP TORQUE 1
102101     3       0.    -.42     .36     0.       1.      1.03  * PUMP TORQUE 2
102111     3      -1.     .98    -.5       .47     0.       .60  * PUMP TORQUE 3
102121     3      -1.     .98    -.5       .92     0.       .83  * PUMP TORQUE 4
102131     3       0.    -.62     .54     0.       1.       .5   * PUMP TORQUE 5
102141     3       0.     .83     .5       .67     1.       .5   * PUMP TORQUE 6
102151     3      -1.   -2.48    -.5     -1.84     0.      -.62  * PUMP TORQUE 7
102161     3      -1.   -2.48    -.5     -1.47     0.      -.42  * PUMP TORQUE 8
*
*
*  VALVES
*11XXY ITCV IACV IACV2 PCV CV1 CV2 CV3
110010  -5    1    0    0.  0.  0.  0.       * SUCTION BLOWDOWN VALVE
110020  -6    2    0    0.  0.  0.  0.       * DISCHARGE BLOWDOWN VALVE
110030   4    3    0    0.  0.  0.  0.       * RECIRC. PUMP ISOLATION VALVE
110040  11    4    0    0.  0.  0.  0.       * VALVE J23
*
*  VALVE AREAS
*      NPTS   TAREA-----
120101  9     0. 0.  .033 0.  .067 .052  .102 .479  .135 .468 * V2 BD VLVE J30
120102       .168 .688   .194 .935   .237 1.   1000. 1.
120201  8     0. 0.  .001 0.  .035 .002  .069 .099   .103 .346 * V10 BD VLV J32
120202       .136 .823   .173 1.   1000. 1.
120301  4     0. 1.   .2 1.   .75 0.   1000. 0.          * ISOLATION VALVE AREA
120401  6     0. 1.  1.25 1.  3.75 .86   7.5 .86   9.7 .70   100. .70
*
*
*  FILLS
*      NFL ITF JX JY    FILL TABLE----
130101 14   3  0  0
130102                 0.0    310.09      47.0733    14.7
130103                  .095  306.4       47.0733    14.7
130104                  .193  295.8       47.0733    14.7
130105                  .289  282.0       47.0733    14.7
130106                  .387  266.6       47.0733    14.7
130107                  .485  235.8       47.0733    14.7
130108                  .624  165.7       47.0733    14.7
130109                  .711  107.3       47.0733    14.7
130110                  .906   46.8       47.0733    14.7
130111                 1.101   47.9       47.0733    14.7
130112                 1.296   46.3       47.0733    14.7
130113                 1.491   35.19      47.0733    14.7
130114                19.104    0.0       47.0733    14.7
130115               100.0      0.0       47.0733    14.7
*
*      NFL ITF JX JY    FILL TABLE----
130201 19   2  0  0
130202                 0.0   -111.40    1192.07    1022.
130203                  .193 -109.8     1192.07    1022.
130204                  .485 -106.9     1192.07    1022.
130205                  .583 -97.5      1192.07    1022.
130206                  .614 -93.1      1192.07    1022.
130207                  .647 -88.6      1192.07    1022.
130208                  .808 -74.0      1192.07    1022.
130209                 1.101 -67.7      1192.07    1022.
130210                 1.491 -64.9      1192.07    1022.
130211                 1.881 -55.3      1192.07    1022.
130212                 2.303 -49.1      1192.07    1022.
130213                 2.889 -40.8      1192.07    1022.
130214                 3.408 -35.4      1192.07    1022.
130215                 4.286 -29.7      1192.07    1022.
130216                 5.78  -15.0      1192.07    1022.
130217                 6.786  -8.5      1192.07    1022.
130218                 7.503  -4.6      1192.07    1022.
130219                 7.67    0.0      1192.07    1022.
130220               100.0     0.0      1192.07    1022.
*
*
*  POWER
*
* SCRAM TABLE
*1410XX PTS TRP POWER CURVE-----
141001  18 7 0  0. 1. .136 1. .636 .982 1.136 .958 1.636 .898 2.136 .84 * POWER
141002 2.636 .796 3.386 .75 6.136 .6 9.136 .485 14.136 .337 19.136 .22
141003 25.136 .128 30.136 .082 35.136 .06 40.136 .05 45.136 .045 50.136 .04
```

```
*
*
*  HEAT CONDUCTORS
*     VL VR GM CE CL CR ASUL  ASUR     VOLUME
150011 0  3  1  0. 12 12  0.  .331340 .00311590       *1ST CORE VOLUME M-25 ROD
150021 0 28  2  0. 12 12  0.  .245437 .00230807       *2ND CORE VOLUME M-25 ROD
150031 0 29  3  0. 12 12  0.  .208621 .00196186       *3RD CORE VOLUME M-25 ROD
150041 0  4  4  0. 12 12  0.  .171806 .00161565       *4TH CORE VOLUME M-25 ROD
150051 0  5  3  0. 12 12  0.  .171806 .00161565       *5TH CORE VOLUME M-25 ROD
150061 0  6  5  0. 12 12  0.  .147262 .00138484       *6TH CORE VOLUME M-25 ROD
150071 0  7  6  0. 12 12  0.  .343612 .00323130       *7TH CORE VOLUME M-25 ROD
150081 0  8  7  0. 12 12  0.  .147262 .00138484       *8TH CORE VOLUME M-25 ROD
150091 0  3  8  0. 12 12  0.  .331340 .00311590       *1ST CORE VOLUME M-14 ROD
150101 0 28  9  0. 12 12  0.  .245437 .00230807       *2ND CORE VOLUME M-14 ROD
150111 0 29 10  0. 12 12  0.  .208621 .00196186       *3RD CORE VOLUME M-14 ROD
150121 0  4 10  0. 12 12  0.  .171806 .00161565       *4TH CORE VOLUME M-14 ROD
150131 0  5 10  0. 12 12  0.  .171806 .00161565       *5TH CORE VOLUME M-14 ROD
150141 0  6 10  0. 12 12  0.  .147262 .00138484       *6TH CORE VOLUME M-14 ROD
150151 0  7 11  0. 12 12  0.  .343612 .00323130       *7TH CORE VOLUME M-14 ROD
150161 0  8 12  0. 12 12  0.  .147262 .00138484       *8TH CORE VOLUME M-14 ROD
150171 0  3 13  0. 12 12  0. 15.5730 .146447          *1ST CORE VOLUME MIX
150181 0 28 14  0. 12 12  0. 11.5355 .108479          *2ND CORE VOLUME MIX
150191 0 29 15  0. 12 12  0.  9.8052 .092208          *3RD CORE VOLUME MIX
150201 0  4 15  0. 12 12  0.  8.0749 .075936          *4TH CORE VOLUME MIX
150211 0  5 15  0. 12 12  0.  8.0749 .075936          *5TH CORE VOLUME MIX
150221 0  6 15  0. 12 12  0.  6.9213 .065088          *6TH CORE VOLUME MIX
150231 0  7 19  0. 12 12  0. 16.1497 .151871          *7TH CORE VOLUME MIX
150241 0  8 20  0. 12 12  0.  6.9213 .0650885         *8TH CORE VOLUME MIX
150251 0  1 17  0.  2  2  0.   17.93  1.936           *VESSEL - LOWER PLENUM
150261 0 15 17  0.  2  2  0.   22.09  2.386           *VESSEL - LOWER ANNULUS
150271 0 14 17  0.  2  2  0.   37.78  4.0802          *VESSEL - UPPER ANNULUS
150281 0 13 17  0.  2  2  0.   19.73  2.1308          *VESSEL - MIXING PLENUM
150291 0 12 17  0.  2  2  0.   14.55  1.5714          *VESSEL - STEAM DOME
150301 0 13 16  0.  2  2  0.   13.0    .172           *INTERNALS IN MIX PLENUM
150311 0 16 18  0.  2  2  0.   17.0    .408           *RECIRC. DISCHARGE OL
150321 0 18 18  0.  2  2  0.   33.56  .8054           *RECIRC. SUCTION OL
150331 0 20 18  0.  2  2  0.    3.61  .086665        *BROKEN RECIRC.
150341 0 21 18  0.  2  2  0.    3.61  .086665        *BROKEN RECIRC.
150351 0 22 18  0.  2  2  0.   32.93  .7903           *DISCHARGE
150361 0 23 18  0.  2  2  0.    3.28  .07872         *TEE TO VESL. NOZ.
150371 0 25 18  0.  2  2  0.   19.83  .47592          *SUCTION BLOWDOWN
150381 0 27 18  0.  2  2  0.   10.13  .2431           *DISCH. BLOWDOWN
*
*15    HDML   HDMR    DHEL  DHER  CHNL  CHNR     IHXQF
150012  0.   .0597    0.  .0597   0.   2.250      0  * S 1-2
150022  0.   .0597    0.  .0597   0.   1.667      0  * S 2-2
150032  0.   .0597    0.  .0597   0.   1.417      0  * S 3-2
150042  0.   .0597    0.  .0597   0.   1.167      0  * S 4-2
150052  0.   .0597    0.  .0597   0.   1.167      0  * S 5-2
150062  0.   .0597    0.  .0597   0.   1.         0  * S 6-2
150072  0.   .0597    0.  .0597   0.   2.333      0  * S 7-2
150082  0.   .0597    0.  .0597   0.   1.         0  * S 8-2
150092  0.   .0597    0.  .0597   0.   2.250      0  * S 9-2
150102  0.   .0597    0.  .0597   0.   1.667      0  * S10-2
150112  0.   .0597    0.  .0597   0.   1.417      0  * S11-2
150122  0.   .0597    0.  .0597   0.   1.167      0  * S12-2
150132  0.   .0597    0.  .0597   0.   1.167      0  *S13-2
150142  0.   .0597    0.  .0597   0.   1.         0  *S14-2
150152  0.   .0597    0.  .0597   0.   2.333      0  *S15-2
150162  0.   .0597    0.  .0597   0.   1.         0  *S16-2
150172  0.   .0597    0.  .0597   0.   2.250      0  *S17-2
150182  0.   .0597    0.  .0597   0.   1.667      0  *S18-2
150192  0.   .0597    0.  .0597   0.   1.417      0  *S19-2
150202  0.   .0597    0.  .0597   0.   1.167      0  *S20-2
150212  0.   .0597    0.  .0597   0.   1.167      0  *S21-2
150222  0.   .0597    0.  .0597   0.   1.         0  *S22-2
150232  0.   .0597    0.  .0597   0.   2.333      0  *S23-2
150242  0.   .0597    0.  .0597   0.   1.         0  *S24-2
150252  0.   .705     0.   0.     0.   0.         0  *S25-2
150262  0.   .910     0.   0.     0.   0.         0  *S26-2
150272  0.   .910     0.   0.     0.   0.         0  *S27-2
150282  0.   .747     0.   0.     0.   0.         0  *S28-2
150292  0.   .970     0.   0.     0.   0.         0  *S29-2
150302  0.   0.       0.   0.     0.   0.         0  *S30-2
150312  0.   0.       0.   0.     0.   0.         0  *S31-2
150322  0.   0.       0.   0.     0.   0.         0  *S32-2
150332  0.   0.       0.   0.     0.   0.         0  *S33-2
150342  0.   0.       0.   0.     0.   0.         0  *S34-2
150352  0.   0.       0.   0.     0.   0.         0  *S35-2
150362  0.   0.       0.   0.     0.   0.         0  *S36-2
150372  0.   0.       0.   0.     0.   0.         0  *S37-2
150382  0.   0.       0.   0.     0.   0.         0  *S38-2
*
*
*  CORE DATA                        *** AXIAL PEAKING FACTOR IS 1.385
*16XXX0 ISLAB  THICK  QFRACTION
160010    1     0.    .00295788                    * 1ST CORE VOLUME M-25 HEATER
160020    2     0.    .00383132                    * 2ND CORE VOLUME M-25 HEATER
160030    3     0.    .00392400                    * 3RD CORE VOLUME M-25 HEATER
160040    4     0.    .00339714                    * 4TH CORE VOLUME M-25 HEATER
160050    5     0.    .00329701                    * 5TH CORE VOLUME M-25 HEATER
160060    6     0.    .00257407                    * 6TH CORE VOLUME M-25 HEATER
160070    7     0.    .00437615                    * 7TH CORE VOLUME M-25 HEATER
160080    8     0.    .00094855                    * 8TH CORE VOLUME M-25 HEATER
160090    9     0.    .00166977                    * 1ST CORE VOLUME M-14 HEATER
160100   10     0.    .00216284                    * 2ND CORE VOLUME M-14 HEATER
160110   11     0.    .00221516                    * 3RD CORE VOLUME M-14 HEATER
160120   12     0.    .00191774                    * 4TH CORE VOLUME M-14 HEATER
160130   13     0.    .00186121                    * 5TH CORE VOLUME M-14 HEATER
160140   14     0.    .00145311                    * 6TH CORE VOLUME M-14 HEATER
160150   15     0.    .00247041                    * 7TH CORE VOLUME M-14 HEATER
160160   16     0.    .00053547                    * 8TH CORE VOLUME M-14 HEATER
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160170   17     0.    .11225649                  * 1ST CORE VOLUME MIX  HEATER
160180   18     0.    .14540484                  * 2ND CORE VOLUME MIX  HEATER
160190   19     0.    .14892229                  * 3RD CORE VOLUME MIX  HEATER
160200   20     0.    .12892684                  * 4RD CORE VOLUME MIX  HEATER
160210   21     0.    .12512670                  * 5TH CORE VOLUME MIX  HEATER
160220   22     0.    .09769018                  * 6TH CORE VOLUME MIX  HEATER
160230   23     0.    .16608185                  * 7TH CORE VOLUME MIX  HEATER
160240   24     0.    .03599898                  * 8TH CORE VOLUME MIX  HEATER
*
*
*  CONDUCTOR GEOMETRY
*      IG NR IGP IM NDX      XO     XR     PF
170101  2  2      2  2  .0104167 .0081633  0.    * HTR RODS VOL. 3 M-25 CERAMIC
170102        0   1  3           .0048575  1.    * HTR RODS VOL. 3 M-25 INCONEL
170201  2  2      2  2  .0104167 .0106342  0.    * HTR RODS VOL.30 M-25 CERAMIC
170202        0   1  3           .0023966  1.    * HTR RODS VOL.30 M-25 INCONEL
170301  2  2      2  2  .0104167 .0110945  0.    * HTR RODS VOL. 5 M-25 CERAMIC
170302        0   1  3           .0019236  1.    * HTR RODS VOL. 5 M-25 INCONEL
170401  2  2      2  2  .0104167 .0111742  0.    * HTR RODS VOL. 4 M-25 CERAMIC
170402        0   1  3           .0018466  1.    * HTR RODS VOL. 4 M-25 INCONEL
170501  2  2      2  2  .0104167 .0109125  0.    * HTR RODS VOL. 6 M-25 CERAMIC
170502        0   1  3           .0021083  1.    * HTR RODS VOL. 6 M-25 INCONEL
170601  2  2      2  2  .0104167 .0099666  0.    * HTR RODS VOL. 7 M-25 CERAMIC
170602        0   1  3           .0030542  1.    * HTR RODS VOL. 7 M-25 INCONEL
170701  2  2      2  2  .0104167 .0063750  0.    * HTR RODS VOL. 8 M-25 CERAMIC
170702        0   1  3           .0066458  1.    * HTR RODS VOL. 8 M-25 INCONEL
170801  2  2      2  2  .0104167 .0103742  0.    * HTR RODS VOL. 3 M-14 CERAMIC
170802        0   1  3           .0026466  1.    * HTR RODS VOL. 3 M-14 INCONEL
170901  2  2      2  2  .0104167 .0116866  0.    * HTR RODS VOL.30 M-14 CERAMIC
170902        0   1  3           .0013342  1.    * HTR RODS VOL.30 M-14 INCONEL
171001  2  2      2  2  .0104167 .0119202  0.    * HTR RODS VOL. 6 M-14 CERAMIC
171002        0   1  3           .0011006  1.    * HTR RODS VOL. 6 M-14 INCONEL
171101  2  2      2  2  .0104167 .0113233  0.    * HTR RODS VOL. 7 M-14 CERAMIC
171102        0   1  3           .0016975  1.    * HTR RODS VOL. 7 M-14 INCONEL
171201  2  2      2  2  .0104167 .0094842  0.    * HTR RODS VOL. 8 M-14 CERAMIC
171202        0   1  3           .0035366  1.    * HTR RODS VOL. 8 M-14 INCONEL
171301  2  2      2  2  .0104167 .0091668  0.    * HTR RODS VOL. 3 MIX  CERAMIC
171302        0   1  3           .0038540  1.    * HTR RODS VOL. 3 MIX  INCONEL
171401  2  2      2  2  .0104167 .0111088  0.    * HTR RODS VOL.30  MIX CERAMIC
171402        0   1  3           .0019120  1.    * HTR RODS VOL.30  MIX INCONEL
171501  2  2      2  2  .0104167 .0114498  0.    * HTR RODS VOL. 6 MIX  CERAMIC
171502        0   1  3           .0015710  1.    * HTR RODS VOL. 6 MIX  INCONEL
171601  1  1      4  1  0.       .01323    0.    *                      GEOM. 16
171701  1  1      5  1  0.       .108      0.    *                      GEOM. 17
171801  1  1      5  1  0.       .024      0.    *                      GEOM. 18
171901  2  2      2  2  .0104167 .0105775  0.    * HTR RODS VOL. 7 MIX  CERAMIC
171902        0   1  3           .0024433  1.    * HTR RODS VOL. 7 MIX  INCONEL
172001  2  2      2  2  .0104167 .0078008  0.    * HTR RODS VOL. 8 MIX  CERAMIC
172002        0   1  3           .0052200  1.    * HTR RODS VOL. 8 MIX  INCONEL
*
*
*  THERMAL CONDUCTIVITY DATA
180101   2      70.    8.36  3000.   23.33            * THERMAL COND. INCONEL 1
180201   6  200.  3.05  400.  2.32  600.  1.83        * THERMAL COND. OXIDE   1
180202    1000.  1.27  1400.  1.1  4000.  1.          * THERMAL COND. OXIDE   2
180300   12                                           * THERMAL COND. ALUMINA 1
180301    70. 17.0      212. 17.0       300. 16.1     * THERMAL COND. ALUMINA 2
180302   400. 12.7      500. 10.9       600.  9.5     * THERMAL COND. ALUMINA 3
180303   700.  8.3      800.  7.35      900.  6.6     * THERMAL COND. ALUMINA 4
180304  1000.  6.      1500.  4.2      2000.  3.4     * THERMAL COND. ALUMINA 5
180401   3   0.  8.4  1000. 12.58  3000. 12.58        *THERMAL COND. SS 304   1
180501  6   32.  30.  212.  29.5   392.  28.3         * THERMAL COND. SA-302  1
180502     572.  26.6  752. 24.7 3000. 24.7           * THERMAL COND. SA-302  2
*
*
*  VOLUMETRIC HEAT CAPACITY
190101   2      70.   56.43  3000.   98.18            * VOL. HT. CAP. INCONEL 1
190201   6  200.  34.0  400.  37.4  600. 40.8        * VOL. HT. CAP. OXIDE   1
190202    1000.  45.1  1400.  48.5  3000.  56.       * VOL. HT. CAP. OXIDE   2
190300   12                                           * VOL. HT. CAP. ALUMINA 1
190301    70.  45.28   200.  52.99  300.  57.72       * VOL. HT. CAP. ALUMINA 2
190302   400.  60.96   500.  63.44  600.  65.43       * VOL. HT. CAP. ALUMINA 3
190303   700.  67.18   800.  68.17  900.  68.92       * VOL. HT. CAP. ALUMINA 4
190304  1000.  69.91  1500.  73.40 2000.  76.13       * VOL. HT. CAP. ALUMINA 5
190401  11  130. 45.09 280. 44.89 400. 45.09         * VOL. HT. CAP. SS-304  1
190402      600. 45.89 800. 47.34  1000. 49.35        * VOL. HT. CAP. SS-304  2
190403     1200. 55.55 1400. 53.86  1600. 55.91       * VOL. HT. CAP. SS-304  3
190404     1800. 57.36 2000. 58.12                   * VOL. HT. CAP. SS-304  4
190501  9 32. 56.9  130. 56.9  350. 60.8  450. 62.3  * VOL. HT. CAP. SA-302  1
190502      530. 65.2   620. 67.2    710. 70.2       * VOL. HT. CAP. SA-302  2
190503      800. 77.5  3000. 77.5                    * VOL. HT. CAP. SA-302  3
*
*
*  VOLUME INITIAL CONDITIONS
*
*       LVOL    PRES       TEMP      ENTH      X   XNC
231001    1    1043.0       0.      525.311    0.   0.        *LOWER PLENUM
231002    2    1036.71      0.      525.309    0.   0.        *FLOW TUBE
231003    3    1034.19      0.      532.03     0.   0.        *1ST CORE VOL.
231004    4    1031.22      0.      581.787    0.   0.        *2ND CORE VOL.
231005    5    1030.27      0.      596.493    0.   0.        *3RD CORE VOL.
231006    6    1029.45      0.      610.215    0.   0.        *4TH CORE VOL.
231007    7    1028.05      0.      625.401    0.   0.        *5TH CORE VOL.
231008    8    1026.62      0.      638.062    0.   0.        *6TH CORE VOL.
231009    9    1031.0       0.      525.401    0.   0.        *GUIDE TUBES
231010   10    1028.0       0.      525.582    0.   0.        *BYPASS TUBES
231011   11    1024.8       0.      631.284    0.   0.        *UPPER PLENUM
231012   12    1020.0       0.     1192.07     0.   0.        *STEAM DOME
231013   13    1021.7       0.      837.664   -1.   0.        *MIXING PLENUM
231014   14    1022.808     0.      546.167    0.   0.        *UPPER DOWNCOM.
231015   15    1024.46      0.      526.602    0.   0.        *LOWER DOWNCOM.
231016   16    1028.228     0.      526.596    0.   0.        *RECIR.SCTN-UNB
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509    231017   17    1152.6       0.      527.046    0.   0.        *RECIR.PUMP-UNB
510    231018   18    1156.689     0.      527.04     0.   0.        *RECIR.DSCH-UNB
511    231019   19    1043.121     0.      526.576    0.   0.        *JET PUMP-UNB
512    231020   20    1024.601     0.      526.601    0.   0.        *RECIR.SCTN-BRK
513    231021   21    1023.458     0.      526.603    0.   0.        *SUCTION BRKN T
514    231022   22    1148.04      0.      526.422    0.   0.        *RECIR.PUMP-BRK
515    231023   23    1139.969     0.      526.435    0.   0.        *RECIR.DSCH-BRK
516    231024   24    1042.963     0.      526.576    0.   0.        *JET PUMP-BRK
517    231025   25    1023.597788  0.      526.603    0.   0.        *RECIR.BLDN-LN
518    231026   26      19.0      80.0       0.       0.   1.        *DISCHARGE TANK
519    231027   27    1177.828928  0.      526.377    0.   0.        *RECIR.BLDN-LN
520    231028   28    1033.244     0.      547.434    0.   0.
521    231029   29    1032.200     0.      564.702    0.   0.
522    *
523    *
524    *  JUNCTION INITIAL CONDITIONS
525    *
526    *        JUN  JESTW    WP    SPLTV1    SPLTV2
527    232001    1     0    37.7                          *   LOWER PLN.-FLOW TUBE
528    232002    2     0    37.7                          *   FLOW TUBE-CORE
529    232003    3     0    37.7                          *
530    232004    4     0    37.7                          *   2ND JUNCTION IN CORE
531    232005    5     0    37.7                          *   3RD JUNCTION IN CORE
532    232006    6     0    37.7                          *   4TH JUNCTION IN CORE
533    232007    7     0    37.7                          *   5TH JUNCTION IN CORE
534    232008    8     0    37.7                          *   CORE-UPPER PLENUM
535    232009    9     0     3.1                          *   LOWER PLN.-GUIDE TUBE
536    232010   10     0     3.1                          *   GUIDE TUBE-BYPASS
537    232011   11     0     3.1                          *   BYPASS-UPPER PLENUM
538    232012   12     0    40.8                          *   STANDPIPE-STEAM-SEP.
539    232013   13     0     5.11                         *   STEAM SEP.-STEAM DOME
540    232014   14     0    35.69                         *   MIX.PLN.-UP.DOWNCOM.
541    232015   15     0    39.11                         *   UP.DOWNC.-LOW DOWNC.
542    232016   16     0    10.                           *   UNBROKEN DOWNC-RECIRC
543    232017   17     0    10.                           *   UNBROKEN PUMP INLET
544    232018   18     0    10.                           *   UNBROKEN PUMP OUTLET
545    232019   19     0    10.                           *   UNBROKEN JET DRIVE
546    232020   20     0    11.5                          *   UNBROKEN JET SUCTION
547    232021   21     0    21.5                          *   UNBROKEN JET DSCH.
548    232022   22     0     9.41                         *   BROKEN DOWNC-RECIRC
549    232023   23     0     9.41                         *   BL SCTN LINE
550    232024   24     0     9.41                         *   PUMP SUCTION-BLOWDOWN
551    232025   25     0     9.41                         *   BRK PUMP 150. VALVE
552    232026   26     0     9.41                         *   BROKEN  JET DRIVE
553    232027   27     0    10.49                         *   BROKEN JET SUCTION
554    232028   28     0    19.9                          *   BROKEN  JET DSCH
555    232033   33     0    37.7                          *
556    232034   34     0    37.7                          *
557    232035   35     0    -5.11                         *   STEAMLINE OUTLET
558    232036   36     0     1.69                         *   FEEDWATER INLET
559    *
560    *
561    . END
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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page    1
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:16
 STANDARD PROBLEM FOUR (TLTA) - RETRAN-3D SAMPLE PROBLEM                                                        CPU TIME =     0.016
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

RETRAN PROBLEM CONTROL AND DESCRIPTION DATA.

    WORD  DESCRIPTION
    ====  ==================================================================
      1   RESTART FILE OPTION (SAVE=-1 / NO SAVE=0) .................... =    0
      2   PRINTER PLOT OPTION (YES=1 / NO=0) ........................... =    0
      3   POWER OPTION (TAPE OPTNS<0 / NO/TBL=0 / PT KIN=1 / 1D=2 / 3D=3) =    0
      4   USE STEADY-STATE SOLUTION (YES=0 / NO=1) ..................... =    1
      5   USE NEUTRON VOID MODEL (YES=1 / NO=0) ........................ =    0
      6   USE GENERALIZED TRANSPORT MODEL (NO=0 / VAP=1 / LIQ=-1) ....... =    0
      7   HEAT TRANSFER MAP OPTION (FORCED=0 / NAT CONV=1) ............. =    0
      8   SLIP OPTION (DYN=1 / Z-L=2 / C-L=3 / Z-L TAUGL=4 / C-L TAUGL=5) =    0
      9   FIVE-EQUATION OPTION (NO= 0 / YES=1) ......................... =    0
     10   NONCONDENSABLE GAS FLOW OPTION (NO=0 / YES=1) ................ =    0
     11   TH MATRIX DIRECT SOLVER OPTION (4-EQ=2 / 6-EQ=3) ............. =    2
     12   TH MATRIX ITERATIVE SOLVER OPTION (NO<=1 / YES=2) ............ =    0

    (DIMENSIONS AND OPTIONS AUTOMATICALLY DETERMINED BY CONTENT OF INPUT DATA)

          NUMBER OF MINOR EDIT SETS (0200XX DATA )...................... =    8
          NUMBER OF TIME-STEP CONTROL SETS (03XXX0 DATA )............... =    3
          NUMBER OF TRIP CONTROL SETS (04XXX0 DATA )..................... =   11
          NUMBER OF CONTROL VOLUME DESCRIPTIONS (05XXXY DATA )........... =   29
          NUMBER OF BUBBLE RISE DESCRIPTIONS (060XXY DATA) ............. =    2
          NUMBER OF TIME DEPENDENT VOLUMES FORM CARDS (07XXYY DATA) ..... =    0
          NUMBER OF JUNCTION DESCRIPTIONS (08XXXY DATA) ................ =   36
          NUMBER OF CENTRIFUGAL PUMP DESCRIPTIONS (090XXY DATA )......... =    2
          NUMBER OF VALVE DESCRIPTIONS (11XXXY DATA) ................... =    4
          NUMBER OF GENERAL DATA TABLE DESCRIPTIONS (12XXYY DATA) ....... =    4
          NUMBER OF FILL DESCRIPTIONS (13XXYY DATA )..................... =    2
          NUMBER OF HEAT CONDUCTOR DESCRIPTIONS (15XXXY DATA) ........... =   38
          NUMBER OF HEAT CONDUCTOR GEOMETRY DESCRIPTIONS (17XXYY DATA) .. =   20
          NUMBER OF HEAT CONDUCTOR MATERIAL DESCRIPTIONS (18XXYY DATA) .. =    5
          NUMBER OF CORE SECTION DESCRIPTIONS (16XXXY DATA) ............ =   24
          NUMBER OF NON-CONDUCTNG HEAT EXCHNGR DESCRIPTIONS (21XXYY DATA) =    0
          NUMBER OF TIME DEP BCS FROM TAPE (IREAD<0 ON 05XXXY DATA) ..... =    0
          NUMBER OF SPECIFIED HEAT TRAN COEF DESCRIPTIONS (015XXX DATA) . =    0
          TWO-REGION NONEQ VOL DESCRIPTIONS (610XXX OR 611XXX DATA) ..... =    0
          TEMP. TRANSPORT DELAY OPTION (MESH>0 ON 05XXXY DATA) .......... =    0
          AUXILIARY DNB MODEL (8001XX DATA INCLUDED) .................... =    0
          CONTROL SYSTEM MODEL (702XXX OR 702XXXX DATA) ................ =    0
          ACCUMULATOR MODEL DESCRIPTIONS (620XXX OR 621XXX DATA)......... =    0
          DYNAMIC GAP CONDUCTANCE MODEL DESCRIPTIONS (225XX0 DATA) ...... =    0
          NUMBER OF HT CONDUCTOR STACK DESCRIPTIONS (2200XY DATA) ....... =    0
          NUMBER OF TURBINE SHAFT DESCRIPTIONS (500XXY DATA) ........... =    0
          NUMBER OF PROFILE FIT DESCRIPTIONS (061XX1 DATA) ............. =    0
          NUMBER OF STEAM-WATER SEPARATOR DESCRIPTIONS (60XXX0 DATA) .... =    0


                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * *                                                  * * *
                   * * *          STEADY-STATE OPTION    =   1            * * *
                   * * *                                                  * * *
                   * * *          SLIP OPTION            =   0            * * *
                   * * *                                                  * * *
                   * * *          NUMERICS OPTION        =   2            * * *
                   * * *                                                  * * *
                   * * *          HEAT TRANSFER OPTION   =   0            * * *
                   * * *                                                  * * *
                   * * *          NEW EQUATIONS OPTION   =   0            * * *
                   * * *                                                  * * *
                   * * *         USING THE 4-EQ SOLVER - SOLVE3           * * *
                   * * *                                                  * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *


INITIAL THERMAL POWER (MEGAWATTS) =  4.56000E+00


AIR IS THE DEFAULT NONCONDENSABLE GAS.
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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   35
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:16
 STANDARD PROBLEM FOUR (TLTA) - RETRAN-3D SAMPLE PROBLEM                                                      CPU TIME =    0.031
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	ENERGY BALANCE (BTU)	TOTAL MASS BALANCE (LBM)	NCG MASS BALANCE (LBM)	AVERAGE TIME STEP (SEC)	CURRENT TIME STEP (SEC)	ELAPSED TIME (SEC)	TIME STEP NUM STANDRD/ACTUL
1.00000E+00	4.56000E+00	1.58490E+07	9.57884E+05	7.43543E+03	1.22067E+00	0.00000E+00	0.00000E+00	0.00000E+00	0 0

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	VOID FRAC.	POWR TO H2O (BTU/SEC)
1	1.04300E+03	1.18412E+02	5.25311E+02	4.74598E+01	5.30617E+02	0.00000E+00	0.00000E+00	0.00000E+00
2	1.03671E+03	1.29128E+01	5.25309E+02	4.74562E+01	5.30606E+02	0.00000E+00	0.00000E+00	0.00000E+00
3	1.03419E+03	1.14199E+01	5.32030E+02	4.70922E+01	5.35958E+02	0.00000E+00	0.00000E+00	5.05307E+02
4	1.03122E+03	2.87813E+00	5.81787E+02	2.28968E+01	5.47949E+02	5.34619E-02	5.31219E-01	5.80343E+02
5	1.03027E+03	2.36287E+00	5.96493E+02	1.87977E+01	5.47835E+02	7.64851E-02	6.24567E-01	5.63235E+02
6	1.02945E+03	1.73619E+00	6.10215E+02	1.61056E+01	5.47737E+02	9.79425E-02	6.85852E-01	4.39734E+02
7	1.02805E+03	3.49244E+00	6.25401E+02	1.38864E+01	5.47569E+02	1.21776E-01	7.36359E-01	7.47590E+02
8	1.02662E+03	1.34177E+00	6.38062E+02	1.24469E+01	5.47398E+02	1.41682E-01	7.69104E-01	1.62041E+02
9	1.03100E+03	9.11950E+01	5.25401E+02	4.74480E+01	5.30671E+02	0.00000E+00	0.00000E+00	0.00000E+00
10	1.02800E+03	4.89071E+01	5.25582E+02	4.74366E+01	5.30812E+02	0.00000E+00	0.00000E+00	0.00000E+00
11	1.02480E+03	3.04682E+01	6.31284E+02	1.31159E+01	5.47179E+02	1.31538E-01	7.53897E-01	0.00000E+00
12	1.02000E+03	7.83259E+00	1.19207E+03	2.27691E+00	5.46601E+02	9.99828E-01	9.99992E-01	0.00000E+00
13	1.02170E+03	2.61666E+01	8.37664E+02	4.76623E+00	5.46806E+02	4.51509E-01	9.43548E-01	0.00000E+00
14	1.02281E+03	3.56414E+02	5.46167E+02	4.61438E+01	5.46940E+02	1.75861E-04	3.55373E-03	0.00000E+00
15	1.02446E+03	1.99943E+02	5.26602E+02	4.73799E+01	5.31622E+02	0.00000E+00	0.00000E+00	0.00000E+00
16	1.02823E+03	9.46512E+01	5.26596E+02	4.73825E+01	5.31623E+02	0.00000E+00	0.00000E+00	0.00000E+00
17	1.15260E+03	1.26642E+01	5.27046E+02	4.74314E+01	5.32176E+02	0.00000E+00	0.00000E+00	2.99500E+01
18	1.15669E+03	2.70849E+01	5.27040E+02	4.74342E+01	5.32177E+02	0.00000E+00	0.00000E+00	0.00000E+00
19	1.04312E+03	2.54023E+00	5.26576E+02	4.73923E+01	5.31630E+02	0.00000E+00	0.00000E+00	0.00000E+00
20	1.02460E+03	2.98494E+00	5.26601E+02	4.73801E+01	5.31621E+02	0.00000E+00	0.00000E+00	0.00000E+00
21	1.02346E+03	9.18447E+00	5.26603E+02	4.73793E+01	5.31621E+02	0.00000E+00	0.00000E+00	0.00000E+00
22	1.14804E+03	8.90387E+01	5.26422E+02	4.74620E+01	5.31669E+02	0.00000E+00	0.00000E+00	4.94205E+01
23	1.13997E+03	5.66631E+00	5.26435E+02	4.74566E+01	5.31667E+02	0.00000E+00	0.00000E+00	0.00000E+00
24	1.04296E+03	2.54022E+00	5.26576E+02	4.73922E+01	5.31630E+02	0.00000E+00	0.00000E+00	0.00000E+00
25	1.02360E+03	2.76743E+01	5.26603E+02	4.73794E+01	5.31621E+02	0.00000E+00	0.00000E+00	0.00000E+00
26	1.90000E+01	6.22288E+03	4.84996E+01	3.11205E+00	8.00000E+01	4.81091E-04	9.50000E-01	0.00000E+00
27	1.17783E+03	1.00614E+01	5.26377E+02	4.74817E+01	5.31679E+02	0.00000E+00	0.00000E+00	0.00000E+00
28	1.03324E+03	8.30249E+00	5.47434E+02	4.62277E+01	5.48029E+02	0.00000E+00	0.00000E+00	6.54528E+02
29	1.03220E+03	4.67808E+00	5.64702E+02	3.06357E+01	5.48066E+02	2.67264E-02	3.54948E-01	6.70344E+02

JUNCTION NUMBER	CONNECTS VOLUMES	CHOK/ PATH	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E VEL. PSI	ELEV. PSI	D I F F E R E N T I A L S FRIC. PSI	ACCL. PSI	PUMP PSI
1	1 TO 2		3.77000E+01	5.25311E+02	2.10705E-02	-3.93174E-01	-4.62053E-01	-5.43456E+00	2.09517E-04	0.00000E+00
2	2 TO 3		3.77000E+01	5.25309E+02	2.10721E-02	-1.96469E-02	-7.30917E-01	-1.79760E+00	-2.81594E-02	0.00000E+00
3	29 TO 4		3.77000E+01	5.73592E+02	3.83255E-02	0.00000E+00	-2.43454E-01	-4.51975E-01	2.84571E-01	0.00000E+00
4	4 TO 5		3.77000E+01	5.89484E+02	4.85990E-02	0.00000E+00	-1.68905E-01	-5.23002E-01	2.58094E-01	0.00000E+00
5	5 TO 6		3.77000E+01	6.03963E+02	5.79816E-02	0.00000E+00	-1.32071E-01	-4.55565E-01	2.32363E-01	0.00000E+00
6	6 TO 7		3.77000E+01	6.16047E+02	6.58274E-02	0.00000E+00	-1.68426E-01	-9.25174E-01	3.06400E-01	0.00000E+00
7	7 TO 8		3.77000E+01	6.35316E+02	7.83739E-02	0.00000E+00	-1.55722E-01	-1.10056E+00	1.73717E-01	0.00000E+00
8	8 TO 11		3.77000E+01	6.40211E+02	8.17219E-02	-3.61678E-01	-2.60946E-01	-1.55742E+00	-3.60047E-01	0.00000E+00
9	1 TO 9		3.10000E+00	5.25311E+02	2.10705E-02	7.55926E-03	2.36596E-02	-7.01024E+00	5.02098E+00	0.00000E+00
10	9 TO 10		3.10000E+00	5.25401E+02	2.10757E-02	-6.49829E-02	-2.69298E+00	-3.91868E-02	2.02854E-01	0.00000E+00
11	10 TO 11		3.10000E+00	5.25582E+02	2.10808E-02	5.23890E-02	-2.36616E+00	-4.12491E-03	8.82108E-01	0.00000E+00
12	11 TO 13		4.08000E+01	6.31284E+02	7.62435E-02	-6.07873E-03	-2.07785E-01	-2.61817E+00	2.67968E-01	0.00000E+00
13	13 TO 12		5.11000E+00	1.19212E+03	4.38453E-01	1.23173E-02	-4.08602E-02	-5.96735E-04	1.67086E+00	0.00000E+00
14	13 TO 14		3.56900E+01	5.46723E+02	2.21352E-02	3.82770E-03	1.43970E+00	-4.12309E-03	3.31403E-01	0.00000E+00
15	14 TO 15		3.91100E+01	5.46167E+02	2.16714E-02	-5.23503E-04	2.12146E+00	-8.46251E-04	4.68087E-01	0.00000E+00
16	15 TO 16		1.00000E+01	5.26602E+02	2.11060E-02	-9.12187E-01	4.15152E+00	-2.65723E-01	-7.94387E-01	0.00000E+00
17	16 TO 17		1.00000E+01	5.26596E+02	2.11049E-02	0.00000E+00	3.59466E+00	-1.35375E-01	6.20602E-01	1.21533E+02
18	17 TO 18		1.00000E+01	5.27046E+02	2.10831E-02	-8.28876E+01	-4.01114E+00	-1.32253E+01	1.73203E+01	1.21533E+02
19	18 TO 19		1.00000E+01	5.27040E+02	2.10819E-02	8.60123E+01	-3.23176E+00	-1.22074E+01	7.14935E+01	-1.12648E+02
20	15 TO 19		1.15000E+01	5.26602E+02	2.11060E-02	-7.65871E+00	5.11942E-01	-2.34836E+01	3.95513E+00	5.32465E+01
21	19 TO 1		2.15000E+01	5.26576E+02	2.11005E-02	5.91985E+00	1.11586E+00	-2.97045E+00	4.18626E+00	0.00000E+00
22	15 TO 20		9.41000E+00	5.26602E+02	2.11060E-02	-1.65230E+00	5.66914E-01	-2.48119E-01	-1.47450E+00	0.00000E+00
23	20 TO 21		9.41000E+00	5.26601E+02	2.11059E-02	7.88235E-01	-1.65172E-01	-9.67223E-01	7.98840E-01	0.00000E+00
24	21 TO 22		9.41000E+00	5.26603E+02	2.11063E-02	1.13687E-13	2.19100E+00	-1.10736E-01	5.53098E-01	1.23055E+02
25	22 TO 23		9.41000E+00	5.26422E+02	2.10695E-02	-7.85451E+01	-2.20363E+00	-1.10730E+01	3.93041E+01	1.23055E+02
26	23 TO 24		9.41000E+00	5.26435E+02	2.10719E-02	8.10558E+01	3.49287E-01	-1.00914E+01	6.79706E+01	-1.00349E+02
27	15 TO 24		1.04900E+01	5.26602E+02	2.11060E-02	-7.08804E+00	7.39028E-01	-1.95466E+01	3.44594E+00	4.78446E+01
28	24 TO 1		1.99000E+01	5.26576E+02	2.11005E-02	5.59843E+00	8.88445E-01	-2.56209E+00	3.88779E+00	0.00000E+00
29	21 TO 25		0.00000E+00	5.26603E+02	2.11062E-02	8.69446E-01	-6.61995E-01	0.00000E+00	6.76625E-02	0.00000E+00
30	25 TO 26		0.00000E+00	5.26603E+02	2.11062E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
31	27 TO 23		0.00000E+00	5.26377E+02	2.10607E-02	-7.94183E+01	4.06994E-01	0.00000E+00	-4.11514E+01	0.00000E+00
32	27 TO 26		0.00000E+00	5.26377E+02	2.10607E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
33	3 TO 28		3.77000E+01	5.38732E+02	2.14031E-02	0.00000E+00	-6.35428E-01	-2.96461E-01	1.41107E-02	0.00000E+00
34	28 TO 29		3.77000E+01	5.56115E+02	2.70494E-02	0.00000E+00	-4.18215E-01	-3.44286E-01	2.81499E-01	0.00000E+00
36	0 TO 15		1.68999E+00	4.70733E+01	1.60744E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
35	0 TO 12		-5.10992E+00	1.19207E+03	4.39191E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

BUBL SET NUMB.	VOL. NUMB.	BUBBLE GRADIENT PARAMETER	BUBBLE VELOCITY (FT/SEC)	MIXTURE LEVEL (FT)	MIXTURE QUALITY	BUBBLE MASS (LB)
1	13	8.00000E-01	3.00000E+00	4.70000E-01	0.00000E+00	0.00000E+00
2	26	0.00000E+00	1.00000E+10	5.00000E+00	0.00000E+00	0.00000E+00

PUMP NUMB.	VOL. NUMB.	PUMP SPEED (RPM)	NORM. PUMP TORQUE	NORM. FRIC. TORQUE	NORM. MOT. TORQUE	POWER TO H2O (BTU/HR)
1	17	3.55000E+03	8.95410E-01	1.00000E+00	1.00000E+00	1.07820E+05
2	22	3.55000E+03	9.31767E-01	1.00000E+00	1.00000E+00	1.77914E+05

HEAT COND. NUMBER	VOL. NUM.	HT TRAN MODE-COR	SURF. FLUX (BTU/HR-FT2)	CRIT. FLUX (BTU/HR-FT2)	H.T. COEF. (BTU/H-F2-F)	SURF. TEMP. (DEG. F)	MASS FLUX (LBM/HR-FT2)	STORD ENRGY (BTU)	POWR TO H20 (BTU/HR)	DRYOUT PNT ()
1 RGHT	3	2-THOM	1.38934E+05	8.00000E+05	5.75156E+03	5.60114E+02	1.25900E+06	9.35871E+01	4.60342E+04	
2 RGHT	28	2-THOM	2.43101E+05	8.00000E+05	1.53900E+04	5.63825E+02	1.25900E+06	6.26877E+01	5.96659E+04	
3 RGHT	29	2-THOM	2.92682E+05	7.73274E+05	1.70468E+04	5.65235E+02	1.25900E+06	5.21788E+01	6.10597E+04	
4 RGHT	4	2-THOM	3.07735E+05	7.46538E+05	1.74660E+04	5.65568E+02	1.25900E+06	4.28591E+01	5.28706E+04	
5 RGHT	5	2-THOM	2.98613E+05	7.23515E+05	1.71923E+04	5.65204E+02	1.25900E+06	4.30103E+01	5.13035E+04	
6 RGHT	6	2-THOM	2.72039E+05	7.02058E+05	1.63988E+04	5.64326E+02	1.25900E+06	3.71222E+01	4.00610E+04	
7 RGHT	7	2-THOM	1.98210E+05	6.78224E+05	1.39822E+04	5.61745E+02	1.25900E+06	9.01676E+01	6.81072E+04	
8 RGHT	8	2-THOM	1.00247E+05	6.58318E+05	9.93245E+03	5.57491E+02	1.25900E+06	4.39010E+01	1.47626E+04	

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9	RGHT	3	2-THOM	7.84302E+04	8.00000E+05	3.69623E+03	5.57177E+02	1.25900E+06	8.17835E+01	2.59871E+04
10	RGHT	28	2-THOM	1.37147E+05	8.00000E+05	1.15205E+04	5.59934E+02	1.25900E+06	5.69624E+01	3.36609E+04
11	RGHT	29	2-THOM	1.65252E+05	7.73274E+05	1.28091E+04	5.60967E+02	1.25900E+06	4.79166E+01	3.44751E+04
12	RGHT	4	2-THOM	1.73721E+05	7.46538E+05	1.31230E+04	5.61187E+02	1.25900E+06	3.95138E+01	2.98463E+04
13	RGHT	5	2-THOM	1.68600E+05	7.23515E+05	1.29184E+04	5.60886E+02	1.25900E+06	3.94676E+01	2.89665E+04
14	RGHT	6	2-THOM	1.53571E+05	7.02058E+05	1.23211E+04	5.60201E+02	1.25900E+06	3.37273E+01	2.26152E+04
15	RGHT	7	2-THOM	1.11893E+05	6.78224E+05	1.05055E+04	5.58220E+02	1.25900E+06	8.10246E+01	3.84477E+04
16	RGHT	8	2-THOM	5.65908E+04	6.58318E+05	7.46266E+03	5.54981E+02	1.25900E+06	3.76257E+01	8.33367E+03
17	RGHT	3	2-THOM	1.12187E+05	8.00000E+05	4.88656E+03	5.58916E+02	1.25900E+06	4.14312E+03	1.74708E+06
18	RGHT	28	2-THOM	1.96175E+05	8.00000E+05	1.38091E+04	5.62235E+02	1.25900E+06	2.81921E+03	2.26297E+06
19	RGHT	29	2-THOM	2.36375E+05	7.73274E+05	1.53195E+04	5.63495E+02	1.25900E+06	2.36130E+03	2.31770E+06
20	RGHT	4	2-THOM	2.48488E+05	7.46538E+05	1.56949E+04	5.63781E+02	1.25900E+06	1.94907E+03	2.00652E+06
21	RGHT	5	2-THOM	2.41164E+05	7.23515E+05	1.54502E+04	5.63444E+02	1.25900E+06	1.94570E+03	1.94737E+06
22	RGHT	6	2-THOM	2.19665E+05	7.02058E+05	1.47359E+04	5.62644E+02	1.25900E+06	1.65993E+03	1.52036E+06
23	RGHT	7	2-THOM	1.60051E+05	6.78224E+05	1.25644E+04	5.60308E+02	1.25900E+06	4.03798E+03	2.58477E+06
24	RGHT	8	2-THOM	8.09461E+04	6.58318E+05	8.92522E+03	5.56467E+02	1.25900E+06	1.92908E+03	5.60252E+05
25	RGHT	1	0	0.00000E+00	9.00000E+04	0.00000E+00	5.30617E+02	1.99946E+05	6.69925E+04	0.00000E+00
26	RGHT	15	0	0.00000E+00	9.00000E+04	0.00000E+00	5.31622E+02	1.54077E+05	8.27486E+04	0.00000E+00
27	RGHT	14	0	0.00000E+00	9.00000E+04	0.00000E+00	5.46940E+02	1.40206E+05	1.46342E+05	0.00000E+00
28	RGHT	13	0	0.00000E+00	9.00000E+04	0.00000E+00	5.46806E+02	1.86396E+05	7.64019E+04	0.00000E+00
29	RGHT	12	0	0.00000E+00	9.00000E+04	0.00000E+00	5.46601E+02	1.78602E+04	5.63191E+04	0.00000E+00
30	RGHT	13	0	0.00000E+00	1.02011E+05	0.00000E+00	5.46806E+02	1.86396E+05	4.29597E+03	0.00000E+00
31	RGHT	16	0	0.00000E+00	1.39562E+05	0.00000E+00	5.31623E+02	7.84827E+05	1.41498E+04	0.00000E+00
32	RGHT	18	0	0.00000E+00	2.21590E+05	0.00000E+00	5.32177E+02	7.50000E+06	2.79665E+04	0.00000E+00
33	RGHT	20	0	0.00000E+00	5.64624E+05	0.00000E+00	5.31621E+02	1.01975E+06	3.00562E+03	0.00000E+00
34	RGHT	21	0	0.00000E+00	1.86173E+05	0.00000E+00	5.31621E+02	7.38522E+05	3.00562E+03	0.00000E+00
35	RGHT	22	0	0.00000E+00	1.69830E+05	0.00000E+00	5.31669E+02	7.38522E+05	2.74112E+04	0.00000E+00
36	RGHT	23	0	0.00000E+00	3.87876E+05	0.00000E+00	5.31667E+02	7.05750E+06	2.73035E+03	0.00000E+00
37	RGHT	25	0	0.00000E+00	9.00000E+04	0.00000E+00	5.31621E+02	0.00000E+00	1.65053E+04	0.00000E+00
38	RGHT	27	0	0.00000E+00	9.00000E+04	0.00000E+00	5.31679E+02	0.00000E+00	8.43199E+03	0.00000E+00

CORE NUMB.	COND. NUMB.	DEPTH REAC. EXT. ZR-H2O (FT)	DEPTH REAC. INT. ZR-H2O (FT)	HEAT GEN. ZR-H2O (BTU/HR)	COND. HEAT-ING RATE (BTU/HR)	DIR. MODER-ATOR HT RT (BTU/HR)	AVG. METAL TEMPERATURE (DEG. F)	CENTERLINE TEMPERATURE (DEG. F)	FUEL ENTHALPY (CAL/GM)
1	1	0.00000E+00	0.00000E+00	0.00000E+00	4.60343E+04	0.00000E+00	5.80013E+02	5.92055E+02	0.00000E+00
2	2	0.00000E+00	0.00000E+00	0.00000E+00	5.96279E+04	0.00000E+00	5.81063E+02	5.90900E+02	0.00000E+00
3	3	0.00000E+00	0.00000E+00	0.00000E+00	6.10703E+04	0.00000E+00	5.81893E+02	5.91298E+02	0.00000E+00
4	4	0.00000E+00	0.00000E+00	0.00000E+00	5.28706E+04	0.00000E+00	5.82379E+02	5.91853E+02	0.00000E+00
5	5	0.00000E+00	0.00000E+00	0.00000E+00	5.13123E+04	0.00000E+00	5.82198E+02	5.91792E+02	0.00000E+00
6	6	0.00000E+00	0.00000E+00	0.00000E+00	4.00610E+04	0.00000E+00	5.81298E+02	5.90920E+02	0.00000E+00
7	7	0.00000E+00	0.00000E+00	0.00000E+00	6.81072E+04	0.00000E+00	5.79655E+02	5.90033E+02	0.00000E+00
8	8	0.00000E+00	0.00000E+00	0.00000E+00	1.47625E+04	0.00000E+00	5.77051E+02	5.89449E+02	0.00000E+00
9	9	0.00000E+00	0.00000E+00	0.00000E+00	2.59871E+04	0.00000E+00	5.63357E+02	5.66911E+02	0.00000E+00
10	10	0.00000E+00	0.00000E+00	0.00000E+00	3.36609E+04	0.00000E+00	5.65382E+02	5.68423E+02	0.00000E+00
11	11	0.00000E+00	0.00000E+00	0.00000E+00	3.44752E+04	0.00000E+00	5.66380E+02	5.69387E+02	0.00000E+00
12	12	0.00000E+00	0.00000E+00	0.00000E+00	2.98463E+04	0.00000E+00	5.66876E+02	5.70036E+02	0.00000E+00
13	13	0.00000E+00	0.00000E+00	0.00000E+00	2.89665E+04	0.00000E+00	5.66409E+02	5.69476E+02	0.00000E+00
14	14	0.00000E+00	0.00000E+00	0.00000E+00	2.26152E+04	0.00000E+00	5.65234E+02	5.68029E+02	0.00000E+00
15	15	0.00000E+00	0.00000E+00	0.00000E+00	3.84477E+04	0.00000E+00	5.63878E+02	5.67062E+02	0.00000E+00
16	16	0.00000E+00	0.00000E+00	0.00000E+00	8.33367E+03	0.00000E+00	5.60938E+02	5.64437E+02	0.00000E+00
17	17	0.00000E+00	0.00000E+00	0.00000E+00	1.74708E+06	0.00000E+00	5.71728E+02	5.79301E+02	0.00000E+00
18	18	0.00000E+00	0.00000E+00	0.00000E+00	2.26298E+06	0.00000E+00	5.73367E+02	5.79657E+02	0.00000E+00
19	19	0.00000E+00	0.00000E+00	0.00000E+00	2.31772E+06	0.00000E+00	5.74513E+02	5.80690E+02	0.00000E+00
20	20	0.00000E+00	0.00000E+00	0.00000E+00	2.00652E+06	0.00000E+00	5.75360E+02	5.81851E+02	0.00000E+00
21	21	0.00000E+00	0.00000E+00	0.00000E+00	1.94738E+06	0.00000E+00	5.74684E+02	5.80986E+02	0.00000E+00
22	22	0.00000E+00	0.00000E+00	0.00000E+00	1.52038E+06	0.00000E+00	5.72889E+02	5.78634E+02	0.00000E+00
23	23	0.00000E+00	0.00000E+00	0.00000E+00	2.58478E+06	0.00000E+00	5.71916E+02	5.78554E+02	0.00000E+00
24	24	0.00000E+00	0.00000E+00	0.00000E+00	5.60262E+05	0.00000E+00	5.68963E+02	5.76606E+02	0.00000E+00

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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   44
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:17
 STANDARD PROBLEM FOUR (TLTA) - RETRAN-3D SAMPLE PROBLEM                                                      CPU TIME =    0.484
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	ENERGY BALANCE (BTU)	TOTAL MASS BALANCE (LBM)	NCG MASS BALANCE (LBM)	AVERAGE TIME STEP (SEC)	CURRENT TIME STEP (SEC)	ELAPSED TIME (SEC)	TIME STEP NUM STANDRD/ACTUL
9.64528E-01	4.39825E+00	1.50789E+07	9.58020E+05	7.43211E+03	1.22067E+00	2.50000E-03	2.50000E-03	1.00000E+00	139 / 336

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	VOID FRAC.	POWR TO H2O (BTU/SEC)
1	1.00849E+03	1.18296E+02	5.25802E+02	4.74134E+01	5.30958E+02	0.00000E+00	0.00000E+00	-4.16921E-01
2	1.00667E+03	1.29060E+01	5.25449E+02	4.74312E+01	5.30672E+02	0.00000E+00	0.00000E+00	0.00000E+00
3	1.00544E+03	1.13173E+01	5.39351E+02	4.66694E+01	5.41681E+02	0.00000E+00	0.00000E+00	5.06834E+02
4	1.00353E+03	1.69994E+00	6.23091E+02	1.35238E+01	5.44602E+02	1.23130E-01	7.44739E-01	5.67145E+02
5	1.00295E+03	1.42086E+00	6.45117E+02	1.13036E+01	5.44531E+02	1.57144E-01	7.94942E-01	5.50536E+02
6	1.00241E+03	1.07549E+00	6.62928E+02	9.97671E+00	5.44465E+02	1.84652E-01	8.24936E-01	4.19245E+02
7	1.00150E+03	2.24182E+00	6.80905E+02	8.91381E+00	5.44353E+02	2.12472E-01	8.48948E-01	7.05740E+02
8	1.00048E+03	8.98987E-01	6.92392E+02	8.33940E+00	5.44229E+02	2.30315E-01	8.61909E-01	1.57323E+02
9	1.00499E+03	9.11758E+01	5.25304E+02	4.74380E+01	5.30554E+02	0.00000E+00	0.00000E+00	0.00000E+00
10	1.00229E+03	4.88976E+01	5.25472E+02	4.74274E+01	5.30684E+02	0.00000E+00	0.00000E+00	0.00000E+00
11	9.99906E+02	2.64931E+01	6.43200E+02	1.14047E+01	5.44159E+02	1.54779E-01	7.92638E-01	0.00000E+00
12	9.97551E+02	7.66752E+00	1.19065E+03	2.22893E+00	5.43870E+02	9.96364E-01	9.99826E-01	3.37445E-01
13	9.97559E+02	1.90942E+01	9.46037E+02	3.47800E+00	5.43871E+02	6.20528E-01	9.71620E-01	3.60607E+01
14	9.98757E+02	3.03729E+02	5.48317E+02	3.93227E+01	5.44018E+02	9.16424E-03	1.62021E-01	7.25680E+01
15	1.00067E+03	1.98578E+02	5.32315E+02	4.70563E+01	5.36129E+02	0.00000E+00	0.00000E+00	-1.82267E+01
16	1.00457E+03	9.46004E+01	5.26810E+02	4.73570E+01	5.31758E+02	0.00000E+00	0.00000E+00	-1.01567E+00
17	1.08798E+03	1.26422E+01	5.27878E+02	4.73490E+01	5.32741E+02	0.00000E+00	0.00000E+00	1.87958E+01
18	1.14014E+03	2.70771E+01	5.27114E+02	4.74205E+01	5.32211E+02	0.00000E+00	0.00000E+00	1.16335E+00
19	1.01044E+03	2.52993E+00	5.29783E+02	4.72001E+01	5.34136E+02	0.00000E+00	0.00000E+00	0.00000E+00
20	9.78891E+02	2.96552E+00	5.31790E+02	4.70718E+01	5.35678E+02	0.00000E+00	0.00000E+00	-1.65715E+01
21	5.65010E+02	2.09288E+00	5.31452E+02	1.07964E+01	4.79459E+02	9.08472E-02	8.04418E-01	1.19875E+02
22	8.05023E+02	5.46511E+01	5.27742E+02	2.91317E+01	5.18494E+02	2.47404E-02	4.09197E-01	3.70409E+02
23	2.40143E+02	2.08056E-01	6.15297E+02	1.74252E+00	3.97597E+02	2.93341E-01	9.77064E-01	5.33322E+02
24	1.00100E+03	2.54109E+00	5.25813E+02	4.74084E+01	5.30955E+02	0.00000E+00	0.00000E+00	0.00000E+00
25	5.09437E+02	5.00613E+00	5.33635E+02	8.57067E+00	4.68664E+02	1.08792E-01	8.49364E-01	2.71454E+02
26	1.96321E+01	6.37465E+03	6.00018E+01	3.18794E+00	9.12303E+01	6.60438E-04	9.48692E-01	0.00000E+00
27	1.45303E+02	1.93886E-01	6.30237E+02	9.14989E-01	3.56248E+02	3.49147E-01	9.89211E-01	2.38325E+00
28	1.00472E+03	4.78142E+00	5.67768E+02	2.66226E+01	5.44747E+02	3.77111E-02	4.48434E-01	6.42536E+02
29	1.00411E+03	2.67977E+00	5.97317E+02	1.75493E+01	5.44672E+02	8.33381E-02	6.53692E-01	6.55538E+02

JUNCTION NUMBER	CONNECTS VOLUMES	CHOK/ PATH	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E VEL. PSI	ELEV. PSI	D I F F E R E N T I A L S FRIC. PSI	ACCL. PSI	PUMP PSI
1	1 TO 2		1.79685E+01	5.25800E+02	2.10910E-02	-5.73745E-02	-4.61725E-01	-1.30976E+00	-6.55576E-03	0.00000E+00
2	2 TO 3		1.79777E+01	5.25449E+02	2.10831E-02	-2.11794E-02	-7.27426E-01	-4.87880E-01	-1.35887E-02	0.00000E+00
3	29 TO 4		2.05178E+01	6.11234E+02	6.60892E-02	-1.77662E-01	-1.41262E-01	-2.80161E-01	-2.79581E-02	0.00000E+00
4	4 TO 5		2.13243E+01	6.34325E+02	8.12967E-02	-1.72723E-01	-1.00702E-01	-3.42499E-01	-3.03018E-02	0.00000E+00
5	5 TO 6		2.20812E+01	6.55276E+02	9.51185E-02	-1.58794E-01	-8.05427E-02	-3.28385E-01	-3.19248E-02	0.00000E+00
6	6 TO 7		2.26959E+01	6.70029E+02	1.04881E-01	-2.07043E-01	-1.07016E-01	-6.55807E-01	-5.33998E-02	0.00000E+00
7	7 TO 8		2.40408E+01	6.90869E+02	1.18716E-01	-1.76001E-01	-1.01327E-01	-8.01278E-01	-6.06721E-02	0.00000E+00
8	8 TO 11		2.45977E+01	6.93342E+02	1.20528E-01	6.08752E-01	-2.18469E-01	-1.01692E+00	-5.19691E-02	0.00000E+00
9	1 TO 9		2.19832E+00	5.25800E+02	2.10910E-02	2.96300E-03	2.38525E-02	-3.53634E+00	-1.94506E-03	0.00000E+00
10	9 TO 10		2.21248E+00	5.25304E+02	2.10802E-02	-1.12811E-03	-2.69245E+00	-2.00571E-02	-1.26243E-02	0.00000E+00
11	10 TO 11		2.21914E+00	5.25472E+02	2.10849E-02	-4.96398E-02	-2.33945E+00	-2.16679E-03	-1.30281E-02	0.00000E+00
12	11 TO 13		3.49155E+01	6.43109E+02	8.76163E-02	1.04679E-02	-1.80576E-01	-2.20866E+00	-2.89502E-02	0.00000E+00
13	13 TO 12		3.06961E+00	1.19301E+03	4.50179E-01	3.03794E-02	-3.97112E-02	-2.41800E-04	-1.35225E-03	0.00000E+00
14	13 TO 14		3.58281E+01	5.86440E+02	5.06583E-02	-7.80935E-03	1.17700E+00	-1.10452E-02	-4.41744E-02	0.00000E+00
15	14 TO 15		9.55086E+01	5.48305E+02	2.54181E-02	-5.49392E-03	1.91130E+00	-5.95145E-03	-1.26159E-02	0.00000E+00
16	15 TO 16		1.11188E+01	5.32298E+02	2.12507E-02	-1.19313E-01	4.14502E+00	-3.28032E-01	-2.05560E-01	0.00000E+00
17	16 TO 17		1.12022E+01	5.26809E+02	2.11161E-02	-1.49138E-03	3.59292E+00	-1.66768E-01	-2.94493E-01	7.97620E+01
18	17 TO 18		1.12148E+01	5.27878E+02	2.11197E-02	-1.23547E+01	-4.00974E+00	-1.64679E+01	-5.27886E+00	7.97620E+01
19	18 TO 19		1.12402E+01	5.27114E+02	2.10879E-02	2.06879E+01	-3.23285E+00	-1.52222E+01	-1.05488E+00	-1.33099E+02
20	15 TO 19		1.60014E+01	5.32298E+02	2.12507E-02	-4.21519E+00	5.09936E-01	-4.57619E+01	-1.04867E-01	5.91438E+01
21	19 TO 1		2.72542E+01	5.29773E+02	2.11861E-02	1.44698E+00	1.11312E+00	-4.69812E+00	-1.78336E-01	0.00000E+00
22	15 TO 20		7.03594E+01	5.32298E+02	2.12507E-02	-1.02788E+01	5.63016E-01	-1.21130E+01	-4.18214E-02	0.00000E+00
23	20 TO 21	XHN	7.03834E+01	5.31773E+02	2.12437E-02	1.02924E+01	-1.64101E-01	-4.03329E+00	-1.07616E-01	0.00000E+00
24	21 TO 22		-3.44677E+01	5.27727E+02	3.42728E-02	2.59677E+01	1.34693E+00	2.15649E+00	1.20705E+00	2.11776E+02
25	22 TO 23		0.00000E+00	5.27727E+02	3.42728E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	2.11776E+02
26	23 TO 24	XHN	-7.15860E+00	5.25813E+02	2.10933E-02	1.96851E-01	-7.62321E-01	-1.87468E-01	4.50593E-03	0.00000E+00
27	15 TO 24		-7.06083E-02	5.25813E+02	2.10933E-02	-3.49259E-01	7.39446E-01	1.15269E-03	6.41168E-02	0.00000E+00
28	24 TO 1		-7.22893E+00	5.25800E+02	2.10910E-02	1.93095E-01	8.88287E-01	6.48955E+00	7.63097E-02	0.00000E+00
29	21 TO 25		1.05785E+02	5.31437E+02	9.25205E-02	-3.28678E+01	-1.19881E-01	-2.33799E+01	-7.89113E-01	0.00000E+00
30	25 TO 26	MDY	1.07958E+02	5.33620E+02	1.16550E-01	1.43810E-09	-1.11420E-01	-6.20426E-13	2.33246E-03	0.00000E+00
31	27 TO 23	MDY	-6.98927E+00	6.16658E+02	5.75053E-01	1.07525E+02	1.84585E-02	-7.89156E+01	-1.09187E-02	0.00000E+00
32	27 TO 26	MDY	7.60602E+00	6.31887E+02	1.08429E+00	1.12827E-13	-1.67161E-02	-2.66538E-13	-2.34171E-03	0.00000E+00
33	3 TO 28		1.80187E+01	5.51807E+02	2.70351E-02	-1.02891E-01	-5.18788E-01	-1.14696E-01	-7.89127E-03	0.00000E+00
34	28 TO 29		1.94559E+01	5.82554E+02	4.72340E-02	-1.77232E-01	-2.40591E-01	-2.17050E-01	-2.33488E-02	0.00000E+00
36	0 TO 15		2.57950E-01	4.70733E+01	1.60744E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
35	0 TO 12		-3.20501E+00	1.19065E+03	4.48626E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

BUBL SET NUMB.	VOL. NUMB.	BUBBLE GRADIENT PARAMETER	BUBBLE VELOCITY (FT/SEC)	MIXTURE LEVEL (FT)	MIXTURE QUALITY	BUBBLE MASS (LB)
1	13	8.00000E-01	3.00000E+00	2.10684E-01	3.09254E-04	2.24146E-03
2	26	0.00000E+00	1.00000E+10	5.13079E+00	0.00000E+00	0.00000E+00

PUMP NUMB.	VOL. NUMB.	PUMP SPEED (RPM)	NORM. PUMP TORQUE	NORM. FRIC. TORQUE	NORM. MOT. TORQUE	POWER TO H2O (BTU/HR)
1	17	2.94160E+03	6.78156E-01	1.00000E+00	0.00000E+00	6.76649E+04
2	22	0.00000E+00	1.05712E+00	0.00000E+00	0.00000E+00	0.00000E+00

HEAT COND. NUMBER	VOL. NUM.	HT TRAN MODE-COR	SURF. FLUX (BTU/HR-FT2)	CRIT. FLUX (BTU/HR-FT2)	H.T. COEF. (BTU/H-F2-F)	SURF. TEMP. (DEG. F)	MASS FLUX (LBM/HR-FT2)	STORD ENRGY (BTU)	POWR TO H20 (BTU/HR)	DRYOUT PNT ()
1 RGHT	3	2-THOM	1.39072E+05	8.00000E+05	9.11666E+03	5.56930E+02	6.01223E+05	9.31825E+01	4.60803E+04	
2 RGHT	28	2-THOM	2.38417E+05	7.62354E+05	1.50542E+04	5.60590E+02	6.26126E+05	6.24243E+01	5.85163E+04	
3 RGHT	29	2-THOM	2.85941E+05	7.16790E+05	1.64784E+04	5.62031E+02	6.68196E+05	5.19670E+01	5.96532E+04	
4 RGHT	4	2-THOM	3.00399E+05	6.77069E+05	1.68822E+04	5.62402E+02	6.99606E+05	4.26874E+01	5.16103E+04	
5 RGHT	5	2-THOM	2.91618E+05	6.43124E+05	1.66259E+04	5.62077E+02	7.25866E+05	4.28387E+01	5.01017E+04	
6 RGHT	6	17-T-SG	2.59475E+05	6.15674E+05	1.41802E+04	5.62770E+02	7.48888E+05	3.70077E+01	3.82109E+04	
7 RGHT	7	17-T-SG	1.86774E+05	5.87911E+05	1.08551E+04	5.61565E+02	7.81746E+05	8.99879E+01	6.41776E+04	
8 RGHT	8	17-T-SG	9.63774E+04	5.70107E+05	7.87661E+03	5.56470E+02	8.13621E+05	4.37925E+01	1.41927E+04	

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9	RGHT	3	2-THOM	7.90818E+04	8.00000E+05	6.43889E+03	5.53958E+02	6.01223E+05	8.14644E+01	2.62030E+04
10	RGHT	28	2-THOM	1.35059E+05	7.62354E+05	1.13305E+04	5.56673E+02	6.26126E+05	5.67554E+01	3.31485E+04
11	RGHT	29	2-THOM	1.62034E+05	7.16790E+05	1.24045E+04	5.57741E+02	6.68196E+05	4.77481E+01	3.38038E+04
12	RGHT	4	2-THOM	1.70190E+05	6.77069E+05	1.27071E+04	5.58002E+02	6.99606E+05	3.93761E+01	2.92396E+04
13	RGHT	5	2-THOM	1.65213E+05	6.43124E+05	1.25142E+04	5.57739E+02	7.25866E+05	3.93317E+01	2.83847E+04
14	RGHT	6	17-T-SG	1.46695E+05	6.15674E+05	1.08071E+04	5.58045E+02	7.48888E+05	3.36343E+01	2.16026E+04
15	RGHT	7	17-T-SG	1.06319E+05	5.87911E+05	8.54302E+03	5.56804E+02	7.81746E+05	8.08438E+01	3.65326E+04
16	RGHT	8	17-T-SG	5.61470E+04	5.70107E+05	6.54921E+03	5.52808E+02	8.13621E+05	3.75124E+01	8.26832E+03
17	RGHT	3	2-THOM	1.12523E+05	8.00000E+05	8.01457E+03	5.55715E+02	6.01223E+05	4.12586E+03	1.75232E+06
18	RGHT	28	2-THOM	1.92576E+05	7.62354E+05	1.35297E+04	5.58986E+02	6.26126E+05	2.80808E+03	2.22146E+06
19	RGHT	29	2-THOM	2.31151E+05	7.16790E+05	1.48158E+04	5.60280E+02	6.68196E+05	2.35228E+03	2.26648E+06
20	RGHT	4	2-THOM	2.42835E+05	6.77069E+05	1.51788E+04	5.60607E+02	6.99606E+05	1.94168E+03	1.96087E+06
21	RGHT	5	2-THOM	2.35723E+05	6.43124E+05	1.49479E+04	5.60306E+02	7.25866E+05	1.93841E+03	1.90344E+06
22	RGHT	6	17-T-SG	2.09421E+05	6.15674E+05	1.27984E+04	5.60834E+02	7.48888E+05	1.65516E+03	1.44947E+06
23	RGHT	7	17-T-SG	1.51084E+05	5.87911E+05	9.90601E+03	5.59611E+02	7.81746E+05	4.02968E+03	2.43996E+06
24	RGHT	8	17-T-SG	7.85836E+04	5.70107E+05	7.32839E+03	5.54958E+02	8.13621E+05	1.92386E+03	5.43900E+05
25	RGHT	1	1-DB-L	-8.37098E+01	9.00000E+04	2.48910E+02	5.30620E+02	9.77993E+04	6.69926E+04	-1.50092E+03
26	RGHT	15	1-DB-L	-2.97039E+03	9.00000E+04	6.76864E+02	5.31727E+02	3.62177E+05	8.27584E+04	-6.56160E+04
27	RGHT	14	2-THOM	6.91490E+03	9.00000E+04	2.55168E+03	5.46733E+02	2.46324E+05	1.46309E+05	2.61245E+05
28	RGHT	13	3-SG	4.68397E+03	9.00000E+04	1.71519E+03	5.46607E+02	1.68830E+05	7.63853E+04	9.24147E+04
29	RGHT	12	18-SG-R	8.34917E+01	9.00000E+04	3.06637E+01	5.46598E+02	1.09743E+04	5.63188E+04	1.21480E+03
30	RGHT	13	3-SG	2.87723E+03	1.02677E+05	1.89986E+03	5.45391E+02	1.68830E+05	4.28879E+03	3.74039E+04
31	RGHT	16	1-DB-L	-2.15083E+02	1.33593E+05	1.78257E+03	5.31636E+02	8.76288E+05	1.41500E+04	-3.65641E+03
32	RGHT	18	1-DB-L	1.24793E+02	2.19878E+05	9.59585E+03	5.32224E+02	8.42432E+06	2.79686E+04	4.18807E+03
33	RGHT	20	1-DB-L	-1.65256E+04	7.83650E+05	1.54569E+04	5.34596E+02	7.62772E+06	3.01684E+03	-5.96576E+04
34	RGHT	21	17-T-SG	1.19543E+05	2.10190E+06	7.63721E+03	4.95160E+02	5.56186E+06	2.85520E+03	4.31549E+05
35	RGHT	22	2-THOM	4.04942E+04	4.33228E+05	5.29584E+03	5.26181E+02	1.35368E+06	2.72174E+04	1.33347E+06
36	RGHT	23	3-SG	5.85353E+05	1.50749E+06	3.88330E+04	4.12910E+02	5.30517E+06	2.34233E+03	1.91996E+06
37	RGHT	25	7-INTR	4.92807E+04	9.00724E+04	1.03205E+03	5.16465E+02	3.84937E+01	1.61576E+04	9.77236E+05
38	RGHT	27	3-SG	8.46961E+02	9.00001E+04	5.00000E+00	5.26554E+02	1.11785E-01	8.36779E+03	8.57971E+03

CORE NUMB.	COND. NUMB.	DEPTH REAC. EXT. ZR-H2O (FT)	DEPTH REAC. INT. ZR-H2O (FT)	HEAT GEN. ZR-H2O (BTU/HR)	COND. HEAT-ING RATE (BTU/HR)	DIR. MODER-ATOR HT RT (BTU/HR)	AVG. METAL TEMPERATURE (DEG. F)	CENTERLINE TEMPERATURE (DEG. F)	FUEL ENTHALPY (CAL/GM)
1	1	0.00000E+00	0.00000E+00	0.00000E+00	4.44014E+04	0.00000E+00	5.77046E+02	5.91853E+02	0.00000E+00
2	2	0.00000E+00	0.00000E+00	0.00000E+00	5.75128E+04	0.00000E+00	5.77616E+02	5.90754E+02	0.00000E+00
3	3	0.00000E+00	0.00000E+00	0.00000E+00	5.89040E+04	0.00000E+00	5.78405E+02	5.91160E+02	0.00000E+00
4	4	0.00000E+00	0.00000E+00	0.00000E+00	5.09952E+04	0.00000E+00	5.78910E+02	5.91719E+02	0.00000E+00
5	5	0.00000E+00	0.00000E+00	0.00000E+00	4.94921E+04	0.00000E+00	5.78773E+02	5.91657E+02	0.00000E+00
6	6	0.00000E+00	0.00000E+00	0.00000E+00	3.86399E+04	0.00000E+00	5.78978E+02	5.90784E+02	0.00000E+00
7	7	0.00000E+00	0.00000E+00	0.00000E+00	6.56913E+04	0.00000E+00	5.78465E+02	5.89890E+02	0.00000E+00
8	8	0.00000E+00	0.00000E+00	0.00000E+00	1.42389E+04	0.00000E+00	5.75601E+02	5.89208E+02	0.00000E+00
9	9	0.00000E+00	0.00000E+00	0.00000E+00	2.50653E+04	0.00000E+00	5.60278E+02	5.66768E+02	0.00000E+00
10	10	0.00000E+00	0.00000E+00	0.00000E+00	3.24669E+04	0.00000E+00	5.62089E+02	5.68298E+02	0.00000E+00
11	11	0.00000E+00	0.00000E+00	0.00000E+00	3.32523E+04	0.00000E+00	5.63092E+02	5.69266E+02	0.00000E+00
12	12	0.00000E+00	0.00000E+00	0.00000E+00	2.87876E+04	0.00000E+00	5.63619E+02	5.69917E+02	0.00000E+00
13	13	0.00000E+00	0.00000E+00	0.00000E+00	2.79390E+04	0.00000E+00	5.63194E+02	5.69359E+02	0.00000E+00
14	14	0.00000E+00	0.00000E+00	0.00000E+00	2.18130E+04	0.00000E+00	5.62849E+02	5.67914E+02	0.00000E+00
15	15	0.00000E+00	0.00000E+00	0.00000E+00	3.70839E+04	0.00000E+00	5.62176E+02	5.66946E+02	0.00000E+00
16	16	0.00000E+00	0.00000E+00	0.00000E+00	8.03806E+03	0.00000E+00	5.58798E+02	5.64300E+02	0.00000E+00
17	17	0.00000E+00	0.00000E+00	0.00000E+00	1.68511E+06	0.00000E+00	5.68710E+02	5.79132E+02	0.00000E+00
18	18	0.00000E+00	0.00000E+00	0.00000E+00	2.18270E+06	0.00000E+00	5.69999E+02	5.79521E+02	0.00000E+00
19	19	0.00000E+00	0.00000E+00	0.00000E+00	2.23551E+06	0.00000E+00	5.71127E+02	5.80561E+02	0.00000E+00
20	20	0.00000E+00	0.00000E+00	0.00000E+00	1.93535E+06	0.00000E+00	5.71995E+02	5.81723E+02	0.00000E+00
21	21	0.00000E+00	0.00000E+00	0.00000E+00	1.87830E+06	0.00000E+00	5.71365E+02	5.80860E+02	0.00000E+00
22	22	0.00000E+00	0.00000E+00	0.00000E+00	1.46645E+06	0.00000E+00	5.70598E+02	5.78510E+02	0.00000E+00
23	23	0.00000E+00	0.00000E+00	0.00000E+00	2.49309E+06	0.00000E+00	5.70565E+02	5.78425E+02	0.00000E+00
24	24	0.00000E+00	0.00000E+00	0.00000E+00	5.40389E+05	0.00000E+00	5.67258E+02	5.76428E+02	0.00000E+00

```
RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   45
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis             11:57:17
 STANDARD PROBLEM FOUR (TLTA) - RETRAN-3D SAMPLE PROBLEM                                                        CPU TIME =     0.484
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
```

SYSTEM ELAPSED TIME (SEC)	SYSTEM ELAPSED TIME (SEC)	TIME STP ACTUAL	VOL 1 AVG. PRESS. (PSIA)	VOL 11 AVG. TEMP. (DEG F)	JUN 1 FLOW (LB/SEC)	JUN 21 FLOW (LB/SEC)	JUN 28 FLOW (LB/SEC)	JUN 32 FLOW (LB/SEC)
0.00000E+00	0.00000E+00	0.00000E+00	1.04300E+03	5.47179E+02	3.77000E+01	2.15000E+01	1.99000E+01	0.00000E+00
2.00000E-02	2.00000E-02	8.00000E+00	1.04693E+03	5.47141E+02	4.04348E+01	2.24387E+01	2.27135E+01	1.54247E-01
4.00000E-02	4.00000E-02	1.40000E+01	1.04731E+03	5.47166E+02	4.29126E+01	2.36746E+01	2.39905E+01	2.17208E+00
6.00000E-02	6.00000E-02	2.60000E+01	1.04118E+03	5.47186E+02	4.13807E+01	2.55464E+01	1.98690E+01	6.79546E+00
8.00000E-02	8.00000E-02	4.30000E+01	1.03740E+03	5.47158E+02	3.85677E+01	2.66375E+01	1.49506E+01	1.35176E+01
1.00000E-01	1.00000E-01	5.00000E+01	1.03506E+03	5.47088E+02	3.43239E+01	2.76313E+01	9.45985E+00	2.44332E+01
1.20000E-01	1.20000E-01	5.80000E+01	1.03457E+03	5.46984E+02	3.05494E+01	2.84025E+01	4.91221E+00	4.42071E+01
1.40000E-01	1.40000E-01	6.10000E+01	1.03333E+03	5.46881E+02	2.74743E+01	2.89949E+01	1.23258E+00	6.16884E+01
1.60000E-01	1.60000E-01	6.30000E+01	1.03231E+03	5.46792E+02	2.50022E+01	2.94766E+01	-1.78147E+00	6.69351E+01
1.80000E-01	1.80000E-01	6.60000E+01	1.03136E+03	5.46711E+02	2.31935E+01	2.98398E+01	-4.01541E+00	6.89574E+01
2.00000E-01	2.00000E-01	6.90000E+01	1.03056E+03	5.46639E+02	2.19813E+01	3.01004E+01	-5.54132E+00	6.62697E+01
2.20000E-01	2.20000E-01	7.30000E+01	1.03011E+03	5.46571E+02	2.12640E+01	3.02656E+01	-6.40066E+00	6.31976E+01
2.40000E-01	2.40000E-01	7.70000E+01	1.02998E+03	5.46502E+02	2.10191E+01	3.03388E+01	-6.63027E+00	5.98876E+01
2.60000E-01	2.60000E-01	8.10000E+01	1.02990E+03	5.46432E+02	2.10464E+01	3.03538E+01	-6.49901E+00	5.64799E+01
2.80000E-01	2.80000E-01	8.50000E+01	1.02991E+03	5.46360E+02	2.13905E+01	3.03199E+01	-5.98223E+00	5.31139E+01
3.00000E-01	3.00000E-01	9.00000E+01	1.03020E+03	5.46288E+02	2.23152E+01	3.02238E+01	-4.78055E+00	4.98651E+01
3.50000E-01	3.50000E-01	1.00000E+02	1.03011E+03	5.46129E+02	2.61616E+01	2.98677E+01	-3.08951E-01	4.26690E+01
4.00000E-01	4.00000E-01	1.09000E+02	1.02632E+03	5.45974E+02	2.56050E+01	2.98636E+01	-1.37535E+00	3.70204E+01
4.50000E-01	4.50000E-01	1.16000E+02	1.02295E+03	5.45766E+02	2.19514E+01	2.99117E+01	-5.49452E+00	3.32795E+01
5.00000E-01	5.00000E-01	1.21000E+02	1.02142E+03	5.45573E+02	2.01892E+01	2.97290E+01	-7.08558E+00	3.08633E+01
5.50000E-01	5.50000E-01	1.26000E+02	1.01999E+03	5.45410E+02	1.92971E+01	2.94886E+01	-7.75384E+00	2.90667E+01
6.00000E-01	6.00000E-01	1.30000E+02	1.01848E+03	5.45230E+02	1.88064E+01	2.92477E+01	-8.02274E+00	2.76259E+01
6.50000E-01	6.50000E-01	1.34000E+02	1.01691E+03	5.45064E+02	1.85712E+01	2.90115E+01	-8.08184E+00	2.61816E+01
7.00000E-01	7.00000E-01	1.48000E+02	1.01904E+03	5.44907E+02	1.82280E+01	2.87706E+01	-6.98288E+00	2.54323E+01
7.50000E-01	7.50000E-01	2.34000E+02	1.01581E+03	5.44753E+02	1.90382E+01	2.84774E+01	-6.53370E+00	2.46707E+01
8.00000E-01	8.00000E-01	2.55000E+02	1.01277E+03	5.44645E+02	1.87687E+01	2.82276E+01	-7.27302E+00	2.14095E+01
8.50000E-01	8.50000E-01	2.76000E+02	1.01185E+03	5.44506E+02	1.83779E+01	2.79772E+01	-7.38843E+00	1.44273E+01
9.00000E-01	9.00000E-01	2.96000E+02	1.01066E+03	5.44400E+02	1.82680E+01	2.77403E+01	-7.34686E+00	8.48220E+00
9.50000E-01	9.50000E-01	3.16000E+02	1.00967E+03	5.44279E+02	1.80409E+01	2.74802E+01	-7.32468E+00	7.24952E+00
1.00000E+00	1.00000E+00	3.36000E+02	1.00849E+03	5.44159E+02	1.79685E+01	2.72542E+01	-7.22893E+00	7.60602E+00

5.0 TURBINE TRIP WITHOUT BYPASS WITH POINT KINETICS

The BWR plant modeled for the Turbine Trip Without Bypass (TTWOB) Sample Problem was a General Electric BWR/4. Since not all these plants are the same, the results are not necessarily totally applicable to a specific plant. The initial power level was 104% of normal, with normal core flow and 105% of normal steam flow assumed. End of core life conditions were used to develop the physics parameters including the scram curve worth for the point kinetics models.

The geometric nodalization used in the TTWOB transient analysis sample problem is shown in Figure VII.5-1. The model utilizes 20 control volumes and 26 junctions. The control system requiring modeling for the TTWOB problem includes the turbine stop valve, the safety relief valves, and the feedwater control system. The model is discussed in greater detail in EPRI NP-454.[VII.5-1]

The TTWOB sample problem input is given below. The restart tape created by this sample problem is used by the RESTRT and REEDIT sample problems discussed in Sections VIII and IX. Selected output for this problem is given below.

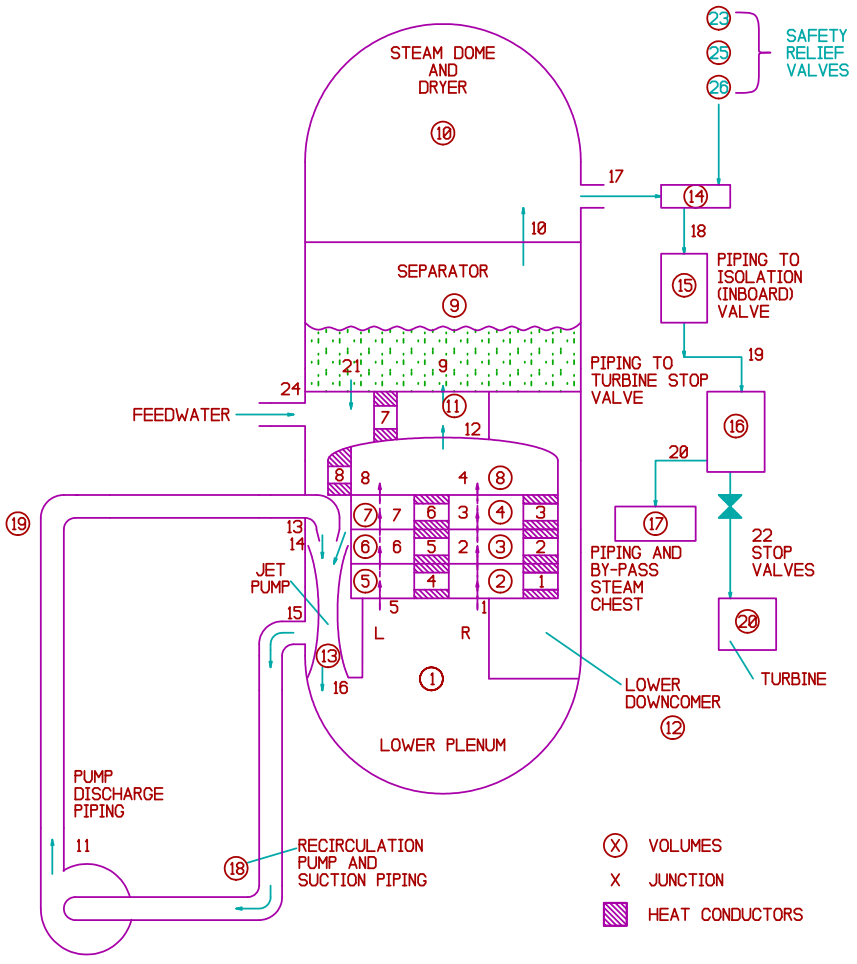


Figure VII.5-1. Schematic Diagram for TTWOB RETRAN Model

```
LISTING OF INPUT DATA FOR CASE  1

    =TTWOB WITH POINT KINETICS - RETRAN-3D SAMPLE PROBLEM
    *
    ********************************************************************************
    *
    *  PROBLEM DIMENSIONS
    *
    *        1     2     3     4     5     6     7     8     9    10    11    12
    *      TAPE PRNPLT  POW   SS  NVOID GENTRN HTMAP SLIP  5EQ  NCOND  NSOL  PNMTH
    010001  -1     0     1     0     0     0     0     3     0     0     2     0
    *
    *
    *10005  POWER
    010005  2533.4
    *
    *  MINOR EDITS
    020000 TIMX  0 NTTS  0
    020001 PRES 10 MIXL  9 PNRM  0
    020002 WP**  1 WP** 15 WP** 16 WP** 17 WP** 24
    020003 REAC  0 RV**  0 RD**  0 RC**  0
    020004 VOIV  4 PRES  4
    *
    *
    * FORMAT FOR TAPE60
    *
    025000 1 1 1
    025001 '(5(1X,1P,E15.7))'
    *
    *
    *3XXX0  RTG  MIN   RST   MAJ  DMP  NCHK  DTMAX   TLAST
    030010  0.   0.05  0.05  2.5  2.5    0   0.001     0.5
    030020  0.   0.05  0.05  2.5  2.5    0   0.001     1.
    030030  0.   0.1   0.1   5.   5.     0   0.05      1.5
    030040  0.   0.1   0.1  15.  15.     0   0.1    1000.
    *
    *
    *  TRIP DATA CARDS
    *    IDTRP IDSIG IX1 IX2 SETPT DELAY  DESCRIPTION
    040010  1   1    0   0    2.    0.    "END OF PROBLEM TIME            "
    040020  1  -2    0   0    1-9   0.    "END OF PROBLEM LOW POWER       "
    040030  2   1    0   0     .001 0.    "TURBINE TRIP    FILL NO.       "
    040040  4   1    0   0     .011  .07  "SCRAM TABLE                     "
    040050  3   1    0   0    0.    0.    "FEEDWATER       FILL NO.       "
    040060  5   1    0   0    1+9   0.    "PUMP                           "
    040070  6   4   14   0 1105.5    .4   "4 S/R VLV 1080PSIG +1%  .4S DEL"
    040080  7   4   14   0 1115.6    .4   "4 S/R VLV 1090PSIG +1%  .4S DEL"
    040090  8   4   14   0 1125.7    .4   "3 S/R VLV 1100PSIG +1%  .4S DEL"
    *
    *
    *  VOLUME DATA
    *5XXX1 BB RD  PRES   TEMP  QUALITY  VOLUME  HEIGHT          VOLUME DATA
    050011  0  0  0.0    0.0     0.     2672.62  17.38         * LOWER PLENUM
    050021  0  0  0.0    0.0     0.      239.48   4.0          * CORE-1
    050031  0  0  0.0    0.0     0.      239.48   4.0          * CORE-2
    050041  0  0  0.0    0.0     0.      239.48   4.0          * CORE-3
    050051  0  0  0.0    0.0     0.      203.12   4.0          * BY PASS-1
    050061  0  0  0.0    0.0     0.      203.12   4.0          * BY PASS-2
    050071  0  0  0.0    0.0     0.      203.12   4.0          * BY PASS-3
    050081  0  0  0.0    0.0     0.      867.58   6.433        * UPPER PLENUM
    050091  1  0  0.0    0.0     0.     2897.55  24.12         * SEPARATORR
    050101  0  0  0.0    0.0     0.     3624.1   17.29         * STEAM DOME-DRY
    050111  0  0  0.0    0.0     0.      211.612  5.484        * STAND PIPES
    050121  0  0  0.0    0.0     0.     3478.28  33.82         * LWR DWNCOMER
    050131  0  0  0.0    0.0     0.      195.36  16.4          * JET PUMPS
    050141  0  0  0.0    0.0     0.      648.3   48.544        * STM LINE TO SR9V
    050151  0  0  0.0    0.0     0.      444.515 17.127        * SR VV TO ISOVVV
    050161  0  0  0.0    0.0     0.     2322.96  42.631        * ISO TO TURB STM
    050171  0  0  0.0    0.0     0.      108.33   3.777        * BYPASS STM CHEST
    050181  0  0  0.0    0.0     0.      541.48  42.175        * RECIRC PMP + SUC
    050191  0  0  0.0    0.0     0.      593.125 51.194        * PUMP DISCHARGE
    050201  0  0  0.0    0.0     0.        1.+9  10.           * TURBINE
    *
    *5XXX2   FLOWL     FLOWA       HDIAM     ELEV   EOVRD
    050012   17.38    153.78       .69        0.          * LOWER PLENUM
    050022    0.0     59.869       .047612   17.38        * CORE-1
    050032    0.0     59.869       .047612   21.38        * CORE-2
    050042    0.0     59.869       .047612   25.38        * CORE-3
    050052    0.0     50.7801      .15208    17.38        * BY PASS
    050062    0.0     50.7801      .15208    21.38        * BY PASS-2
    050072    0.0     50.7801      .15208    25.38        * BY PASS-3
    050082    6.433   89.67      15.29       29.38        * UPPER PLENUM
    050092   24.12   120.13        .552      41.294     * STM DRYER AND SEPARATR
    050102    0.0    265.18      18.38       52.02        * STEAM DOME
    050112    0.0     32.702       .50542    35.81        * STAND PIPES
    050122    0.0     93.34       3.58        9.27        * LWR  DOWNCOMER
    050132    0.0     31.52        .1833      9.27        * JET PUMPS
    050142    0.0     10.1389     1.797       5.6815      * STM LINE TO SRVALVE
    050152    0.0     10.1389     1.797      -9.649       * SR VV TO ISO STLN
    050162    0.0     10.1389     1.797     -37.232       * STMLIN ISO VAL
    050172    0.0      2.0         .797       5.232       * TURB STP VAL
    050182    0.0      7.1489     2.1333    -27.65        * RECIRC PMP + SUCT
    050192    0.0      7.2131     1.0943    -23.32        * PUMP DISCHARGE
    050202    0.0      1.+9       1.+9       -0.5         * TURBINE  2
    *
    *
    *  BUBBLE SEPARATION DATA
    *6XXX1   GRADIENT  VBUB    ZM     WILSON
    060011     .05      0.0    5.13     1
    *
    *
    *  JUNCTION DATA
```

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


```
*8XXXY FM TO PP VV FLOWRATE JNAREA JUNELEVTN INERTIA     *JUNCTION DATA-1
080011  1  2  0  0     0.0  38.8889 17.38     .1433  *LWR PLNM TO CORE V2
080021  2  3  0  0     0.0  38.8889 21.38     .066   *COREV2 TO COREV3
080031  3  4  0  0     0.0  38.8889 25.38     .066   *COREV3 TO COREV4
080041  4  8  0  0     0.0  38.8889 29.38     .051   *COREV4 TO UPPR PLENUM
080051  1  5  0  0     0.0  14.967  17.38     .1497  *LWR PLENUM TO BYPASS-1
080061  5  6  0  0     0.0  50.7801 21.38     .0788  *BYPASS-1 TO BYPASS-2
080071  6  7  0  0     0.0  50.7801 25.38     .0788  *BYPASS-2 TO BYPASS-3
080081  7  8  0  0     0.0  50.7801 29.38     .0574  *BYPASS-3 TO UPR PLENUM
080091 11  9  0  0     0.0  32.702  41.294    .919   *STAND PIPES TO SEPARATOR
080101  9 10  0  0     0.0  99.75   53.       .1     *SEPERATOR TO DRYER
080111 18 19  1  0     0.0   7.1489 -22.25  10.04    *RECIRC PUMP DISCHARGE
080121  8 11  0  0     0.0  32.702  35.81    1.117   *UPPR PLENUM TO STAND PIPES
080131 12 13  0  0     0.0   3.9    25.67    1.57    *LWR DWNCOMER TO JET PUMPS
080141 19 13  0  0     0.0   1.26   25.67    6.78    *RECIRC TO JET PUMPS
080151 12 18 -1  0     0.0   7.1489 13.46    4.54    *LWR DWNCOMER TO RECIRC
080161 13  1  0  0     0.0  31.52    9.27     .6003  *JET PUMPS TO LWR PLENUM4
080171 10 14  0  0     0.0  10.139  53.33    3.183   *STM DOME TO STM LINE
080181 14 15  0  0     0.0  10.139   6.58    5.315   *STM LINE SR TO ISOLATON5VV
080191 15 16  0  0     0.0  10.139  -8.75   13.461   *ISO VV TO TURB STOP VV
080201 16 17  0  0     0.0   2.      5.399  22.549   *STM LINE TO BYPASS STMCCHS
080211  9 12  0  0     0.0  93.     41.3      .8803  *SEP TO LWR DOWNCOMER
080221 16 20  0  4     0.0  10.1389  4.5     11.25    *TURB STOP VLV LEAK
080231  0 14  4  3     0.0    .414  10.39    0.0     *SAFETY RELIEF VLV NEGFFIL
080241  0 12  1  0     0.0   1.     40.29    0.0     *FEEDWATER FILL
080251  0 14  2  1     0.0    .552  10.39    0.0     *SAFETY RELIEF VLV NEG FIL
080261  0 14  3  2     0.0    .552  10.39    0.0     *SAFETY RELIEF VLV NEG FIL
*
*  JUNCTON DATA CARD 2
*8XXX2 FLOSS   RLOSS     JV JC CL MV HDIAMJ  CON IFRJ JTPMJ IHQCOR ISP ANG1 ANG2
080012   0.0    0.0      1 -1  0  0  0.      1.   0     0     1
080022    .893   .893    0 -1  0  0  0.      1.   0     0     1
080032   1.326  1.326    0 -1  0  0  0.      1.   0     0     1
080042    .86    .86     0 -1  0  0  0.      1.   0     0     1
080052   0.0    0.0      0 -1  0  0  0.      1.   0     0     1
080062   6.492  6.492    0 -1  0  0  0.      1.   0     0     1
080072   7.151  7.151    0 -1  0  0  0.      1.   0     0     1
080082  96.09  95.568    0 -1  0  0  0.      1.   0     0     1
080092    .449   .254    0 -1  0  0   .50542 1.  -2     0     0
080102    .648   .958    0 -1  0  0  2.43    1.   0     0     0
080112   0.0    0.0      1 -1  0  0  2.1333  1.   0     0     0
080122    .364   .664    0 -1  0  0   .50542 1.  -2     0     0
080132    .272  1.067    0 -1  0  2   .29    1.   0     0     0
080142   0.0     .686    0 -1  0  2   .2833  1.   0     0     0
080152   1.153  1.153    0 -1  0  0  2.1333  1.   0     0     0
080162    .875   .605    0 -1  0  0  1.42    1.   0     0     0
080172    .81    .81     1 -1  0  0  1.797   1. -99     0     0
080182   1.152  1.152    1 -1  0  0  1.797   1. -99     0     0
080192  10.251  9.991    1 -1  0  0  1.797   1. -99     0     0
080202   2.3    2.3      0 -1  0  0  1.797   1. -99     0     0
080212   1.813  1.413    0 -1  0  0  0.      1. -99     0     0
080222   1.0     .45     1 -1  1 0   0.      1. -99     0     0
080232   0.     0.       1 -1  3  3  0.      1.   0     0     0    0  0. 180.0
080242   0.     0.       1 -1  3  0  0.      1.   0     0     0
080252   0.     0.       1 -1  3  3  0.      1.   0     0     0    0  0. 180.0
080262   0.     0.       1 -1  3  3  0.      1.   0     0     0    0  0. 180.0
*
*
*  PUMP DATA
*90XXY IPC TRP REV ZPH MTQ  RPM  SRO   GPM    HEAD  TORQUE  INERTIA DENS TORKMR
090011  1   5   0   0   0  1665.  1. 90400.   530. 33200. 14059.8   47.2 0. 332.
*
*  PUMP CURVE INDICATOR
*100000  NPC(J)  NC(J)
100000    0    4
*
*  PUMP  HOMOLOGOUS CURVES
*10XYYZ  N  PHD(1) OR PTK(1)  PHD(2) OR PTK(2)
101011  -6  0. 1.36  .265 1.31  .531 1.24  .796 1.13  .885 1.08  1. 1. *HEAD 1
101021  -4  .752 .373  .870 .649  .943 .839  1. 1.                    *HEAD 2
101091  -6  0. 0.  .265 .182  .531 .537 .796 .874  .885 .95  1. 1.    *TORQUE 1
101101  -4  .752 .474  .870 .733  .943 .885  1. 1.                    *TORQUE 2
*
*
*  VALVE DATA
*11XXX0 ICV CV1 CV2 PCV  CV1  CV2  CV3
110010  -6   2   0   0.   0.   0.   0. * 4 S/R VALVES AT 1080 PSIG +1 PCT
110020  -7   3   0   0.   0.   0.   0. * 4 S/R VALVES AT 1090 PSIG +1 PCT
110030  -8   4   0   0.   0.   0.   0. * 3 S/R VALVES AT 1100 PSIG +1 PCT
110040   2   1   0   0.   0.   0.   0. * MSTV
*
*
*  LEAK - AREA VS TIME DATA
*        LEAK DATA   STEAM LINE  MTSV  AREA CLOSURE RATE
*12XXYY PTS TRP PRES    TIME  NORM AREA
120101   3    0.         1.  .1          0.  1.+9        0.   * TURB STOP VALVE
120201   3    0.         0.  .1          1.  1.+9        1.   * S/R VALVE
120301   3    0.         0.  .1          1.  1.+9        1.   * S/R VALVE
120401   3    0.         0.  .1          1.  1.+9        1.   * S/R VALVE
120501  -6    0.          .08333        10.0  .08333
120502   25.6  .500000  40.0 .750000    50.0 1.0       200.0  1.0
*
*
*  FILL TABLE    S/R VALVE  CAPACITY     DIA=5.030 INCH  AREA=0.138  FT*2
*13XXYY PTS TRP JX JY FILTBL(1) FILTBL(2) FILENT(1) FILPRS(1)
130101  -2 1000 -10 0
130102                 100.    100. 405.708 1200. 1000.   1000.  405.708  1200.
130201   2   6   10 0  1044.7 -1547.9 1193. 1011.8 1250.7 -1851.85 1193. 1011.8
130301   2   7   10 0  1044.7 -1547.9 1193. 1011.8 1250.7 -1851.85 1193. 1011.8
130401   2   8   10 0  1044.7 -1547.9 1193. 1011.8 1250.7 -1851.85 1193. 1011.8
*
*
```


PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

```
*  KINETICS CONSTANTS DATA
*14000       B/L
140000     121.826
*
*
*  REACTIVITY COEFFICIENT
*140X0  DENWT   FTWT   ATF  ATW  *********EOC-H*******
* WEIGHTING FACTOR   CORE BYPASS AREA WTNG
*140XX0  DENWT     FTWT     ALPHM    ALPHW
140010  .263849   .413294    0.       0.          *BTM CORE
140020  .273239   .428003    0.       0.          *MID CORE
140030  .101317   .158703    0.       0.          *TOP CORE
140040  .149445  0.          0.       0.          *BTM B.P.
140050  .154764  0.          0.       0.          *MIB B.P.
140060  .057386  0.          0.       0.          *TOP B.P.
*
*  DIRECT MODERATOR HEATING CARDS
*144400X     QPMOD    QDMOD
0144000    .025438  .025438
0144001    .025438  .025438
0144002    .025438  .025438
0144003    .735     .735
0144004    .732     .732
0144005    .691     .691
*
*
*  SCRAM CURVE  EOC -$32.    EOC HALING $40. X 0.8
141001  13  4  0
141002  0. 0.  .2 0.  .564 -.372  .9 -.703  1.267 -1.10  1.633 -1.63  2.  -2.6
141003  2.75 -4.82  3.5 -10.9  4.25 -22.7  5. -31.  5.75 -32.  500. -32.
*
*  DENSITY REACTIVITY  (-15.1 CENT/PERCENT OF VOID CHANGE)
* VOID TIMES 1.3
142001    -8
142002   19.816   -18.46  24.187  -14.04    28.558  -9.88
142003   32.928    -6.5   37.299   -3.64    41.670  -1.56
142004   46.041     0.0   50.0      0.0
*
*
*  DOPPLER TABLE
*143XX PTS   TEMP(F)   REAC($)   TEMP(F)   REAC($)   TEMP(F)   REAC($)
*       DOPPPER COEFFICIENT.... -0.00173 $/F.
143001  6
143002  500.  0.    1000.  -.865     1500.  -1.73     2000.  -2.60
143003 3000. -4.33  5000. -7.79
*
*
*  HEAT CONDUCTOR DATA
*15XX1         IVL IVR IGM  CELEV   IMCL  IMCR  ASUL     ASUR     VOLS
150011   0   2   1  17.38    10     10   0.     16177.86   189.7528
150021   0   3   1  21.38    10     10   0.     16177.86   189.7528
150031   0   4   1  25.38    10     10   0.     16177.86   189.7528
150041   2   5   2  17.38     2      2  4000.63  4000.63    26.6709
150051   3   6   2  21.38     2      2  4000.63  4000.63    26.6709
150061   4   7   2  25.38     2      2  4000.63  4000.63    26.6709
150071  11  12   3  35.81     2      2  1674.78  1822.52    40.925 * STAND PIPES
150081   8  12   4  29.38     2      2   377.1    398.2    188.87  * UPPER PLEN.
*
*15XX2  HDML     HDMR     DHEL     DHER     CHNL     CHNR  IHXQF PFR HTC
150012  0.         .047612   0.         .059211    0.      4.     0
150022  0.         .047612   0.         .059211    0.      4.     0
150032  0.         .047612   0.         .059211    0.      4.     0
150042   .047612   .189472    .243067   .200100    4.      4.     0
150052   .047612   .189472    .243067   .200100    4.      4.     0
150062   .047612   .189472    .243067   .200100    4.      4.     0
150072  0.        2.657      0.        3.2        0.      0.     0
150082  0.         .2367     0.         .5169     0.      0.     0
*
*
*  CORE DATA
*                  N1 = 7  IS AT UO-2 PELLET SURFACE.
*                  N2 = 9  IS AT ZR-2 CLADDING INSIDE SURFACE.
*                  N3 = 11 IS AT A HALF DEPTH OF CLADDING.
*                  EOC  HALING  CORE DATA
*
*16XX0        ISLB   CLDTHK    QFRAC    QFRACR  IRGF IRGL  * LOCATION
160010   1     0.       .372157                      * CORE-1 (BOT)
160020   2     0.       .378722                      * CORE-2 (MID)
160030   3     0.       .230616                      * CORE-3 (TOP)
160040   4     0.       .007017                      * BYPASS-1 (BOT)
160050   5     0.       .007140                      * BYPASS-2 (MID)
160060   6     0.       .004348                      * BYPASS-3 (TOP)
*
*
*  HEAT CONDUCTOR GEOMETRY
*17XYY  IG  NR  IM  NDX   RADDIST   REGWIDTH   PFRACT
170101   2    3   1   6    0.        .02029167  1.     * UO-2 PELLET
170102        1   3   1             5.0-4      0.     * HE GAP
170103        0   2   4              .00266667 0.     * ZIRCALOY-2 CLADDING
170201  1     1   2   3    0.        .00666667  1.     * FUEL CHANNEL WALL (ZRR4)
170301  2     1   4   1     .25271   .02229     0.     * STAND PIPES
170401  2     1   4   1    7.65      .16667     0.     * UPPER PLENUM
*
* NO HEAT GENERATION IN FUEL CHANNEL WALL, USE FOR MODERATOR(CORE BY-PASS)
* DIRECT AND CONDUCTION HEATING.
*
*  THERMAL CONDUCTIVITY DATA
*        THERM COND  U02  REF  GEMP-482 FIG-13  86 W/CM
180101  -11                                        * THERM COND  UO2   1
180102   212.  4.28   392.  3.47   752.  2.66  1112.  2.20 * THERM COND  U02   2
180103  1472.  1.88  1832.  1.62  2192.  1.44  2912.  1.21 * THERM COND  U02   3
180104  3632.  1.16  5072.  1.16              5500.  1.16 * THERM COND  U02   4
```

```
*
*        THERMAL COND  ZR-4  REF  BRASSFIELD(1968)GEMP-482 RECOM... LWR LOCA
180201  -8      0.   8.    1490. 12.32  2150. 17.5          * THERM COND ZR-4   1
180202  2372. 19.7   2552. 21.8   2732. 24.0   3292. 28.9  * THERM COND ZR-4   2
180203  3360. 33.1                                          * THERM COND ZR-4   3
*
*        THERMAL COND HELIUM  REF  THETA1-B EQN
180301   -6                                                 * THERM COND HELIUM 1
180302   100. .0937  1100. .163   2100. .212   3100. .253  * THERM COND HELIUM 2
180303  4100. .289   5100. .322                             * THERM COND HELIUM 3
*
*        THERM CON  SS-304 9REF  NUC SYS MATLS HDBK  PROP CODE 3112 PG 1.0
180401   -2    100. 8.536   1500. 14.62                    * THERM COND  SS-304
*
*        SA-302   REF   TOULOUKIAN
180501 -5   32.  30.  212.  29.5   392.  28.3          * THERMAL COND. SA-3022 1
180502     572.  26.6  752. 24.7                       * THERMAL COND. SA-3022 2
*
*
*  VOLUMETRIC HEAT CAPACITY
*
*        SPEC HEAT  U02  REF  BRASSFIELD(1968)GEMP-482 RECOM...LWR LOCA
*        SPEC HEAT  U02  95 PCT  TH DEN AT 1000F  642 LB/FT3
*        SPEC HEAT  U02  REF  BRASSFIELD(1968)GEMP-482 TOULOUKIAN SAME TO 3750 F
*
190101  -19                                                 * VOL HT CAP U02    1
190102    77. 36.22        100. 37.12        200. 40.05    * VOL HT CAP U02    2
190103   300. 41.98        400. 43.88        600. 45.18    * VOL HT CAP U02    3
190104   800. 46.41       1000. 47.32                      * VOL HT CAP U02    4
190105                                     2400. 50.77    * VOL HT CAP U02    5
190106  2600. 51.43       2800. 52.61       3000. 54.57    * VOL HT CAP U02    6
190107  3200. 57.42       3400. 61.23       3600. 65.93    * VOL HT CAP U02    7
190108  4600. 95.15       4800. 99.31       5000. 101.57   * VOL HT CAP U02    8
190109  5074. 101.76                                       * VOL HT CAP UO2    9
*
*  ACTIVATE FUEL ENTHALPY EDIT
*
*      NRO  TEMP (F)    DENSITY      DESCRIPTION
1190101 -3   500.0       645.43     * DENSITY UO2 - LB/FT^3
1190102      1200.0      685.49
1190103      2240.0      655.77
*
*        SPEC HEAT  ZR-2   REF BMI-1803 ELDR1DGE ET AL (1967)             DEN 4
190201   15                                          * VOL HT CAP  ZR-2       1
190202    32.  28.75     932.  32.56    1112.  34.40  * VOL HT CAP  ZR-2       2
190203  1184.  35.22    1490.  35.22    1508.  49.14  * VOL HT CAP  ZR-2       3
190204  1544.  57.74    1580.  60.20    1616.  70.43  * VOL HT CAP  ZR-2       4
190205  1652.  79.85    1688.  75.35    1724.  59.38  * VOL HT CAP  ZR-2       5
190206  1760.  45.86    1787.  34.81    3300.  34.81  * VOL HT CAP  ZR-2       6
*
*        SPEC HEAT  HELIUM  REF  KREITH  AT 1 ATM  DEN 0.012 LB/FT3
190301  -2      32. .0149       3400. .0149              * VOL HT CAP HELIUM 1
*
*        SPEC HEAT  SS-304  REF  NUC SYS MATLS HDBK     DENSITY = 494 LB/FT3 AT
190401  -12                                               * VOL HT CAP SS-3UU 1
190402   100. 54.74    150. 56.51    200. 58.             * VOL HT CAP SS-3UU 2
190403   300. 54.43    400. 62.      600. 64.02           * VOL HT CAP SS-3U4 3
190404   800. 65.36   1000. 66.94   1200. 69.11           * VOL HT CAP SS-3UU 4
190405  1400. 71.63   1450. 72.27   1500. 72.87           * VOL HT CAP SS-3UU 5
*
190501 -7   130. 56.9   350. 60.8    450. 62.3         * VOL. HT. CAP. SA-302  1
190502      530. 65.2   620. 67.2    710. 70.2         * VOL. HT. CAP. SA-3022 2
190503      800. 77.5                                  * VOL. HT. CAP. SA-3022 3
*
*
*  COEF OF LINEAR THERMAL EXPANSION
*
*        THERM EXPAN COEF  U02  REF  GEMP-482
200101  -2   0. 3.72-6   4082. 11.0-6                    * EXPAN COEF  U02   1
*
*        THERM EXPAN COEF  ZR-4  REF  GEMP-482 (1968)
200201   -4                                              * THERM EXPAN ZR-4  1
200202     0.  3.10-6   1580.  4.64-6   1584.  5.4-6     * THERM EXPAN ZR-44 2
200203  3400.  5.40-6                                    * THERM EXPAN ZR-44 3
*
*        THERM EXPAN COEF  HELIUM
200301  -2     0. 0.    1+9 0.                          * THER EXPAN  ZR-44
*
*        THERM EXPAN COEF  SS-304
200401  -2     0. 0.   2650. 0.                         * THER EXPAN  SS-T04
*
200501  -2     0. 0.  10000. 0.              * THERMAL EXP. DUMMY CSSTEL
*
*
*  STEADY STATE CONVERGENCE CARD
*      LCOUNT
230000   -50   0.0
*
*
*  POWER BALANCE CARD
*    ISGNUM  JBIAS  JBAL  POWF
230011  0    24     22    1.0
*
*
*  VOLUME INITIAL CONDITIONS
*
*       LVOL   PRES     TEMP    ENTH      X   XNC
231001    1     0.0       0.    526.350   0.    0.
231009    9     0.0       0.      0.     -1.    0.
231013   13  1057.5       0.      0.      0.    0.
231019   19  1181.119     0.      0.      0.    0.
231020   20     0.0       0.   1189.66    0.    0.
```

```
*
*
*  JUNCTION INITIAL CONDITIONS
*
*        JUN  JESTW    WP    SPLTV1    SPLTV2
232001    1     1    20011.45
232005    5     1     1377.44
232009    9     0    21388.89
232010   10     0     3054.1
232011   11     1     9500.
232012   12     0    21388.89
232013   13     0    11888.89
232014   14     1     9500.
232015   15     0     9500.
232016   16     0    21388.89
232017   17     0     3054.1
232021   21     0    18334.79
232022   22     0     3054.1
*
*
*  SEPARATOR MODEL INPUT
*     ISEV JIN JSTM JRSC IUDC ZVAN COVI XIND  ZMD  ICO1 ICO2 ICU1 ICU2
600010 9    9   10   21    9  0.0  0.01 0.12  5.13   0    0    0    0
*
*
*  NON-EQUILIBRIUM VOLUME DATA
*61XXXY  NEQVOL  SEPFG  VRAIN  IHTC  VLHTC
*610090      9      1     0.0    0     0.0
*61XXXY  NEQVOL  SEPFG   NNODEP  IHTC  CFCV/CONST CTRB  VRAIN
611090      9      1     0       1     0.0        0.0    0.0
*
*
*  FEEDWATER  CONTROL  SYSTEM
701000    4    10
*702XXX    IDC    VAR    REG   GAIN    CIC
702001      1      LIQL,  9    8.00    39.78      * LIQUID  LEVEL  VOL 9
702002      2      WP**, 17    0.012   36.649     * STEAM  FLOW
702003      3      WP**, 24    0.012   36.649     * FEEDWATE FLOW
702004      4      CONS,  0    1.0      1.0       * SETPOINT CONSTANT
*703XXX   IDC ITYPE  INC1  INC2   CGAIN   CP1   CP2    CIC     CMIN    CMAX
703001    -1   SUM,    1    -2     1.0    1.0   1.0   39.78
703002    -2   SUM,    2     3     0.8   -1.0   1.0    0.0    -32.0    32.0
703003    -3   SUM,   -1     4     1.0    1.0 -39.78   0.0
703004    -4   LLG,   -3     0    -1.67   0.6   6.0    0.0
703005    -5   INT,   -4     0     0.025  0.0   0.0    0.0    -15.6    24.4
703006    -6   SUM,   -5    -4     1.0    1.0   1.0    0.0    -50.0    50.0
703007    -7   SUM,   -6     4     1.0    1.0  44.747 44.747    0.0    50.0
703008    -8   DLY,   -7    10     1.0    0.2   0.0   44.747    0.0    50.0
703009    -9   FNG,   -8     5  3515.81   0.0   0.0 3054.1    292.98 3515.81
703010   -10   VLM,   -9     0     1.0  732.5 732.5 3054.1    292.98 3515.81
*
*  AUX DNB DATA CARDS
*
800100    2      0         0    4         0       13       3
800200  1.03   1.40      1.0  1.0       1.0     5.0     11.0
800300  0.0615 0.04692   0.047612       0.0     0.956057
800400  0.0    0.0       0.08333        1.081904 .16667  1.25934 0.25 1.267476
800401  0.3333 1.238666  0.41667 1.203747  0.5  1.166797 0.58333 1.113869
800402  0.6667 1.039859  0.75 0.934232  0.83333 0.76685  0.91667 0.498281
800403  1.0    0.0
800500  2  3  4
*
*
. END
```

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page    1
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:19
 TTWOB WITH POINT KINETICS - RETRAN-3D SAMPLE PROBLEM                                                           CPU TIME =    0.031
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *

RETRAN PROBLEM CONTROL AND DESCRIPTION DATA.

    WORD  DESCRIPTION
    ====  ==================================================================
      1   RESTART FILE OPTION (SAVE=-1 / NO SAVE=0) .................... =   -1
      2   PRINTER PLOT OPTION (YES=1 / NO=0) ........................... =    0
      3   POWER OPTION (TAPE OPTNS<0 / NO/TBL=0 / PT KIN=1 / 1D=2 / 3D=3) =    1
      4   USE STEADY-STATE SOLUTION (YES=0 / NO=1) ..................... =    0
      5   USE NEUTRON VOID MODEL (YES=1 / NO=0) ........................ =    0
      6   USE GENERALIZED TRANSPORT MODEL (NO=0 / VAP=1 / LIQ=-1) ....... =    0
      7   HEAT TRANSFER MAP OPTION (FORCED=0 / NAT CONV=1) ............. =    0
      8   SLIP OPTION (DYN=1 / Z-L=2 / C-L=3 / Z-L TAUGL=4 / C-L TAUGL=5) =    3
      9   FIVE-EQUATION OPTION (NO= 0 / YES=1) ......................... =    0
     10   NONCONDENSABLE GAS FLOW OPTION (NO=0 / YES=1) ................ =    0
     11   TH MATRIX DIRECT SOLVER OPTION (4-EQ=2 / 6-EQ=3) ............. =    2
     12   TH MATRIX ITERATIVE SOLVER OPTION (NO<=1 / YES=2) ............ =    0

    (DIMENSIONS AND OPTIONS AUTOMATICALLY DETERMINED BY CONTENT OF INPUT DATA)

          NUMBER OF MINOR EDIT SETS (0200XX DATA )...................... =   16
          NUMBER OF TIME-STEP CONTROL SETS (03XXX0 DATA )............... =    4
          NUMBER OF TRIP CONTROL SETS (04XXX0 DATA ).................... =    9
          NUMBER OF CONTROL VOLUME DESCRIPTIONS (05XXXY DATA )........... =   20
          NUMBER OF BUBBLE RISE DESCRIPTIONS (060XXY DATA) ............. =    1
          NUMBER OF TIME DEPENDENT VOLUMES FORM CARDS (07XXYY DATA) ..... =    0
          NUMBER OF JUNCTION DESCRIPTIONS (08XXXY DATA) ................ =   26
          NUMBER OF CENTRIFUGAL PUMP DESCRIPTIONS (090XXY DATA )......... =    1
          NUMBER OF VALVE DESCRIPTIONS (11XXXY DATA) ................... =    4
          NUMBER OF GENERAL DATA TABLE DESCRIPTIONS (12XXYY DATA) ....... =    5
          NUMBER OF FILL DESCRIPTIONS (13XXYY DATA )..................... =    4
          NUMBER OF HEAT CONDUCTOR DESCRIPTIONS (15XXXY DATA) ........... =    8
          NUMBER OF HEAT CONDUCTOR GEOMETRY DESCRIPTIONS (17XXYY DATA) .. =    4
          NUMBER OF HEAT CONDUCTOR MATERIAL DESCRIPTIONS (18XXYY DATA) .. =    5
          NUMBER OF CORE SECTION DESCRIPTIONS (16XXXY DATA) ............ =    6
          NUMBER OF NON-CONDUCTNG HEAT EXCHNGR DESCRIPTIONS (21XXYY DATA) =    0
          NUMBER OF TIME DEP BCS FROM TAPE (IREAD<0 ON 05XXXY DATA) ..... =    0
          NUMBER OF SPECIFIED HEAT TRAN COEF DESCRIPTIONS (015XXX DATA) . =    0
          TWO-REGION NONEQ VOL DESCRIPTIONS (610XXX OR 611XXX DATA) ..... =    1
          TEMP. TRANSPORT DELAY OPTION (MESH>0 ON 05XXXY DATA) .......... =    0
          AUXILIARY DNB MODEL (8001XX DATA INCLUDED) ................... =    1
          CONTROL SYSTEM MODEL (702XXX OR 702XXXX DATA) ................ =    1
          ACCUMULATOR MODEL DESCRIPTIONS (620XXX OR 621XXX DATA)......... =    0
          DYNAMIC GAP CONDUCTANCE MODEL DESCRIPTIONS (225XX0 DATA) ...... =    0
          NUMBER OF HT CONDUCTOR STACK DESCRIPTIONS (2200XY DATA) ....... =    0
          NUMBER OF TURBINE SHAFT DESCRIPTIONS (500XXY DATA) ........... =    0
          NUMBER OF PROFILE FIT DESCRIPTIONS (061XX1 DATA) ............. =    0
          NUMBER OF STEAM-WATER SEPARATOR DESCRIPTIONS (60XXX0 DATA) .... =    1


                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * *                                                  * * *
                   * * *           STEADY-STATE OPTION    =   0           * * *
                   * * *                                                  * * *
                   * * *           SLIP OPTION            =   3           * * *
                   * * *                                                  * * *
                   * * *           NUMERICS OPTION        =   2           * * *
                   * * *                                                  * * *
                   * * *           HEAT TRANSFER OPTION   =   0           * * *
                   * * *                                                  * * *
                   * * *           NEW EQUATIONS OPTION   =   0           * * *
                   * * *                                                  * * *
                   * * *          USING THE 4-EQ SOLVER - SOLVE3          * * *
                   * * *                                                  * * *
                   * * *      USING STANDARD STEADY-STATE SOLUTION        * * *
                   * * *                                                  * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *


INITIAL THERMAL POWER (MEGAWATTS) =  2.53340E+03


AIR IS THE DEFAULT NONCONDENSABLE GAS.
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PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   42
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:19
 TTWOB WITH POINT KINETICS - RETRAN-3D SAMPLE PROBLEM                                                           CPU TIME =    0.078
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  NORMALIZED    CORE         THERMAL      ENERGY       TOTAL MASS   NCG MASS     AVERAGE      CURRENT      ELAPSED     TIME STEP NUM
  CORE          POWER        POWER        BALANCE      BALANCE      BALANCE      TIME STEP    TIME STEP    TIME        STANDRD/ACTUL
  POWER         (MW)         (BTU/HR)     (BTU)        (LBM)        (LBM)        (SEC)        (SEC)        (SEC)                   0
  1.00000E+00   2.53340E+03  8.67334E+09  2.36764E+12  2.13941E+09  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00             0

VOLUME          AVG. PRES.   TOT. MASS    AVG. ENTH.   AVG. DEN.    AVG. TEMP.   AVG. QUAL.   VOID FRAC.   POWR TO H2O
NUMBER          (PSIA)       (LB)         (BTU/LB)     (LB/FT3)     (DEG. F)                               (BTU/SEC)
     1          1.05977E+03  1.26720E+05  5.26350E+02  4.74142E+01  5.31475E+02  0.00000E+00  0.00000E+00  0.00000E+00
     2          1.03384E+03  1.08182E+04  5.48511E+02  4.51739E+01  5.48261E+02  1.20833E-03  2.36212E-02  8.94189E+05
     3          1.03103E+03  5.51125E+03  5.81407E+02  2.30134E+01  5.47926E+02  5.29153E-02  5.28575E-01  9.11590E+05
     4          1.02704E+03  4.03092E+03  6.05560E+02  1.68320E+01  5.47448E+02  9.12273E-02  6.69380E-01  5.55446E+05
     5          1.02890E+03  9.56124E+03  5.32344E+02  4.70719E+01  5.36198E+02  0.00000E+00  0.00000E+00  1.65122E+04
     6          1.02759E+03  9.43075E+03  5.43846E+02  4.64295E+01  5.45233E+02  0.00000E+00  0.00000E+00  1.51753E+04
     7          1.02632E+03  8.96130E+03  5.48231E+02  4.41183E+01  5.47361E+02  2.54401E-03  4.89653E-02  8.89185E+03
     8          1.02457E+03  1.34178E+04  6.13230E+02  1.54657E+01  5.47151E+02  1.03623E-01  7.00489E-01 -9.71613E+01
     9 LIQ REG  1.01936E+03  2.69705E+04  5.47482E+02  4.37641E+01  5.46523E+02  3.02561E-03  7.99303E-01  0.00000E+00
       VAP REG               5.23962E+03  1.18574E+03  2.29679E+00  5.46523E+02  9.90000E-01               0.00000E+00
    10          1.01948E+03  8.32486E+03  1.18574E+03  2.29708E+00  5.46538E+02  9.90007E-01  9.99505E-01  0.00000E+00
    11          1.01992E+03  3.25469E+03  6.12838E+02  1.53805E+01  5.46592E+02  1.03972E-01  7.02498E-01 -2.30398E+03
    12          1.02604E+03  1.64916E+05  5.26001E+02  4.74130E+01  5.31144E+02  0.00000E+00  0.00000E+00  2.40114E+03
    13          1.05750E+03  9.26257E+03  5.26350E+02  4.74128E+01  5.31471E+02  0.00000E+00  0.00000E+00  0.00000E+00
    14          1.01175E+03  1.47732E+03  1.18574E+03  2.27876E+00  5.45603E+02  9.89583E-01  9.99488E-01  0.00000E+00
    15          1.00644E+03  1.00734E+03  1.18574E+03  2.26617E+00  5.44957E+02  9.89294E-01  9.99478E-01  0.00000E+00
    16          9.60100E+02  5.00999E+03  1.18574E+03  2.15673E+00  5.39207E+02  9.86894E-01  9.99396E-01  0.00000E+00
    17          9.64096E+02  2.34657E+02  1.18574E+03  2.16614E+00  5.39710E+02  9.87093E-01  9.99402E-01  0.00000E+00
    18          1.11532E+03  2.56788E+04  5.26786E+02  4.74234E+01  5.31910E+02  0.00000E+00  0.00000E+00  7.45813E+03
    19          1.18112E+03  2.81509E+04  5.26786E+02  4.74619E+01  5.32012E+02  0.00000E+00  0.00000E+00  0.00000E+00
    20          9.57778E+02  2.13894E+09  1.18966E+03  2.13894E+00  5.38913E+02  9.92734E-01  9.99668E-01  0.00000E+00

JUNCTION    CONNECTS     CHOK/ JUN. FLOW    JUN. ENTH.   JUN. SPVL.   P  R  E  S  S  U  R  E    D  I  F  F  E  R  E  N  T  I  A  L  S
NUMBER      VOLUMES      PATH  (LB/SEC)     (BTU/LB)     (FT3/LB)     VEL. PSI     ELEV. PSI    FRIC. PSI    ACCL. PSI    PUMP PSI
     1        1 TO      2      2.00115E+04  5.26350E+02  2.10907E-02 -3.60807E-01 -3.48873E+00 -2.20841E+01 -7.32034E-09  0.00000E+00
     2        2 TO      3      2.00115E+04  5.65602E+02  3.30487E-02 -3.97154E-01 -9.47046E-01 -1.46724E+00 -2.46072E-08  0.00000E+00
     3        3 TO      4      2.00115E+04  5.96830E+02  5.33228E-02 -4.02603E-01 -5.53408E-01 -3.03080E+00 -1.44930E-08  0.00000E+00
     4        4 TO      8      2.00115E+04  6.14301E+02  6.50233E-02  3.07020E-01 -5.79233E-01 -2.20202E+00  2.89706E-08  0.00000E+00
     5        1 TO      5      1.37744E+03  5.26350E+02  2.10907E-02  3.70285E-02 -3.51509E+00 -2.73928E+01 -4.38081E-11  0.00000E+00
     6        5 TO      6      1.37744E+03  5.38338E+02  2.13946E-02 -9.16953E-05 -1.29863E+00 -1.19231E-02 -5.18724E-10  0.00000E+00
     7        6 TO      7      1.37744E+03  5.47518E+02  2.20882E-02 -1.95430E-04 -1.25761E+00 -1.35396E-02 -1.19132E-09  0.00000E+00
     8        7 TO      8      1.37744E+03  5.49012E+02  2.31686E-02 -6.17734E-01 -9.58209E-01 -1.77330E-01 -1.50285E-09  0.00000E+00
     9       11 TO      9      2.13889E+04  6.12838E+02  6.50175E-02  2.99433E+00 -1.96250E+00 -1.60150E+00  8.83940E-09  0.00000E+00
    10        9 TO     10      3.05410E+03  1.18574E+03  4.35391E-01  2.77250E-01 -1.16626E-01 -3.61521E-02 -4.14932E-11  0.00000E+00
    11       18 TO     19      9.50000E+03  5.26786E+02  2.10866E-02  7.53022E-02 -2.91766E+00 -1.89627E+01  1.06780E-08  8.76006E+01
    12        8 TO     11      2.13889E+04  6.13230E+02  6.46591E-02 -2.73750E+00 -6.38003E-01 -1.26472E+00 -5.14690E-09  0.00000E+00
    13       12 TO     13      1.18889E+04  5.26001E+02  2.10913E-02 -1.42094E+00  2.86782E+00 -5.81919E+00 -6.24615E-10  3.58358E+01
    14       19 TO     13      9.50000E+03  5.26786E+02  2.10695E-02  6.31313E+00 -5.01036E+00 -4.88114E+01  2.25292E-09 -7.61103E+01
    15       12 TO     18      9.50000E+03  5.26001E+02  2.10913E-02 -3.98059E+00  1.07821E+01 -5.11517E+00  1.70960E-08  8.76006E+01
    16       13 TO      1      2.13889E+04  5.26350E+02  2.10913E-02  4.91656E-01  2.89087E+00 -1.11134E+00 -9.84730E-10  0.00000E+00
    17       10 TO     14      3.05410E+03  1.18574E+03  4.35335E-01 -4.29100E+00  4.86934E-01 -3.92105E+00  1.79944E-10  0.00000E+00
    18       14 TO     15      3.05410E+03  1.18574E+03  4.38835E-01 -5.81603E-02  4.90513E-01 -5.74679E+00  5.24639E-11  0.00000E+00
    19       15 TO     16      3.05410E+03  1.18574E+03  4.41274E-01 -2.43152E-01  2.27953E-01 -4.63248E+01  4.41881E-10  0.00000E+00
    20       16 TO     17      0.00000E+00  1.18574E+03  4.61652E-01  4.34084E+00 -3.45144E-01  0.00000E+00 -1.34037E-10  0.00000E+00
    21        9 TO     12      1.83348E+04  5.47379E+02  2.27832E-02  2.28122E-01  6.64616E+00 -1.92960E-01 -1.87637E-09  0.00000E+00
    22       16 TO     20      3.05410E+03  1.18574E+03  4.63666E-01  4.32111E+00 -3.05783E-01 -6.33774E+00 -6.62295E-11  0.00000E+00
    26        0 TO     14      0.00000E+00  1.18574E+03  4.38835E-01  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
    25        0 TO     14      0.00000E+00  1.18574E+03  4.38835E-01  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
    24        0 TO     12      3.20872E+03  3.96877E+02  1.89228E-02  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
    23        0 TO     14      0.00000E+00  1.18574E+03  4.38835E-01  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00

JUNCTION  FLOW  SLIP VEL.    VOID         LIQUID FLOW  GAS FLOW     SLIP CNVCTN  GAS VEL.     LIQ. VEL.    VG/VL        SLIP ACCEL.
NUMBER    REG.  (FT/SEC)     FRACTION     (LB/SEC)     (LB/SEC)     (BTU/SEC)    (FT/SEC)     (FT/SEC)                  (FT/SEC**2)
     2       0 -5.31646E+00  3.63383E-01  1.92873E+04  7.24145E+02  1.08691E+05  2.21751E+01  1.68587E+01  1.31535E+00  2.34327E-07
     3       0 -1.18577E+01  6.25542E-01  1.78601E+04  2.15131E+03  3.95373E+05  3.83853E+01  2.65276E+01  1.44700E+00  3.37938E-07
     4       0 -1.66101E+01  7.02421E-01  1.69830E+04  3.02847E+03  6.01202E+05  4.83294E+01  3.17194E+01  1.52366E+00 -1.32017E-06
     7       0 -1.49818E+00  2.24829E-02  1.37195E+03  5.49169E+00  2.52985E+03  2.09563E+00  5.97449E-01  3.50762E+00  3.25727E-07
     8       0 -1.76941E+00  7.07117E-02  1.35776E+03  1.96813E+01  9.36323E+03  2.39122E+00  6.21817E-01  3.84554E+00  7.39444E-07
     9      -2 -1.81379E+01  7.02498E-01  1.83151E+04  3.07375E+03  5.49522E+05  5.87771E+01  4.06392E+01  1.44632E+00 -1.21910E-08
    12      -2 -1.79160E+01  7.00489E-01  1.83309E+04  3.05804E+03  5.43446E+05  5.83501E+01  4.04340E+01  1.44309E+00 -8.67002E-09

  BUBL          BUBBLE       BUBBLE       MIXTURE      MIXTURE      BUBBLE
  SET    VOL.   GRADIENT     VELOCITY     LEVEL        QUALITY      MASS
  NUMB.  NUMB.  PARAMETER    (FT/SEC)     (FT)                      (LB)
     1      9   5.00000E-02  0.00000E+00  5.13000E+00  3.02561E-03  8.16022E+01

  PUMP   VOL.   PUMP SPEED   NORM. PUMP   NORM. FRIC.  NORM. MOT.   POWER TO H2O
  NUMB.  NUMB.  (RPM)        TORQUE       TORQUE       TORQUE       (BTU/HR)
     1     18   1.66500E+03  1.00237E+00  1.00000E+00  1.00000E+00  2.68493E+07

 HEAT COND.   VOL. HT TRAN   SURF. FLUX   CRIT. FLUX   H.T. COEF.   SURF. TEMP.  MASS FLUX    STORD ENRGY  POWR TO H2O  DRYOUT PNT
 NUMBER       NUM. MODE-COR  (BTU/HR-FT2) (BTU/HR-FT2) (BTU/H-F2-F) (DEG. F)     (LBM/HR-FT2) (BTU)        (BTU/HR)     ()
     1 RGHT      2    2-THOM  1.93845E+05  7.98792E+05  1.38911E+04  5.62216E+02  1.20331E+06  1.26583E+07  3.13600E+09
     2 RGHT      3    2-THOM  1.97265E+05  7.47085E+05  1.39818E+04  5.62034E+02  1.20331E+06  1.27957E+07  3.19132E+09
     3 RGHT      4    2-THOM  1.20121E+05  7.08773E+05  1.08761E+04  5.58492E+02  1.20331E+06  9.59717E+06  1.94330E+09
     4 LEFT      2    2-THOM  3.07076E+02  1.24553E+06  5.52881E+02  5.48817E+02  1.20331E+06               1.22849E+06
       RGHT      5    1-DB-L  3.71184E+03  1.40590E+05  3.24606E+02  5.47633E+02  9.76521E+04  4.52510E+05  1.48497E+07
     5 LEFT      3    2-THOM  1.77592E+03  1.06188E+06  1.32663E+03  5.49264E+02  1.20331E+06               7.10479E+06
       RGHT      6    2-THOM  2.35974E+03  1.37927E+05  6.16336E+02  5.49061E+02  9.76521E+04  4.53347E+05  9.44045E+06
     6 LEFT      4    2-THOM  1.39585E+03  1.06188E+06  1.17243E+03  5.48639E+02  1.20331E+06               5.58429E+06
       RGHT      7    2-THOM  1.50790E+03  1.36082E+05  1.21788E+03  5.48600E+02  9.76521E+04  4.52808E+05  6.03255E+06
     7 LEFT     11    1-DB-L -4.95249E+03  3.06876E+05  4.94470E+03  5.45591E+02  2.35460E+06              -8.29434E+06
       RGHT     12    1-DB-L  4.55107E+03  2.26174E+05  1.05119E+03  5.35473E+02  8.24941E+05  1.40263E+06  8.29434E+06
     8 LEFT      8    1-DB-L -9.27555E+02  9.00000E+04  1.11582E+03  5.46320E+02  8.58704E+05              -3.49781E+05
       RGHT     12    1-DB-L  9.07777E+02  2.11828E+05  1.70499E+03  5.31676E+02  8.24941E+05  6.45414E+06  3.49781E+05

  CORE   COND.  DEPTH REAC.  DEPTH REAC.  HEAT GEN.    COND. HEAT-  DIR. MODER-  AVG. METAL   CENTERLINE   FUEL
  NUMB.  NUMB.  EXT. ZR-H2O  INT. ZR-H2O  ZR-H2O       ING RATE     ATOR HT RT   TEMPERATURE  TEMPERATURE  ENTHALPY
                (FT)         (FT)         (BTU/HR)     (BTU/HR)     (BTU/HR)     (DEG. F)     (DEG. F)     (CAL/GM)
     1      1   0.00000E+00  0.00000E+00  0.00000E+00  3.13600E+09  8.18558E+07  1.70250E+03  2.42734E+03  6.36524E+01
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      2       2   0.00000E+00  0.00000E+00  0.00000E+00  3.19132E+09  8.32997E+07  1.72020E+03  2.46325E+03  6.43836E+01
      3       3   0.00000E+00  0.00000E+00  0.00000E+00  1.94330E+09  5.07239E+07  1.29801E+03  1.66745E+03  4.70135E+01
      4       4   0.00000E+00  0.00000E+00  0.00000E+00  1.60782E+07  4.45943E+07  5.48432E+02
      5       5   0.00000E+00  0.00000E+00  0.00000E+00  1.65452E+07  4.51907E+07  5.49376E+02
      6       6   0.00000E+00  0.00000E+00  0.00000E+00  1.16168E+07  2.59781E+07  5.48769E+02
0        AVERAGE CORE            MINIMUM  HEIGHT              HOT  SPOT                    MINUMUM DNBR POSITION
          (RETRAN)               (HOT CHANNEL)              (HOT CHANNEL)                    (HOT CHANNEL)
   LHGR(KW/FT)      DNBR      LHGR(KW/FT)      DNBR      LHGR(KW/FT)      DNBR      POS. (FT)    LHGR(KW/FT)  MDNBR
   7.70004E+00  4.41024E+00  1.27784E+01  1.67871E+00  1.34549E+01  0.00000E+00  8.00000E+00  1.10390E+01  1.53909E+00

  REACTOR      FISSION      DECAY HEAT   TOTAL        CONTROL      COOL. TEMP.  VOID         FUEL TEMP.   DOPPLER
  PERIOD       POWER        POWER        REACTIVITY   REACTIVITY   REACTIVITY   REACTIVITY   REACTIVITY   REACTIVITY
  (SEC)                                  ($)          ($)          ($)          ($)          ($)          ($)
  0.00000E+00  1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00


  DATA RECORD NUMBER     1 WAS WRITTEN TO UNIT 14
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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE -- NRC APPROVED VERSION 29/08/14 Page 49
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis 11:57:20
TTWOB WITH POINT KINETICS - RETRAN-3D SAMPLE PROBLEM CPU TIME = 0.499
* *

NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	ENERGY BALANCE (BTU)	TOTAL MASS BALANCE (LBM)	NCG MASS BALANCE (LBM)	AVERAGE TIME STEP (SEC)	CURRENT TIME STEP (SEC)	ELAPSED TIME (SEC)	TIME STEP NUM STANDRD/ACTUL
4.91152E-01	1.24428E+03	4.27369E+09	2.36764E+12	2.13942E+09	0.00000E+00	2.00000E-02	1.70708E-02	2.00000E+00	1015 / 1105

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	VOID FRAC.	POWR TO H2O (BTU/SEC)
1	1.22767E+03	1.26885E+05	5.27032E+02	4.74760E+01	5.32281E+02	0.00000E+00	0.00000E+00	0.00000E+00
2	1.19986E+03	1.10235E+04	5.52760E+02	4.60310E+01	5.52462E+02	0.00000E+00	0.00000E+00	9.95696E+05
3	1.19735E+03	6.40995E+03	5.98375E+02	2.67661E+01	5.66656E+02	4.38292E-02	4.30068E-01	1.00913E+06
4	1.19377E+03	4.39366E+03	6.28293E+02	1.83467E+01	5.66275E+02	9.33168E-02	6.29796E-01	6.06807E+05
5	1.19586E+03	9.55649E+03	5.34631E+02	4.70485E+01	5.38288E+02	0.00000E+00	0.00000E+00	1.09778E+04
6	1.19455E+03	9.41817E+03	5.46843E+02	4.63675E+01	5.47873E+02	0.00000E+00	0.00000E+00	1.16828E+04
7	1.19325E+03	9.35520E+03	5.52226E+02	4.60575E+01	5.52038E+02	0.00000E+00	0.00000E+00	7.76789E+03
8	1.19155E+03	1.43482E+04	6.38477E+02	1.65382E+01	5.66038E+02	1.10334E-01	6.72679E-01	-2.03636E+03
9 LIQ REG	1.18847E+03	2.42112E+04	5.60856E+02	4.55462E+01	5.58632E+02	0.00000E+00	8.16544E-01	0.00000E+00
VAP REG		6.27387E+03	1.19253E+03	2.65171E+00	5.69773E+02	1.00000E+00		0.00000E+00
10	1.18961E+03	9.48510E+03	1.19776E+03	2.61723E+00	5.73168E+02	1.00000E+00	1.00000E+00	0.00000E+00
11	1.18893E+03	3.52473E+03	6.37237E+02	1.66566E+01	5.65758E+02	1.08827E-01	6.69929E-01	-1.12525E+04
12	1.19604E+03	1.64916E+05	5.27866E+02	4.74132E+01	5.32900E+02	0.00000E+00	0.00000E+00	2.29694E+03
13	1.22559E+03	9.27079E+03	5.27407E+02	4.74549E+01	5.32579E+02	0.00000E+00	0.00000E+00	0.00000E+00
14	1.18642E+03	1.68752E+03	1.19880E+03	2.60299E+00	5.73433E+02	1.00000E+00	1.00000E+00	0.00000E+00
15	1.18719E+03	1.15536E+03	1.19960E+03	2.59915E+00	5.74060E+02	1.00000E+00	1.00000E+00	0.00000E+00
16	1.18741E+03	5.98925E+03	1.20272E+03	2.57828E+00	5.76199E+02	1.00000E+00	1.00000E+00	0.00000E+00
17	1.18737E+03	2.78985E+02	1.20314E+03	2.57532E+00	5.76487E+02	1.00000E+00	1.00000E+00	0.00000E+00
18	1.28500E+03	2.57079E+04	5.27643E+02	4.74771E+01	5.32860E+02	0.00000E+00	0.00000E+00	7.48409E+03
19	1.35004E+03	2.81878E+04	5.27468E+02	4.75242E+01	5.32822E+02	0.00000E+00	0.00000E+00	0.00000E+00
20	9.57778E+02	2.13894E+09	1.18966E+03	2.13894E+00	5.38913E+02	9.92734E-01	9.99668E-01	0.00000E+00

JUNCTION NUMBER	CONNECTS VOLUMES	CHOK/ PATH	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E VEL. PSI	ELEV. PSI	D I F F E R E N T I A L S FRIC. PSI	ACCL. PSI	PUMP PSI
1	1 TO	2	2.08633E+04	5.27032E+02	2.10632E-02	-2.94268E-01	-3.50426E+00	-2.39177E+01	7.42995E-02	0.00000E+00
2	2 TO	3	2.07464E+04	5.78296E+02	2.58923E-02	-2.90972E-01	-1.00984E+00	-1.17918E+00	6.41645E-02	0.00000E+00
3	3 TO	4	1.96179E+04	6.17515E+02	4.81033E-02	-3.53741E-01	-6.24934E-01	-2.64245E+00	-2.48309E-02	0.00000E+00
4	4 TO	8	1.90970E+04	6.40219E+02	6.12238E-02	2.77896E-01	-6.23618E-01	-1.89415E+00	-1.55821E-02	0.00000E+00
5	1 TO	5	1.40180E+03	5.27032E+02	2.10632E-02	4.01766E-02	-3.51849E+00	-2.83609E+01	1.17397E-03	0.00000E+00
6	5 TO	6	1.39242E+03	5.40693E+02	2.14066E-02	-1.98239E-05	-1.29743E+00	-1.22032E-02	7.42944E-04	0.00000E+00
7	6 TO	7	1.38940E+03	5.50872E+02	2.16747E-02	-3.68657E-05	-1.28369E+00	-1.34578E-02	-6.78627E-05	0.00000E+00
8	7 TO	8	1.39683E+03	5.52223E+02	2.17119E-02	-5.26088E-01	-1.00902E+00	-1.71127E-01	1.16207E-03	0.00000E+00
9	11 TO	9	2.06367E+04	6.37152E+02	5.99347E-02	2.51583E+00	-1.85919E+00	-1.38831E+00	-2.62453E-01	0.00000E+00
10	9 TO	10	2.91684E+03	1.19267E+03	3.77102E-01	2.48157E-01	-1.32888E-01	-3.09904E-02	-1.67582E+00	0.00000E+00
11	18 TO	19	9.57223E+03	5.27639E+02	2.10625E-02	6.21025E-02	-2.92239E+00	-1.92218E+01	5.11727E-01	8.73754E+01
12	8 TO	11	2.02866E+04	6.38503E+02	6.04810E-02	-2.35432E+00	-6.86682E-01	-1.07530E+00	-2.02345E+00	0.00000E+00
13	12 TO	13	1.26665E+04	5.27842E+02	2.10904E-02	-1.54135E+00	2.87026E+00	-6.58595E+00	8.90854E-01	3.51823E+01
14	19 TO	13	9.57894E+03	5.27469E+02	2.10418E-02	6.29655E+00	-5.01806E+00	-4.95334E+01	3.74769E-01	-7.59374E+01
15	12 TO	18	9.55389E+03	5.27842E+02	2.10904E-02	-4.03607E+00	1.07899E+01	-5.17256E+00	1.36557E-01	8.73754E+01
16	13 TO	1	2.22537E+04	5.27397E+02	2.10723E-02	5.34177E-01	2.89356E+00	-1.19846E+00	3.75226E-01	0.00000E+00
17	10 TO	14	3.29172E+03	1.19787E+03	3.81826E-01	-1.58969E-01	5.56025E-01	-4.06513E+00	2.43454E-01	0.00000E+00
18	14 TO	15	6.36719E+02	1.19888E+03	3.84120E-01	-4.87990E-02	5.60879E-01	-2.35089E-01	4.00627E-01	0.00000E+00
19	15 TO	16	6.13860E+02	1.19957E+03	3.84871E-01	1.66931E-01	2.66395E-01	-1.70502E+00	5.39577E-01	0.00000E+00
20	16 TO	17	2.88600E+01	1.20255E+03	3.88503E-01	1.56546E-01	-4.11745E-01	-2.54103E-02	-7.13462E-02	0.00000E+00
21	9 TO	12	1.90455E+04	5.60714E+02	2.19515E-02	1.84596E-01	6.51815E+00	-1.99020E-01	-1.32513E+00	0.00000E+00
22	16 TO	20	0.00000E+00	1.20255E+03	3.88503E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
26	0 TO	14	-9.70491E+02	1.19888E+03	3.84120E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
25	0 TO	14	-9.70491E+02	1.19888E+03	3.84120E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
24	0 TO	12	2.82598E+03	3.96877E+02	1.89228E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
23	0 TO	14	-7.27868E+02	1.19888E+03	3.84120E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

JUNCTION NUMBER	FLOW REG.	SLIP VEL. (FT/SEC)	VOID FRACTION	LIQUID FLOW (LB/SEC)	GAS FLOW (LB/SEC)	SLIP CNVCTN (BTU/SEC)	GAS VEL. (FT/SEC)	LIQ. VEL. (FT/SEC)	VG/VL	SLIP ACCEL. (FT/SEC**2)
2	0	-2.30080E+00	1.48599E-01	2.04921E+04	2.54253E+02	2.27145E+04	1.60896E+01	1.37888E+01	1.16686E+00	8.12320E+00
3	0	-9.19285E+00	5.71790E-01	1.76302E+04	1.98769E+03	3.17722E+05	3.27693E+01	2.35765E+01	1.38992E+00	4.18268E+00
4	0	-1.36983E+01	6.77483E-01	1.60733E+04	3.02375E+03	5.37798E+05	4.22187E+01	2.85204E+01	1.48030E+00	9.43615E+00
9	-2	-1.41629E+01	6.69250E-01	1.76479E+04	2.98888E+03	4.62124E+05	5.04471E+01	3.62842E+01	1.39033E+00	5.96379E+00
12	-2	-1.42813E+01	6.72776E-01	1.72892E+04	2.99740E+03	4.69416E+05	5.02242E+01	3.59429E+01	1.39733E+00	1.05031E+01

BUBL SET NUMB.	VOL. NUMB.	BUBBLE GRADIENT PARAMETER	BUBBLE VELOCITY (FT/SEC)	MIXTURE LEVEL (FT)	MIXTURE QUALITY	BUBBLE MASS (LB)
1	9	5.00000E-02	0.00000E+00	4.42497E+00	0.00000E+00	0.00000E+00

PUMP NUMB.	VOL. NUMB.	PUMP SPEED (RPM)	NORM. PUMP TORQUE	NORM. FRIC. TORQUE	NORM. MOT. TORQUE	POWER TO H2O (BTU/HR)
1	18	1.66500E+03	1.00586E+00	1.00000E+00	0.00000E+00	2.69427E+07

HEAT COND. NUMBER	VOL. NUM.	HT TRAN MODE-COR	SURF. FLUX (BTU/HR-FT2)	CRIT. FLUX (BTU/HR-FT2)	H.T. COEF. (BTU/H-F2-F)	SURF. TEMP. (DEG. F)	MASS FLUX (LBM/HR-FT2)	STORD ENRGY (BTU)	POWR TO H2O (BTU/HR)	DRYOUT PNT ()
1 RGHT	2	2-THOM	2.18750E+05	8.00000E+05	7.99851E+03	5.79922E+02	1.24957E+06	1.36615E+07	3.53891E+09	
2 RGHT	3	2-THOM	2.22430E+05	7.55843E+05	1.69422E+04	5.79787E+02	1.21393E+06	1.38077E+07	3.59845E+09	
3 RGHT	4	2-THOM	1.34156E+05	7.06363E+05	1.31201E+04	5.76500E+02	1.16575E+06	1.02520E+07	2.17035E+09	
4 LEFT	2	1-DB-L	1.15887E+03	1.46044E+06	3.32708E+03	5.52921E+02	1.24957E+06		4.63620E+06	
RGHT	5	1-DB-L	4.40653E+03	1.46577E+05	3.28630E+02	5.51708E+02	9.91013E+04	4.56210E+05	1.76289E+07	
5 LEFT	3	1-DB-L	-3.25126E+03	1.06275E+06	4.03423E+03	5.65852E+02	1.21393E+06		-1.30071E+07	
RGHT	6	1-DB-L	4.97229E+03	1.43276E+05	3.29963E+02	5.62945E+02	9.86745E+04	4.66777E+05	1.98923E+07	
6 LEFT	4	1-DB-L	-3.23598E+03	1.05866E+06	4.45548E+03	5.65549E+02	1.16575E+06		-1.29460E+07	
RGHT	7	1-DB-L	3.66047E+03	1.41079E+05	3.31498E+02	5.63071E+02	9.88438E+04	4.66637E+05	1.46442E+07	
7 LEFT	11	1-DB-L	-2.41877E+04	3.06926E+05	4.66396E+03	5.60628E+02	2.26385E+06		-4.05091E+07	
RGHT	12	1-DB-L	4.93964E+03	2.74075E+05	1.07676E+03	5.37470E+02	8.49885E+05	1.42631E+06	9.00250E+06	
8 LEFT	8	1-DB-L	-1.94402E+04	9.00000E+04	1.04507E+03	5.47436E+02	8.21156E+05		-7.33091E+06	
RGHT	12	1-DB-L	-1.90371E+03	2.32668E+05	1.74646E+03	5.31792E+02	8.49885E+05	6.46212E+06	-7.33530E+05	

CORE NUMB.	COND. NUMB.	DEPTH REAC. EXT. ZR-H2O (FT)	DEPTH REAC. INT. ZR-H2O (FT)	HEAT GEN. ZR-H2O (BTU/HR)	COND. HEAT-ING RATE (BTU/HR)	DIR. MODER-ATOR HT RT (BTU/HR)	AVG. METAL TEMPERATURE (DEG. F)	CENTERLINE TEMPERATURE (DEG. F)	FUEL ENTHALPY (CAL/GM)
1	1	0.00000E+00	0.00000E+00	0.00000E+00	1.53950E+09	4.09590E+07	1.82832E+03	2.59779E+03	6.88618E+01
2	2	0.00000E+00	0.00000E+00	0.00000E+00	1.56089E+09	4.74413E+07	1.84665E+03	2.63522E+03	6.96320E+01
3	3	0.00000E+00	0.00000E+00	0.00000E+00	9.52267E+08	2.71001E+07	1.38323E+03	1.77674E+03	5.05112E+01

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      4      4   0.00000E+00  0.00000E+00  0.00000E+00  7.90808E+06  2.18913E+07  5.52595E+02
      5      5   0.00000E+00  0.00000E+00  0.00000E+00  8.15597E+06  2.21658E+07  5.64485E+02
      6      6   0.00000E+00  0.00000E+00  0.00000E+00  5.14461E+06  1.33202E+07  5.64328E+02
0         AVERAGE CORE            MINIMUM  HEIGHT              HOT  SPOT                    MINUMUM DNBR POSITION
            (RETRAN)               (HOT CHANNEL)             (HOT CHANNEL)                   (HOT CHANNEL)
    LHGR(KW/FT)      DNBR      LHGR(KW/FT)      DNBR      LHGR(KW/FT)      DNBR      POS. (FT)    LHGR(KW/FT)  MDNBR
    8.66558E+00  3.93197E+00  1.44220E+01  1.56857E+00  1.51915E+01  0.00000E+00  8.00000E+00  1.24177E+01  1.42630E+00

  REACTOR      FISSION      DECAY HEAT   TOTAL        CONTROL      COOL. TEMP.  VOID         FUEL TEMP.   DOPPLER
  PERIOD       POWER        POWER        REACTIVITY   REACTIVITY   REACTIVITY   REACTIVITY   REACTIVITY   REACTIVITY
  (SEC)                                  ($)          ($)          ($)          ($)          ($)          ($)
 -2.06243E+00  4.91152E-01  0.00000E+00 -1.35143E+00 -2.38591E+00  0.00000E+00  1.24473E+00  0.00000E+00 -2.10253E-01


  DATA RECORD NUMBER    31 WAS WRITTEN TO UNIT 14

  TRAILER LABEL WRITTEN ON UNIT 14
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PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   50
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:20
 TTWOB WITH POINT KINETICS - RETRAN-3D SAMPLE PROBLEM                                                           CPU TIME =     0.499
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SYSTEM ELAPSED TIME (SEC)	SYSTEM ELAPSED TIME (SEC)	TIME STP ACTUAL	VOL 10 AVG. PRESS. (PSIA)	BUBL 9 MIX. LEVEL (FEET)	SYSTEM NORM. POWER	JUN 1 FLOW (LB/SEC)	JUN 15 FLOW (LB/SEC)	JUN 16 FLOW (LB/SEC)
0.00000E+00	0.00000E+00	0.00000E+00	1.01948E+03	5.13000E+00	1.00000E+00	2.00115E+04	9.50000E+03	2.13889E+04
5.00000E-02	5.00000E-02	5.00000E+01	1.01949E+03	5.13064E+00	1.00043E+00	2.00610E+04	9.49255E+03	2.14365E+04
1.00000E-01	1.00000E-01	1.00000E+02	1.01950E+03	5.13130E+00	1.00121E+00	2.00259E+04	9.51461E+03	2.14039E+04
1.50000E-01	1.50000E-01	1.50000E+02	1.01952E+03	5.13213E+00	1.00162E+00	2.00304E+04	9.50016E+03	2.14100E+04
2.00000E-01	2.00000E-01	2.00000E+02	1.01971E+03	5.13076E+00	1.00221E+00	2.00255E+04	9.49886E+03	2.14040E+04
2.50000E-01	2.50000E-01	2.50000E+02	1.02077E+03	5.11178E+00	1.00274E+00	2.00307E+04	9.50488E+03	2.14138E+04
3.00000E-01	3.00000E-01	3.00000E+02	1.02343E+03	5.05540E+00	9.92857E-01	2.01499E+04	9.52418E+03	2.15481E+04
3.50000E-01	3.50000E-01	3.50000E+02	1.02755E+03	4.96474E+00	9.53345E-01	2.04300E+04	9.55458E+03	2.18599E+04
4.00000E-01	4.00000E-01	4.00000E+02	1.03270E+03	4.84758E+00	9.29839E-01	2.08905E+04	9.59233E+03	2.23624E+04
4.50000E-01	4.50000E-01	4.50000E+02	1.04091E+03	4.79933E+00	9.28275E-01	2.15147E+04	9.66594E+03	2.30494E+04
5.00000E-01	5.00000E-01	5.01000E+02	1.04950E+03	4.74101E+00	9.74284E-01	2.21783E+04	9.74533E+03	2.38370E+04
5.50000E-01	5.50000E-01	5.51000E+02	1.05776E+03	4.65993E+00	1.11047E+00	2.28582E+04	9.78210E+03	2.46057E+04
6.00000E-01	6.00000E-01	6.02000E+02	1.06527E+03	4.54924E+00	1.44811E+00	2.32250E+04	9.86273E+03	2.50479E+04
6.50000E-01	6.50000E-01	6.52000E+02	1.07067E+03	4.42884E+00	2.19799E+00	2.31698E+04	9.84860E+03	2.49421E+04
7.00000E-01	7.00000E-01	7.02000E+02	1.07476E+03	4.30859E+00	4.05870E+00	2.25033E+04	9.78997E+03	2.42299E+04
7.50000E-01	7.50000E-01	7.52000E+02	1.07855E+03	4.20215E+00	8.88833E+00	2.12839E+04	9.70361E+03	2.29543E+04
8.00000E-01	8.00000E-01	8.02000E+02	1.08289E+03	4.12292E+00	1.40870E+01	1.96418E+04	9.57072E+03	2.12312E+04
8.50000E-01	8.50000E-01	8.53000E+02	1.08799E+03	4.08512E+00	7.76984E+00	1.79265E+04	9.41723E+03	1.92840E+04
9.00000E-01	9.00000E-01	9.04000E+02	1.09453E+03	4.09877E+00	2.95892E+00	1.62365E+04	9.28032E+03	1.74675E+04
9.50000E-01	9.50000E-01	9.54000E+02	1.10301E+03	4.16047E+00	1.61368E+00	1.50674E+04	9.19450E+03	1.61806E+04
1.00000E+00	1.00000E+00	1.00600E+03	1.11313E+03	4.25621E+00	1.06814E+00	1.46603E+04	9.17348E+03	1.57326E+04
1.10000E+00	1.10000E+00	1.03200E+03	1.13407E+03	4.47624E+00	6.35870E-01	1.64180E+04	9.31078E+03	1.76593E+04
1.20000E+00	1.20000E+00	1.04400E+03	1.15059E+03	4.60184E+00	5.03554E-01	1.98486E+04	9.55778E+03	2.13886E+04
1.30000E+00	1.30000E+00	1.04800E+03	1.16185E+03	4.57743E+00	4.78790E-01	2.20850E+04	9.73702E+03	2.37875E+04
1.40000E+00	1.40000E+00	1.06000E+03	1.17189E+03	4.47459E+00	5.33407E-01	2.24920E+04	9.77745E+03	2.41886E+04
1.50000E+00	1.50000E+00	1.07000E+03	1.17946E+03	4.36639E+00	6.13881E-01	2.15695E+04	9.68317E+03	2.31269E+04
1.60000E+00	1.60000E+00	1.08200E+03	1.18105E+03	4.31880E+00	7.08013E-01	1.98936E+04	9.51541E+03	2.12337E+04
1.70000E+00	1.70000E+00	1.08500E+03	1.18734E+03	4.35633E+00	6.94378E-01	1.89955E+04	9.43528E+03	2.02546E+04
1.80000E+00	1.80000E+00	1.09300E+03	1.19361E+03	4.41154E+00	6.10096E-01	1.93900E+04	9.45287E+03	2.06831E+04
1.90000E+00	1.90000E+00	1.10000E+03	1.19403E+03	4.43722E+00	5.34993E-01	2.03955E+04	9.52209E+03	2.17680E+04
2.00000E+00	2.00000E+00	1.10500E+03	1.18961E+03	4.42497E+00	4.91152E-01	2.08633E+04	9.55389E+03	2.22537E+04

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   51
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:20
 TTWOB WITH POINT KINETICS - RETRAN-3D SAMPLE PROBLEM                                                           CPU TIME =     0.499
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SYSTEM ELAPSED TIME (SEC)	JUN 17 FLOW (LB/SEC)	JUN 24 FLOW (LB/SEC)	REAC KIN REACTIVITY ($)	REAC KIN VOID ($)	REAC KIN DOPPLER ($)	REAC KIN CONTROL REAC ($)	VOL 4 VOID FRACTN	VOL 4 AVG. PRESS. (PSIA)
0.00000E+00	3.05410E+03	3.20872E+03	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	6.69380E-01	1.02704E+03
5.00000E-02	3.05431E+03	3.20872E+03	6.09559E-04	6.10527E-04	-9.68197E-07	0.00000E+00	6.69378E-01	1.02704E+03
1.00000E-01	3.05507E+03	3.20872E+03	1.25870E-03	1.26869E-03	-9.98916E-06	0.00000E+00	6.69369E-01	1.02705E+03
1.50000E-01	3.04955E+03	3.20872E+03	1.64369E-03	1.66797E-03	-2.42784E-05	0.00000E+00	6.69365E-01	1.02705E+03
2.00000E-01	2.91861E+03	3.20872E+03	2.20878E-03	2.25212E-03	-4.33344E-05	0.00000E+00	6.69358E-01	1.02706E+03
2.50000E-01	2.40140E+03	3.18543E+03	2.71800E-03	2.78587E-03	-6.78739E-05	0.00000E+00	6.69347E-01	1.02708E+03
3.00000E-01	1.69615E+03	3.18395E+03	-1.42115E-02	5.29115E-03	-8.50491E-05	-1.94176E-02	6.69297E-01	1.02718E+03
3.50000E-01	1.13016E+03	3.18150E+03	-5.41442E-02	1.61755E-02	1.96753E-04	-7.05165E-02	6.69115E-01	1.02760E+03
4.00000E-01	5.89948E+02	3.16252E+03	-7.60049E-02	4.48046E-02	8.05819E-04	-1.21615E-01	6.68771E-01	1.02869E+03
4.50000E-01	8.71354E+01	3.12598E+03	-7.20834E-02	9.90920E-02	1.53894E-03	-1.72714E-01	6.68302E-01	1.03075E+03
5.00000E-01	-3.76776E+02	3.08926E+03	-2.07381E-03	2.19592E-01	2.14733E-03	-2.23813E-01	6.66153E-01	1.03580E+03
5.50000E-01	-7.39525E+02	3.05273E+03	1.32635E-01	4.05785E-01	1.76282E-03	-2.74912E-01	6.61353E-01	1.04252E+03
6.00000E-01	-7.73180E+02	3.01545E+03	3.67021E-01	6.94131E-01	-1.09893E-03	-3.26011E-01	6.52906E-01	1.05504E+03
6.50000E-01	-5.91179E+02	2.97948E+03	6.18743E-01	1.00452E+00	-8.84727E-03	-3.76926E-01	6.43000E-01	1.06934E+03
7.00000E-01	-2.88536E+02	2.94286E+03	8.59073E-01	1.31400E+00	-2.87439E-02	-4.26182E-01	6.32155E-01	1.08463E+03
7.50000E-01	3.68944E+00	2.90623E+03	9.93572E-01	1.54937E+00	-8.03580E-02	-4.75438E-01	6.22039E-01	1.10032E+03
8.00000E-01	3.55657E+02	2.86961E+03	9.00239E-01	1.61586E+00	-1.90932E-01	-5.24693E-01	6.14363E-01	1.11681E+03
8.50000E-01	8.91999E+02	2.83226E+03	6.24610E-01	1.49569E+00	-2.97125E-01	-5.73949E-01	6.10389E-01	1.13069E+03
9.00000E-01	1.35095E+03	2.79620E+03	3.24367E-01	1.27841E+00	-3.30837E-01	-6.23205E-01	6.11813E-01	1.13892E+03
9.50000E-01	1.63627E+03	2.75973E+03	-7.32433E-02	9.37062E-01	-3.37845E-01	-6.72461E-01	6.19263E-01	1.14196E+03
1.00000E+00	1.80045E+03	2.72280E+03	-5.35927E-01	5.24005E-01	-3.36379E-01	-7.23553E-01	6.32265E-01	1.14070E+03
1.10000E+00	2.01369E+03	2.73442E+03	-1.39227E+00	-2.35655E-01	-3.24888E-01	-8.31728E-01	6.64634E-01	1.13350E+03
1.20000E+00	1.64503E+03	2.80677E+03	-1.86161E+00	-6.12671E-01	-3.09033E-01	-9.39902E-01	6.89110E-01	1.13377E+03
1.30000E+00	1.12494E+03	2.82218E+03	-1.87071E+00	-5.26461E-01	-2.96175E-01	-1.04808E+00	6.96481E-01	1.14878E+03
1.40000E+00	5.74343E+02	2.75669E+03	-1.48564E+00	-3.16086E-02	-2.78727E-01	-1.17530E+00	6.91150E-01	1.17059E+03
1.50000E+00	1.36159E+03	2.68672E+03	-1.09070E+00	4.95277E-01	-2.65867E-01	-1.32011E+00	6.77529E-01	1.19139E+03
1.60000E+00	2.14786E+03	2.60535E+03	-7.59354E-01	9.59341E-01	-2.53777E-01	-1.46492E+00	6.61908E-01	1.20375E+03
1.70000E+00	2.20629E+03	2.60963E+03	-7.63683E-01	1.09024E+00	-2.44201E-01	-1.60973E+00	6.50048E-01	1.20370E+03
1.80000E+00	2.74941E+03	2.68967E+03	-9.86776E-01	1.10351E+00	-2.32988E-01	-1.85730E+00	6.41337E-01	1.19857E+03
1.90000E+00	3.17574E+03	2.75696E+03	-1.21074E+00	1.13303E+00	-2.22163E-01	-2.12161E+00	6.35162E-01	1.19448E+03
2.00000E+00	3.29172E+03	2.82598E+03	-1.35143E+00	1.24473E+00	-2.10253E-01	-2.38591E+00	6.29796E-01	1.19377E+03

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6.0 UNCONTROLLED ROD WITHDRAWAL

A Westinghouse three-loop plant was used to develop the Uncontrolled Rod Withdrawal (UCRW) Sample Problem. However, the results are not necessarily totally applicable to a specific plant. Initial conditions assumed for this sample problem are given in Table VII.6-1. The pressurizer steady-state initialization option is used during steady state. During steady-state initialization, a fraction of flow from the cold leg flows in to the pressurizer through the spray valve. This initializes the pressurizer and more realistic values of liquid and vapor regions can be obtained. The pressurizer thermal stratification model is also used. The cold leg and hot leg volumes are subnodalized. The UCRW transient consists of a linear time-dependent reactivity insertion which results in a core power rise and, hence, system pressure and temperature rise until scram occurs due to a high neutron flux (overpower) or an overpower or overtemperature trip.

Figure VII.6-1 gives a schematic of the PWR model nodalization. The basic model consists of 20 volumes, 31 junctions, and 7 heat conductors. All pertinent control systems and safety and relief valves are modeled in some detail. A more detailed discussion of the model is found in EPRI NP-454.[VII.5-1]

The input for the UCRW Sample Problem is given below. The restart tape created by this problem is used by the RESTRT and REEDIT sample problems discussed in Sections VIII and IX. Selected output for this sample problem is given below.

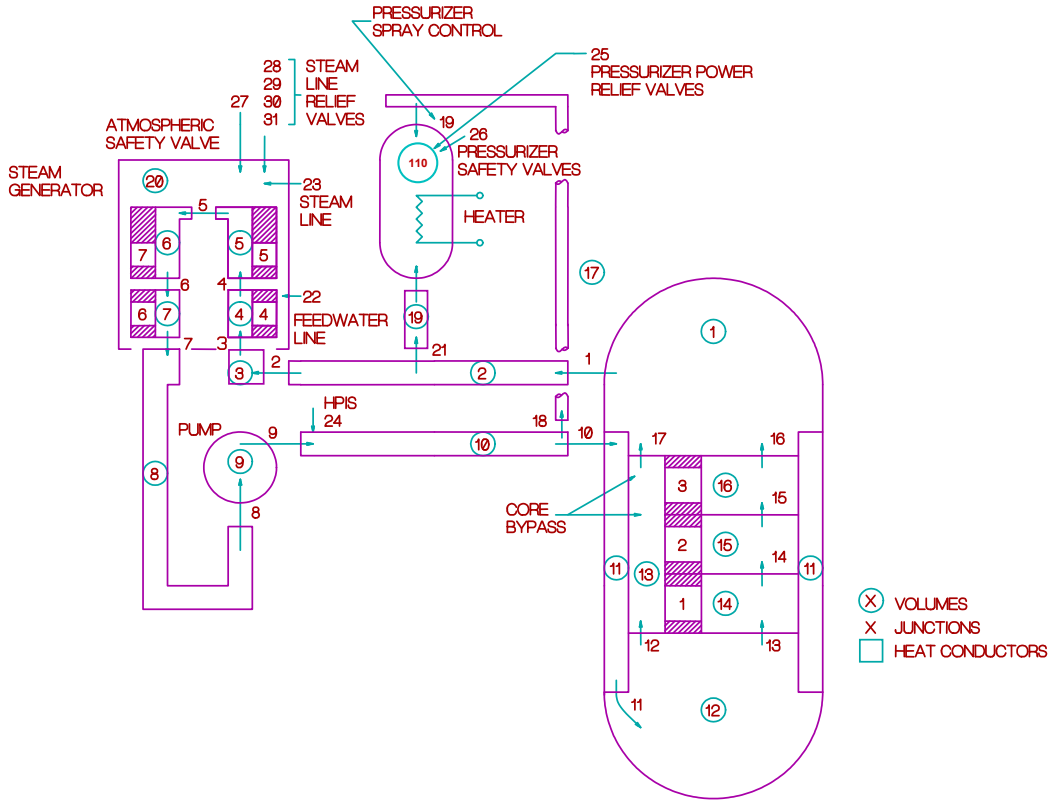


Figure VII.6-1. Schematic Diagram of the UCRW Sample Problem

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Table VII.6-1

PWR Base Case Initial Conditions

Parameter	Units	Value
Thermal Power	MW	2244.
Steam Flow	10^6 lb/hr	9.86
Core Flow	10^6 lb/hr	98.4
Core Bypass Flow	10^6 lb/hr	3.08
Pressurizer Pressure	psia	2220.
Core Inlet Temperature	F	550.2
Scram Curve	MWD/T	BOL
Scram Worth	$	-8.79
Moderator Coefficient	¢/%	0.0
Doppler Coefficient	¢/F	-0.7(nom)

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```
 LISTING OF INPUT DATA FOR CASE  1

     1    =UNCONTROLLED ROD WITHDRAWAL - RETRAN-3D SAMPLE PROBLEM
     2    *
     3    ********************************************************************************
     4    *
     5    *  PROBLEM DIMENSIONS
     6    *
     7    *        1     2     3     4     5     6     7     8     9    10    11    12
     8    *      TAPE PRNPLT  POW   SS  NVOID GENTRN HTMAP SLIP  5EQ  NCOND  NSOL  PNMTH
     9    010001  -1     0     1    0     0     0     1     0     0     0     3     0
    10    *
    11    *
    12    *10005  POWER
    13    010005  2244.
    14    *
    15    *   EDIT VARIABLES
    16    *
    17    020000 TIMX  0  NTTS  0
    18    020001 PRES  1  PRES  2 PRES 19 PRES 110
    19    020002 PNRM  0  TEMP  2 TEMP 19 TEMP  17
    20    020003 WP** 13  WP**  1 WP** 19 WP**  21 WP** 20 WP** 2
    21    020004 MIXL 110 HW** 110
    22    020005 BUBM 110 CMXL 110
    23    *
    24    *
    25    * FORMAT FOR TAPE60
    26    *
    27    025000 1
    28    025001 '(5(1X,1P,E15.7))'
    29    *
    30    *
    31    *  TIME STEPS
    32    *3XXX0  RTG  MIN  RST  MAJ  DMP NCHK  DTMAX  TLAST
    33    030010  0.   0.01 0.01 0.1  0.1   0    0.01    0.1
    34    030020  0.   0.05 0.05 0.4  0.4   0    0.05    0.5
    35    030030  0.   0.5  0.5  3.   3.    0    0.05   70.0
    36    *
    37    *
    38    *  TRIP CONTROLS    ** TRIP ACTION IDENTIFICATION
    39    *                       1 = END OF PROBLEM TIME TRIP
    40    *                       2 = LOW STEAM GENERATOR LEVEL
    41    *                       3 = FLOW MISMATCH
    42    *                       4 = TURBINE TRIP
    43    *                       5 = SAFETY INJECTION SYSTEM
    44    *                       6 = LOW PRESSURIZER PRESSURE
    45    *                       7 = LOW PRESSURIZER LEVEL
    46    *                       8 = HIGH STEAM FLOW
    47    *                       9 = LOW TAVG
    48    *                      10 = LOW STEAM PRESSURE
    49    *                      11 = FEEDWATER ISOLATION
    50    *                      12 = PRESSURIZER POWER RELIEF VALVES
    51    *                      13 = PRESSURIZER SAFTEY VALVES
    52    *                      14 = STEAM LINE SAFTEY VALVES
    53    *                      15 = STEAM LINE RELIEF VALVE 1
    54    *                      16 = REACTOR SCRAM
    55    *                      17 = STEAM LINE RELIEF VALVE 2
    56    *                      18 = STEAM LINE RELIEF VALVE 3
    57    *                      19 = STEAM LINE RELIEF VALVE 4
    58    *                      20 = MISC GENL TIME  0.0  TRIP  START FILL TABLES ETC
    59    *                      21 = REACTOR COOLANT PUMP
    60    *                      22 = PRESSURIZER CONTROL HEATERS 1
    61    *                      23 = PRESSURIZER BACKUP  HEATERS 1
    62    *                      24 = PRESSURIZER CONTROL HEATERS 2
    63    *                      25 = UNCONTROLLED ROD WITHDRAWL
    64    *
    65    *      IDTRP IDSIG IX1 IX2    SETPT    DELAY  DESCRIPTION
    66    040010   1     1    0   0       3.0    0.0   "PROBLEM END TIME              "
    67    040020   4     1    0   0       1.+9   0.0   "TURBINE TRIP MANUAL           "
    68    040030   6    -4   110   0     1860.0    0.0   "LOW PRESSURIZER PRESS         "
    69    040040   7    -6   110   0       13.31   0.0   "LOW PRESSURIZER LEVEL         "
    70    040050   5    13    6   7        0.0    1.0   "LOW PRESS AND LEVEL           "
    71    040060   9   -14   -2   0      531.0    0.0   "LOW TAVG                      "
    72    040070  16     6   110   0       42.45   1.0   "HIGH PRESSURIZER LEVEL        "
    73    040080  16    12    6   0        0.0    1.0   "LOW PRESSURIZER PRESS         "
    74    040090  16     4   110   0     2425.0    1.0   "HIGH PRESSURIZER PRESS        "
    75    040100  16     2    0   0        1.18   0.5   "NUCLEAR OVERPOWER             "
    76    040110  16    14   -9   0        0.0    2.3   "OVER TEMPERATURE DELTA T      "
    77    040120  16    14  -16   0        0.0    2.3   "OVER POWER DELTA T            "
    78    040130  16    -9    9   0    24528.8    0.6   "LOW COOLANT FLOW ALL PUMPS    "
    79    040140  16    12    4   0        0.0    1.0   "SCRAM FROM TURBINE TRIP       "
    80    040150  16    12    5   0        0.0    0.5   "SCRAM FROM SIS                "
    81    040160   5    12   16   0        0.0    1.0   "TURBINE TRIP FROM SCRAM       "
    82    040170  11    13    9  16        0.0    2.0   "FW ISOLATION SRAM AND TAVG    "
    83    040180  11    12    5   0        0.0    0.5   "FW ISOLATION FROM SIS         "
    84    040190  21     1    0   0        1+9    0.0   "RECIRC PUMP TRIP         SS   "
    85    040200  13     4   110   0     2500.0    1.0   "OPEN PRES SAFETY VALVE        "
    86    040210 -13    -4   110   0     2400.0    1.0   "CLOSE PRES SAFETY VALVE       "
    87    040220  12     4   110   0     2350.0    0.5   "OPEN  PRES RELIEF VALVE       "
    88    040230 -12    -4   110   0     2250.     0.5   "CLOSE PRES RELIEF VALVE       "
    89    *
    90    ***   ***   S/R SET POINTS RAISED 70 PSI TO ALLOW FOR INITIALIZATION
    91    040240  14     4   20   0     1050.0    0.5   "OPEN  S.L. SAFETY VALVES      "
    92    040250 -14    -4   20   0      950.      .5   "CLOSE S.L. SAFETY VALVES      "
    93    040260  15     4   20   0     1100.      .5   "OPEN  S.L. RELIEF VALVE  1    "
    94    040270 -15    -4   20   0     1000.      .5   "CLOSE S.L. RELIEF VALVE  1    "
    95    040280  17     4   20   0     1115.      .5   "OPEN  S.L. RELIEF VALVE  2    "
    96    040290 -17    -4   20   0     1015.      .5   "CLOSE S.L. RELIEF VALVE  2    "
    97    040300  18     4   20   0     1130.      .5   "OPEN  S.L. RELIEF VALVE  3    "
    98    040310 -18    -4   20   0     1030.      .5   "CLOSE S.L. RELIEF VALVE  3    "
    99    040320  19     4   20   0     1145.      .5   "OPEN  S.L. RELIEF VALVE  4    "
   100    040330 -19    -4   20   0     1045.      .5   "CLOSE S.L. RELIEF VALVE  4    "
```

```
040340  20     1    0   0        0.     0.    "GENL MISC TRIP AT TIME 0.     "
040350  22    -4   110   0     2235.     0.    "PRESSUR HEATERS  CONTROL  ON  "
040360 -22    +4   110   0     2235.     0.    "PRESSUR HEATERS  CONTROL OFF  "
040370  23    -4   110   0     2195.     0.    "PRESSUR HEATERS BACKUP    ON  "
040380 -23    +4   110   0     2195.     0.    "PRESSUR HEATERS  BACKUP  OFF  "
040390  24    -4   110   0     2213.     0.    "PRESSUR HEATERS  CONTROL  ON  "
040400 -24    +4   110   0     2227.     0.    "PRESSUR HEATERS CONTROL  OFF  "
040410  16     1    0   0      1+9      0     "SCRAM ON TIME LOSS PUMP POWER "
040420  25     1    0   0        0.     0.    "URW REACTIVITY INSER          "
*
*
*  VOLUME DATA
*5XXXY B V   PRES  ENTH  QUAL VOLUM  ZVOL  FL FLOWA  DIA    ELEV
050011 0 0   0.0   0.0   0.0  984.3 11.58  0  1.+9    .5    -4.71   * UP PLEN
050021 0 0   0.0   0.0   0.0  295.2  2.82  0  13.77  2.42   -1.21   * HOT L57
050031 0 0   0.0   0.0   0.0  405.9  5.05  0 113.6   6.      1.61   * S7 PLEN
050041 0 0   0.0   0.0   0.0  607.5 14.87  0  40.84   .05    6.66   * SG T
050051 0 0   0.0   0.0   0.0  607.5 14.87  0  40.84   .05   21.53   * SG TUB
050061 0 0   0.0   0.0   0.0  607.5 14.87  0  40.84   .05   21.53   * SG TU 3
050071 0 0   0.0   0.0   0.0  607.5 14.87  0  40.84   .05    6.66   * SG TUB4
050081 0 0   0.0   0.0   0.0  801.6 16.46  0  15.72  2.58   -9.8    * PMP SUC
050091 0 0   0.0   0.0   0.0  576.   5.19  0  1.+9   1.+9   -4.04   * PMPS
050101 0 0   0.0   0.0   0.0  247.8  2.3   0  12.36  2.29   -1.15   * CL4 L5G
050111 0 0   0.0   0.0   0.0  789.9 26.77  0  29.51  1.45   -19.9   * DN3MR
050121 0 0   0.0   0.0   0.0  806.2  9.85  0  1.+9    .5    -26.55  * LW PLEN
050131 0 0   0.0   0.0   0.0   42.7 12.     0   3.52   .026  -16.7   * BYPASS
050141 0 0   0.0   0.0   0.0  167.4  4.     0  43.75   .0412 -16.7   * BTM CORE
050151 0 0   0.0   0.0   0.0  167.4  4.     0  43.75   .0412 -12.7   * MID COR5
050161 0 0   0.0   0.0   0.0  167.4  4.     0  43.75   .0412  -8.7   * TOP CORE
050171 0 0   0.0   0.0   0.0    5.075 43.3 0    .1015 .359    1.15  * SPAY LN
051101 1 0   0.0   0.0   0.0 1300.  33.77  0  38.48  7.0     8.78  * PRZR
050191 0 0   0.0   0.0   0.0   28.6  8.78  0    .7213 .9538   0.0   * SURGE
050201 2 0   0.0   0.0   0.0 8543.  63.0   0  33.9    .112    6.66  * SG SC
*
*
*5XXXY  EOVRD   MESH  IHTLG  IMAP  IVFIT  IFRIC
050022    0.     20
050082    0.     20
050102    0.     20
050112    0.     20
050132    0.     20
050172    0.     20
051102    0.     10
*
*
*  BUBBLE RISE DATA
*      ALPH  VBUB
060011   1.   0.0  21.95    1    * PRESSURIZER
060021   0.  14.07 49.5           * STEAM GENERATOR  SECONDARY
*
*
*  JUNCTION DATA CARDS - CARD 1 (WORDS 1-10)
*8XXX1 VI VO PP VV  FLOWRT       AREA   ELEV   INERT    FLOSS   RLOSS
080011  1  2  0  0       0.0      13.77   0.     2.4     .4187    0.0     * SG EN
080021  2  3  0  0       0.0      13.77   1.61   1.19    .7534    0.0     * S7 TU
080031  3  4  0  0       0.0      32.04   6.66    .49   1.0645    0.0     * SG TU
080041  4  5  0  0       0.0      32.04  21.53    .75    .3984    0.0     * SG BE
080051  5  6  0  0       0.0      32.04  36.3     .75    .5470    0.0     * SG TU
080061  6  7  0  0       0.0      32.04  21.53    .75    .2983    0.0     * SG TU
080071  7  8  0  0       0.0      15.72   6.66   2.8     .3463    0.0     * PUMP
080081  8  9 -1  0       0.0      12.36  -4.04   2.54    .0712    0.0     * PUMP
080091  9 10  1  0       0.0      12.36   0.     1.32   0.        0.0     * VESSE
080101 10 11  0  0       0.0      12.36   0.     1.67   1.1502    0.0     * LOWER
080111 11 12  0  0       0.0      19.69 -19.9     .59    .9106     .88    * BY PA
080121 12 13  0  0       0.0       1.5  -16.7    1.8   16.938     0.0     * CORE
080131 12 14  0  0       0.0      43.75 -16.7     .18   8.9129    0.0     * CORE
080141 14 15  0  0       0.0      43.75 -12.7     .09   2.8927    0.0     * CORE
080151 15 16  0  0       0.0      43.75  -8.7     .09   2.7894    0.0     * CORE
080161 16  1  0  0       0.0      43.75  -4.7     .05   7.7418    0.0     * BY PA
080171 13  1  0  0       0.0       1.5   -4.7    1.8    0.        0.0     * PRESS
080181 10 17  0  8       0.0      .1015   1.15 247.5    1.         .5
080191 17 110 0  1       0.0     .253614 42.08 123.3  100.      100.0     * PRESS
080201 19 110 0  0       0.0      .6013    8.78   0.0    2.8       2.3     * FEEDW
080211  2 19  0  0       0.0      .6013    0.0    0.0    2.3       2.8
080221  0 20  4  9       0.0        3.     6.66   0.0    0.0       0.0     * S.G.
080231  0 20  5 10       0.0        3.    69.66   0.0    0.0       0.0     *    HP
080241  0 10  6  0       0.0        4.     0.0    0.0    0.0       0.0     *  PRES
080251  0 110 1  2       0.0        2.    41.7    0.0    0.0       0.0     *  PRES
080261  0 110 2  3       0.0        3.    41.7    0.0    0.0       0.0     *  STEA
080271  0 20  3  4       0.0        3.    62.2    0.0    0.0       0.0     *  STEA
080281  0 20  7  5       0.0        3.    62.2    0.0    0.0       0.0
080291  0 20  7  6       0.0        3.    62.2    0.0    0.0       0.0
080301  0 20  7  7       0.0        3.    62.2    0.0    0.0       0.0
080311  0 20  7  8       0.0        3.    62.2    0.0    0.0       0.0
*
*   JUNCTION CARDS - CARD 2 (WORDS 11-20)
*8XXX1  V  C  CL M  HDI  CON     IFRJ   JTPMJ  IHQCOR  ISP  ANGL1  ANGL2
080012  0  0  0  0   0.   1.      0      0      0
080022  0  0  0  0   0.   1.      0      0      0
080032  0  0  0  0   0.   1.      0      0      1
080042  0  0  0  0   0.   1.      0      0      1
080052  0  0  0  0   0.   1.      0      0      1
080062  0  0  0  0   0.   1.      0      0      1
080072  0  0  0  0   0.   1.      0      0      1
080082  0  0  0  0   0.   1.      0      0      0
080092  0  0  0  0   0.   1.      0      0      0
080102  0  0  0  0   0.   1.      0      0      0
080112  0  0  0  0   0.   1.      0      0      0
080122  0  0  0  0   0.   1.      0      0      0
080132  0  0  0  0   0.   1.      0      0      1
080142  0  0  0  0   0.   1.      0      0      1
080152  0  0  0  0   0.   1.      0      0      1
```

```
080162  0  0  0  0   0.   1.      0      0      1
080172  0  0  0  0   0.   1.      0      0      0
080182  0  0  0  0   0.   1.      0      0      0
080192  2  0  2  0   0.   1.      0      0      0      1
080202  2  0  2  0   0.   1.      0      0      0
080212  0  0  2  3   0.   1.      0      0      0
080222  0  0  0  0   0.   1.      0      0      0
080232  0  0  0  3   0.   1.      0      0      0      0     0.  180.0
080242  0  0  0  0   0.   1.      0      0      0
080252  0  0  0  0   0.   1.      0      0      0      0     0.  180.0
080262  0  0  0  0   0.   1.      0      0      0      0     0.  180.0
080272  0  0  0  0   0.   1.      0      0      0      0     0.  180.0
080282  0  0  0  0   0.   1.      0      0      0      0     0.  180.0
080292  0  0  0  0   0.   1.      0      0      0      0     0.  180.0
080302  0  0  0  0   0.   1.      0      0      0      0     0.  180.0
080312  0  0  0  0   0.   1.      0      0      0      0     0.  180.0
*
*  PUMP DATA CARDS
*     PUMP CURVE INPUT OPTION
100000    2    0
*     PUMP DESCRIPTION
*90  RATED CONDITIONS 1180. 1. 265500. 260. 77535. 210000. 47.66 3606. 0.
****    RATED TORQUE EFFICIENCY = 77 PER CENT   TIME CONST = 6.5 SEC
*       TR P RV 2P MT RPM   SR  FLOW   HEAD TORQUE INERTIA  DENS  MT  FRIC
090011  1  21 0  1  0 1180. 1. 265500. 260. 59319. 210000. 47.66 3606. 0.
*     PUMP HEAD AND TORQUE MULTIPLIER
*      NPTS  PHDM------
091011  11   0.00 0.00   0.10 0.00   0.15 0.05   0.24 0.80   0.30 0.96  *HEAD
091012       0.40 0.98   0.60 0.97   0.80 0.90   0.90 0.80   0.96 0.50
091013       1.00 0.00
*      NPTS  PTKM-----
092011   2   0.00 0.00   1.00 0.00     * TORQUE
*
*
*  VALVE DATA
*       ITCV  IACV IACV2 PCV CV1 CV2 CV3
110010  1000  -19    0    0.  0.  0.  0.  * PRESSURIZER SPRAY VALVE
110020  -12     1    0    0.  0.  0.  0.  * PRESS  POWER RELIEF VALVES   2 EACH
110030  -13     2    0    0.  0.  0.  0.  * PRESS SAFETY VALVE    3 EACH
110040  -14     3    0    0.  0.  0.  0.  * ATM. SAFETY VALVE
110050  -15     4    0    0.  0.  0.  0.  * STM LINE RELIEF VALVE 1
110060  -17     5    0    0.  0.  0.  0.  * STM LINE RELIEF VALVE 2
110070  -18     6    0    0.  0.  0.  0.  * STM LINE RELIEF VALVE 3
110080  -19     7    0    0.  0.  0.  0.  * STM LINE RELIEF VALVE 4
110090   11     0    0    0.  0.  0.  0.  * FEEDWATER FLOW VALVE
110100    4     0    0    0.  0.  0.  0.  * STEAM LINE ISOLATION VALVE
*
*
*  AREA TABLES
*      NAREA        TAREA-------
120101  -3          0. 0.   .1 1.   1+9 1.   * PRESS POWER RELIEF VALVE
120201  -3          0. 0.   .1 1.   1+9 1.   * PRESS SAFETY VALVE
120301  -3          0. 0.   .1 1.   1+9 1.   * STM LINE ATM. SAFETY VALVE
120401  -3          0. 0.   .1 1.   1+9 1.   * STM LINE RELIEF VALVE 1
120501  -3          0. 0.   .1 1.   1+9 1.   * STM LINE RELIEF VALVE 2
120601  -3          0. 0.   .1 1.   1+9 1.   * STM LINE RELIEF VALVE 3
120701  -3          0. 0.   .1 1.   1+9 1.   * STM LINE RELIEF VALVE 4
*
*  FUNCTION GENERATOR TABLE
120801  4   0.0 7.886-4    25. 7.886-4    40. 1.    1.+9 1.
*
*
*  FILL DATA
*
*        PRES POWER RELIEF VALVE         PSIA VS LMB/SEC
130101  -2  20  1  0
130102               2250. -54.255 1100. 2250.
130103               2350. -58.333 1100. 2350.
*        PRESS SAFTEY VALVES           PRES(PSIA) VS  FLOW(LBM/SEC)  EACH VALVE
130201  -2  20  1  0
130202               2400. -74.407 1100. 2400.
130203               2500. -80.    1100. 2400.
*        ATMOSPHERIC SAFTEY VALVES     PRES(PSIA) VS FLOW (LBM/SEC)  EACH VALVE
130301  -2  20  1  0
130302               950. -25.0206 1100.  950.
130303              1050. -27.972  1100. 1050.
*        SG FEEDWATER         102 PCT FLOW
130401  -2  20  0  0
130402                .0  913.262   415.503  853.4
130403               1.+9 913.262   415.503  853.4
*        SG STEAM FLOW     102 PCT FLOW
130501  -2  20  0  0
130502                .0  -913.262  1100.  500.
130503              1.+9  -913.262  1100.  500.
*        HPIS                PRESSURE (PSIA)  VS  FLOW (GPM)  EACH PUMP
130601  -2  4  1  1
130602              100. 100. 100. 100.
130603              101. 100. 100. 100.
*        STEAMLINE RELIEF VALVES     PSIA VS LBM/SEC     4 EACH
130701  -2  20  1  0
130702              1100. -227.173  1100.  1100.
130703              1145. -236.473  1100.  1145.
*
*
*  POINT KINETICS DATA
*      BOVL
140000  400.
*
*
*  REACTIVITY COEFFICIENTS
*
*         DENWT     FTWT    ALPHTM    ALPHTW
```

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140010  0.22780    0.22780    .0        .0
140020  0.54450    0.54450    .0        .0
140030  0.22780    0.22780    .0        .0
*
*
*  SCRAM CURVE (-8.79 $ TOTAL WORTH)
141001   15   16   0
141002  0.    0.     0.2  -.0659   0.4  -0.176   .8 -0.615   1.0 -1.05
141003  1.2  -1.71   1.4  -2.72    1.6  -4.34   1.7 -5.71    1.8 -7.74
141004  1.85 -8.35   1.9  -8.57    1.95 -8.66   2.3 -8.79    1+9 -8.79
*
*141101 PTS  TRP     RAPID ROD WITHDRAWL 5.625E-4 DK/SEC  EQ  .078125 $/SEC
141101   3   25   0   0. 0.   19.73 1.542   1+9 1.542
*
*
*  DENSITY REACTIVITY CURVE -  MODERATOR COEFFICIENT = ZERO
142001     -2     0.0  0.0     1000.0  0.0
*
*
*  DOPPLER REACTIVITY CURVE
143001   -8   550. 0.   700. -.01354   800.  -.03646  1000. -.1059
143002   1200. -.1948   1400. -.3031   1700. -.5031   1950. -.6941
*
*
*  HEAT CONDUCTOR DATA
*      IVSL IVSR IGOM CELEV IMCL IMCR   ASUL    ASUR    VOLS    HDML
150011  0    14   1   -16.7   2    2       0.  14153.  124.43  0.
150021  0    15   1   -12.7   2    2       0.  14153.  124.43  0.
150031  0    16   1    -8.7   2    2       0.  14153.  124.43  0.
150041  4    20   2     6.66  2    2   29514.  33322.  131.    0.0646
150051  5    20   2     6.66  2    2   29514.  33322.  131.    0.0646
150061  7    20   2     6.66  2    2   29514.  33322.  131.    0.0646
150071  6    20   2     6.66  2    2   29514.  33322.  131.    0.0646
*
*       HDMR    DHEL    DHER    CHNL    CHNR    IHXQF
150012  .04    0.       .047     0.      4.       0
150022  .04    0.       .047     0.     48.       0
150032  .04    0.       .047     0.     12.       0
150042  .112    .0646   .112    14.87   14.87     1
150052  .112    .0646   .112    29.75   29.75     1
150062  .112    .0646   .112    59.5    29.75     1
150072  .112    .0646   .112    44.62   14.87     1
*
*
*  CORE DATA
*      ISLB           CLTI    QFRAC
160010  1              0.       0.282
160020  2              0.       0.436
160030  3              0.       0.282
*
* GEOMETRY DATA
170101  2   3   1   4    .0   .01529     1.    *  FUEL PELLET
170102  1       4   1        3.35-4      0.    *  GAP
170103  0       2   3        1.958-3     0.    *  CLAD
170201  2   1   3   3  .0323  .00417     0.    *  S. G. TUBES
*
*
*  THERMAL CONDUCTIVITY DATA
*
*        THERM COND  UO2  REF GEAP-5591 LYONS ET AL (1968)   95 PCT TH DEN   93
*18XXYY
180101  -15                                                    * THERM COND  UO2  1
180102    32. 5.49  212. 4.40   392. 3.67   752. 2.76         * THERM COND  UO2  2
180103  1112. 2.23  1472. 1.88  1832. 1.65  2192. 1.48        * THERM COND  UO2  3
180104  2500. 1.40  3000. 1.33  3500. 1.33  4000. 1.39        * THERM COND  UO2  4
180105  4500. 1.51  4800. 1.61  5100. 1.73                    * THERM COND  UO2  5
*
*        THERMAL COND  ZR-4  REF  BRASSFIELD(1968)GEMP-482 RECOM... LWR LOCA
180201  -8      0.   8.    1490. 12.32  2150. 17.5          * THERM COND ZR-4   1
180202  2372. 19.7   2552. 21.8   2732. 24.0   3292. 28.9  * THERM COND ZR-4   2
180203  3360. 33.1                                          * THERM COND ZR-4   3
*
180301  -3       212.  10.     752.  11.   1832.  18.      * INCONEL-600
*
* GAP
180400   1          0.  .136
*
*
*  VOLUMETRIC HEAT CAPACITY
*
* SPEC HEAT  U02  REF  BRASSFIELD(1968)GEMP-482 RECOM...LWR LOCA
* SPEC HEAT  U02  95 PCT  TH DEN AT 1000F  642 LB/FT3
* SPEC HEAT  U02  REF  BRASSFIELD(1968)GEMP-482 TOULOUKIAN SAME TO 3750 F
*
190101  -19                                                  * VOL HT CAP U02    1
190102    77. 36.22        100. 37.12        200. 40.05     * VOL HT CAP U02    2
190103   300. 41.98        400. 43.88        600. 45.18     * VOL HT CAP U02    3
190104   800. 46.41       1000. 47.32                       * VOL HT CAP U02    4
190105                                     2400. 50.77     * VOL HT CAP U02    5
190106  2600. 51.43       2800. 52.61       3000. 54.57     * VOL HT CAP U02    6
190107  3200. 57.42       3400. 61.23       3600. 65.93     * VOL HT CAP U02    7
190108  4600. 95.15       4800. 99.31       5000. 101.57    * VOL HT CAP U02    8
190109  5074. 101.76                                        * VOL HT CAP U02    9
*
*        SPEC HEAT  ZR-2   REF BMI-1803 ELDR1DGE ET AL (1967)              DEN 4
190201   15                                              * VOL HT CAP  ZR-2       1
190202    32.  28.75      932.  32.56   1112.  34.40   * VOL HT CAP  ZR-2       2
190203  1184.  35.22    1490.  35.22   1508.  49.14   * VOL HT CAP  ZR-2       3
190204  1544.  57.74    1580.  60.20   1616.  70.43   * VOL HT CAP  ZR-2       4
190205  1652.  79.85    1688.  75.35   1724.  59.38   * VOL HT CAP  ZR-2       5
190206  1760.  45.86    1787.  34.81   3300.  34.81   * VOL HT CAP  ZR-2       6
*
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*        INCONEL-600, CP....REF. NUCLEAR SYSTEMS MATERIALS HANDBOOK, SEC. 3.
190301 -8  200. 57.2600   400. 60.1409   450. 60.6320   500. 61.1216*INCONEL-600
190302     550. 61.6216   600. 62.0564   800. 64.1549  1000. 67.2913
*
* GAP
*        SPEC HEAT  HELIUM  REF  KREITH  AT 1 ATM  DEN 0.012 LB/FT3
190401  -2      32. .0149       3400. .0149               * VOL HT CAP HELIUM 1
*
*
*  COEF OF LINEAR THERMAL EXPANSION
*
*        THERM EXPAN COEF  U02  REF  GEMP-482
200101  -2   0. 3.72-6   4082. 11.0-6                     * EXPAN COEF  U02   1
*
*        THERM EXPAN COEF  ZR-4  REF  GEMP-482 (1968)
200201   -4                                               * THERM EXPAN ZR-4  1
200202     0.  3.10-6   1580.  4.64-6   1584.  5.4-6      * THERM EXPAN ZR-4  2
200203  3400.  5.40-6                                     * THERM EXPAN ZR-4  3
*
200300  -2   0. 0.  2000. 0.            *  INCONEL 600
*
* GAP
200400  -2
200401     0.0    0.0    2000.  0.
*
*
*  HEAT EXCHANGER DATA   FOR  PRESSURIZER HEATERS
*21XXYY  IHTX TRIP  VOL TYPE    KW  TC
210101   0   22   110   5     200. 1.-9    *  CONTROL HEATER
210201   0   23   110   5     900. 30.     * 2 BACKUP HEATERS  450 KW EACH
210301   0   24   110   5     200. 30.     *  CONTROL HEATER
*
*  STEADY STATE CONVERGENCE CARD
230000   -25
*
*
*  POWER BALANCE CARD
*      ISGNUM  JBIAS  JBAL  POWF
230011   1      22     23   1.0
*
*
*  VOLUME INITIAL CONDITIONS
*
*       LVOL   PRES     TEMP      ENTH      X   XNC
231002    2       0.0     0.     622.842    0.   0.
*231017   17       0.0     0.     547.596    0.   0.
231018  110    2220.0     0.       0.0      0.   0.
*231019   19       0.0     0.     697.896    0.   0.
231020   20     871.12    0.     614.934   -1.   0.
*
*  JUNCTION INITIAL CONDITIONS
*
*        JUN  JESTW    WP    SPLTV1    SPLTV2
232002    2      0   28194.
232009    9      1       0.
232012   12      0     856.
232013   13      0   27338.
232017   17      1       0.
*
*
*  NON-EQUILIBRIUM VOLUME DATA
*61XXXY  NEQVOL  SEPFG  VRAIN  IHTC  VLHTC
*610180     110      0     4.0    0     0.0  10
*61XXXY  NEQVOL  SEPFG  NNODEP IHTC  CFCV  CTRB  VRAIN
611180     110      0    10    1     0.0   0.0   4.0
*
*
*  CONTROL SYSTEM DATA
*
701000   5   19
* OVER TEMPERATURE DELTA-T TRIP CONTROL SYSTEM
*702XXX    IDC    VAR    REG   GAIN    CIC
702001      1     TEMP,   2     1.0    606.5      * HOT LEG TEMPERATURE
702002      2     TEMP,   8     1.0    549.51     * COLD LEG TEMPERATURE
702003      3     PRES,  110    1.0   2220.0      * PRESSURIZER  PRESS
702004      4     CONS,   0     1.0      1.0      * CONSTANT BLOCK  1.0
702005      5     CONS,   0    56.99    56.99     * CONSTANT BLOCK 56.99
*
*703XXX   IDC ITYPE  INC1  INC2   CGAIN   CP1    CP2    CIC    CMIN    CMAX
703001    -1   SUM,   1     2       1.0   1.0   -1.0   56.99
703002    -2   SUM,   1     2       0.5   1.0    1.0  578.005
703003    -3   SUM,  -2     4    -0.0107  1.0  -578.005  0.0
703004    -4   SUM,   3     4   0.000453  1.0  -2220.    0.0
703005    -5   SUM,  -4     4       1.0   1.0    0.0     0.0
703006    -6   SUM,  -3    -5       1.0   1.0    1.0     0.0
703007    -7   SUM,  -6     4       1.0   1.0   1.095   1.095
703008    -8   MUL,   5    -7       1.0   0.0    0.0   62.404
703009    -9   SUM,  -8    -1       1.0  -1.0    1.0   -5.414
* OVER POWER DELTA-T TRIP CONTROL SYSTEM
703010   -10   DER,  -2     0       0.2   0.0    0.0     0.0   0.0     1.+9
703011   -11   SUM, -10     4       1.0  -1.0    0.0     0.0
703012   -12   SUM,  -2     4   0.00068   1.0  -578.005  0.0   0.0     1.+9
703013   -13   SUM, -12     4       1.0  -1.0    1.11    1.11
703014   -14   SUM, -11   -13       1.0   1.0    1.0     1.11
703015   -15   MUL, -14     5       1.0   0.0    0.0   63.259
703016   -16   SUM, -15    -1       1.0  -1.0    1.0   -6.269
* PRESSURIZER SPRAY CONTROL SYSTEM
703017   -17   SUM,   3     4       1.0   1.0  -2220.    0.0     0.0   1.+9
703018   -18   FNG, -17     8       1.0   0.0    0.0     7.886-4
703019   -19   LAG, -18     0       1.0   1.0    0.0     7.886-4
* FUNCTION GENERATOR PRESSURIZER SPRAY CONTROL SYSTEM
*
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PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


```
*
*  DNB MODEL DATA
*
*8001XX LWR ICW NUH ICHF ITCROF  NOA     N1
800100   1   0    1   1    0      11     3
*
*8002XX FQENG  FRN  FQUNC FDHCOR FDELH  ZMIN ZMAX
800200   1.03  1.73   1.   .95    1.0     5.   12.
*
*8003XX      PITCH          DIAM          EQHEATDIA     TDC  PF
800300    0.04691666667  0.03516666667     0.04452      .0  0.974
*
*8004XX   Z/L  VS  PROF
800400  0.   .21   .1  .45   .2  .75   .3 1.1   .4 1.33   .5 1.62
800401  0.6 1.81   .7 1.47   .8 1.05   .9  .64  1.  .24
*
*8005XX   NVLDNB(1)    NVLDNB(2) ........NVLDNB(N1)
800500    14     15    16
*
*
* hjk changes
*
* SPECIFY BUBBLE VELOCITY FOR PRESSURIZER
*      ALPH  VBUB
060011   0.1  1.0  21.95   0    * PRESSURIZER                                    *** THIS CARD IS A REPLACEMENT CARD. ***
*
* CHANGE JUNCTION INITIAL CONDITION
* REMOVE FLOW IN JUN 2 and SPECIFY FLOW IN JUN 19
*  JUNCTION INITIAL CONDITIONS
*
*        JUN  JESTW    WP    SPLTV1    SPLTV2
*232002    2      0   27198.
232002                                                                          *** THIS CARD IS A REPLACEMENT CARD. ***
232009    9      1       0.                                                     *** THIS CARD IS A REPLACEMENT CARD. ***
232012   12      0     856.                                                     *** THIS CARD IS A REPLACEMENT CARD. ***
232013   13      0   26338.                                                     *** THIS CARD IS A REPLACEMENT CARD. ***
232017   17      1       0.                                                     *** THIS CARD IS A REPLACEMENT CARD. ***
232019   19      0       4.0
*
* SPECIFY VALVE IN SPRAY JUNCTION AND LINE CONNECTING SPRAY LINE
* PRESSURIZER SPRAY LINE JUNCTIONS
*8XXX1 VI VO PP VV  FLOWRT       AREA   ELEV   INERT    FLOSS   RLOSS
080181 10 17  0  1      0.0      .1015   1.15 247.5    5.         .5
                                                                                *** THIS CARD IS A REPLACEMENT CARD. ***
080191 17 110  0 11      0.0     .253614 42.08 123.3    10.      10.0
                                                                                *** THIS CARD IS A REPLACEMENT CARD. ***
*
* SPECIFY NEW VALVE USED FOR SPRAY JUNCTION
*       ITCV IACV IACV2 PCV CV1 CV2 CV3
110110 -1007   7    0    0.  0.  0.  0.
*
* TURN ON HEATER DURING S.S., TRIP TO OPEN SPRAY VALVE DURING TRANSIENT
*  TIME STEPS
*3XXX0  RTG  MIN  RST  MAJ  DMP NCHK  DTMAX  TLAST
030010  0.   0.01 0.01 0.1  0.1   0    0.01    0.25
                                                                                *** THIS CARD IS A REPLACEMENT CARD. ***
030020  0.   0.05 0.05 0.4  0.4   0    0.01    0.75                            *** THIS CARD IS A REPLACEMENT CARD. ***
030030  0.   0.5  0.5  3.   3.    0    0.05    70.0                            *** THIS CARD IS A REPLACEMENT CARD. ***
* TURN ON HEATER DURING S.S., TRIP TO OPEN SPRAY VALVE DURING TRANSIENT
040370  23     1    0   0        0.     0.    "PRESSUR HEATERS BACKUP    ON  "
                                                                                *** THIS CARD IS A REPLACEMENT CARD. ***
*040420  25     1    0   0        0.     0.25    "URW REACTIVITY INSER    "
040430  7    -6   110   0       13.31   0.0   "LOW PRESSURIZER LEVEL        "
*040340  20     1    0   0        0.     0.    "GENL MISC TRIP AT TIME 0.     "
*
*
703019   -19   LAG, -18     0       1.0   1.0    0.0     1.0
                                                                                *** THIS CARD IS A REPLACEMENT CARD. ***
*
* SUBNODALIZATION DATA  -  HOT LEG
**       SVOL NSUB  SPLT IV   WP     AJUN    ZJUN    INERT   FJNF  FJNR
580011   2    4     0    0    0.0    13.77   0.      0.0     0.0 0.0
**       VRT CHK CAL MVMX  DIAM  CONC IFR TPM IHQ  ISP ANG1 ANG2  SLPMUL
580012   0  -1   2   0     0.    1.  0   0   0   0   0.0  0.0   1.0
**       JUN1  DIST
580013  21    12.0
**
*** SUBNODALIZATION DATA  -  COLD LEG
***       SVOL NSUB  SPLT IV   WP     AJUN    ZJUN    INERT   FJNF  FJNR
580021    10   5     0    0    0.0    12.36   0.      0.0   0.0 0.0
**       VRT CHK CAL MVMX  DIAM  CONC IFR TPM IHQ  ISP ANG1 ANG2  SLPMUL
580022   0  -1   2   0     0.    1.   0   0   0   0    0.0   0.0   1.0
**       JUN1  DIST   JUN2  DIST
580023  24    10.0    18    30.0
*
* SUBNODALIZATION DATA  - PRESSURIZER
*       SVOL NSUB  SPLT IV     WP     AJUN    ZJUN   INERT     FJNF     FJNR
580031   110  10    1    0     0.0     0.0     0.0      0.0      0.0      0.0
*       VRT CHK CAL MVMX  DIAM     CONC   IFR TPM IHQ ISP   ANG1     ANG2
580032   0   -1   2   0    0.       1.0     0   0   0   0       0.       0.
*
*
. END
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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page    1
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:26
 UNCONTROLLED ROD WITHDRAWAL - RETRAN-3D SAMPLE PROBLEM                                                         CPU TIME =     0.031
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *

RETRAN PROBLEM CONTROL AND DESCRIPTION DATA.

    WORD  DESCRIPTION
    ====  ==================================================================
      1   RESTART FILE OPTION (SAVE=-1 / NO SAVE=0) .................... =   -1
      2   PRINTER PLOT OPTION (YES=1 / NO=0) ........................... =    0
      3   POWER OPTION (TAPE OPTNS<0 / NO/TBL=0 / PT KIN=1 / 1D=2 / 3D=3) =    1
      4   USE STEADY-STATE SOLUTION (YES=0 / NO=1) ..................... =    0
      5   USE NEUTRON VOID MODEL (YES=1 / NO=0) ........................ =    0
      6   USE GENERALIZED TRANSPORT MODEL (NO=0 / VAP=1 / LIQ=-1) ....... =    0
      7   HEAT TRANSFER MAP OPTION (FORCED=0 / NAT CONV=1) ............. =    1
      8   SLIP OPTION (DYN=1 / Z-L=2 / C-L=3 / Z-L TAUGL=4 / C-L TAUGL=5) =    0
      9   FIVE-EQUATION OPTION (NO= 0 / YES=1) ......................... =    0
     10   NONCONDENSABLE GAS FLOW OPTION (NO=0 / YES=1) ................ =    0
     11   TH MATRIX DIRECT SOLVER OPTION (4-EQ=2 / 6-EQ=3) ............. =    3
     12   TH MATRIX ITERATIVE SOLVER OPTION (NO<=1 / YES=2) ............ =    0

    (DIMENSIONS AND OPTIONS AUTOMATICALLY DETERMINED BY CONTENT OF INPUT DATA)

          NUMBER OF MINOR EDIT SETS (0200XX DATA )...................... =   20
          NUMBER OF TIME-STEP CONTROL SETS (03XXX0 DATA )............... =    3
          NUMBER OF TRIP CONTROL SETS (04XXX0 DATA ).................... =   43
          NUMBER OF CONTROL VOLUME DESCRIPTIONS (05XXXY DATA )........... =   20
          NUMBER OF BUBBLE RISE DESCRIPTIONS (060XXY DATA) ............. =    2
          NUMBER OF TIME DEPENDENT VOLUMES FORM CARDS (07XXYY DATA) ..... =    0
          NUMBER OF JUNCTION DESCRIPTIONS (08XXXY DATA) ................ =   31
          NUMBER OF CENTRIFUGAL PUMP DESCRIPTIONS (090XXY DATA )......... =    1
          NUMBER OF VALVE DESCRIPTIONS (11XXXY DATA) ................... =   11
          NUMBER OF GENERAL DATA TABLE DESCRIPTIONS (12XXYY DATA) ....... =    8
          NUMBER OF FILL DESCRIPTIONS (13XXYY DATA )..................... =    7
          NUMBER OF HEAT CONDUCTOR DESCRIPTIONS (15XXXY DATA) ........... =    7
          NUMBER OF HEAT CONDUCTOR GEOMETRY DESCRIPTIONS (17XXYY DATA) .. =    2
          NUMBER OF HEAT CONDUCTOR MATERIAL DESCRIPTIONS (18XXYY DATA) .. =    4
          NUMBER OF CORE SECTION DESCRIPTIONS (16XXXY DATA) ............ =    3
          NUMBER OF NON-CONDUCTNG HEAT EXCHNGR DESCRIPTIONS (21XXYY DATA) =    3
          NUMBER OF TIME DEP BCS FROM TAPE (IREAD<0 ON 05XXXY DATA) ..... =    0
          NUMBER OF SPECIFIED HEAT TRAN COEF DESCRIPTIONS (015XXX DATA) . =    0
          TWO-REGION NONEQ VOL DESCRIPTIONS (610XXX OR 611XXX DATA) ..... =    1
          TEMP. TRANSPORT DELAY OPTION (MESH>0 ON 05XXXY DATA) .......... =    0
          AUXILIARY DNB MODEL (8001XX DATA INCLUDED) .................... =    1
          CONTROL SYSTEM MODEL (702XXX OR 702XXXX DATA) ................ =    1
          ACCUMULATOR MODEL DESCRIPTIONS (620XXX OR 621XXX DATA)......... =    0
          DYNAMIC GAP CONDUCTANCE MODEL DESCRIPTIONS (225XX0 DATA) ...... =    0
          NUMBER OF HT CONDUCTOR STACK DESCRIPTIONS (2200XY DATA) ....... =    0
          NUMBER OF TURBINE SHAFT DESCRIPTIONS (500XXY DATA) ........... =    0
          NUMBER OF PROFILE FIT DESCRIPTIONS (061XX1 DATA) ............. =    0
          NUMBER OF STEAM-WATER SEPARATOR DESCRIPTIONS (60XXX0 DATA) .... =    0


                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * *                                                 * * *
                   * * *          STEADY-STATE OPTION    =   0           * * *
                   * * *                                                 * * *
                   * * *          SLIP OPTION            =   0           * * *
                   * * *                                                 * * *
                   * * *          NUMERICS OPTION        =   3           * * *
                   * * *                                                 * * *
                   * * *          HEAT TRANSFER OPTION   =   1           * * *
                   * * *                                                 * * *
                   * * *          NEW EQUATIONS OPTION   =   0           * * *
                   * * *                                                 * * *
                   * * *         USING THE 6-EQ SOLVER - SOLVE4          * * *
                   * * *                                                 * * *
                   * * *      USING STANDARD STEADY-STATE SOLUTION       * * *
                   * * *                                                 * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *


INITIAL THERMAL POWER (MEGAWATTS) =  2.24400E+03


AIR IS THE DEFAULT NONCONDENSABLE GAS.
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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   43
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis               11:57:26
 UNCONTROLLED ROD WITHDRAWAL - RETRAN-3D SAMPLE PROBLEM                                                            CPU TIME =     0.047
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *

  NORMALIZED      CORE          THERMAL       ENERGY        TOTAL MASS    NCG MASS      AVERAGE       CURRENT       ELAPSED      TIME STEP NUM
  CORE            POWER         POWER         BALANCE       BALANCE       BALANCE       TIME STEP     TIME STEP     TIME         STANDRD/ACTUL
  POWER           (MW)          (BTU/HR)      (BTU)         (LBM)         (LBM)         (SEC)         (SEC)         (SEC)                    0
  1.00000E+00     2.24400E+03   7.69557E+09   2.83773E+08   4.88511E+05   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00              0

VOLUME            AVG. PRES.    TOT. MASS     AVG. ENTH.    AVG. DEN.     AVG. TEMP.    AVG. QUAL.    VOID FRAC.    POWR TO H2O
NUMBER            (PSIA)        (LB)          (BTU/LB)      (LB/FT3)      (DEG. F)                                  (BTU/SEC)
     1            2.24180E+03   4.18180E+04   6.22827E+02   4.24851E+01   6.06021E+02   0.00000E+00   0.00000E+00   0.00000E+00
  2001            2.22793E+03   3.13441E+03   6.22827E+02   4.24717E+01   6.05982E+02   0.00000E+00   0.00000E+00   0.00000E+00
  2002            2.22779E+03   3.13433E+03   6.22842E+02   4.24705E+01   6.05992E+02   0.00000E+00   0.00000E+00   0.00000E+00
  2003            2.22765E+03   3.13432E+03   6.22842E+02   4.24704E+01   6.05992E+02   0.00000E+00   0.00000E+00   0.00000E+00
     2            2.22751E+03   3.13431E+03   6.22842E+02   4.24703E+01   6.05991E+02   0.00000E+00   0.00000E+00   0.00000E+00
     3            2.22858E+03   1.72391E+04   6.22842E+02   4.24713E+01   6.05994E+02   0.00000E+00   0.00000E+00   0.00000E+00
     4            2.22055E+03   2.64324E+04   6.06849E+02   4.35102E+01   5.94870E+02   0.00000E+00   0.00000E+00 -8.70014E+05
     5            2.21118E+03   2.74305E+04   5.79958E+02   4.51531E+01   5.75287E+02   0.00000E+00   0.00000E+00 -5.92821E+05
     6            2.20626E+03   2.80650E+04   5.61673E+02   4.61975E+01   5.61373E+02   0.00000E+00   0.00000E+00 -4.01897E+05
     7            2.20655E+03   2.84772E+04   5.49268E+02   4.68761E+01   5.51679E+02   0.00000E+00   0.00000E+00 -2.72925E+05
     8            2.20103E+03   3.77875E+04   5.44250E+02   4.71400E+01   5.47691E+02   0.00000E+00   0.00000E+00   0.00000E+00
     9            2.25025E+03   2.71592E+04   5.44595E+02   4.71513E+01   5.48055E+02   0.00000E+00   0.00000E+00   9.36731E+03
 10001            2.27117E+03   2.33744E+03   5.44595E+02   4.71639E+01   5.48093E+02   0.00000E+00   0.00000E+00   0.00000E+00
 10002            2.27105E+03   2.33744E+03   5.44595E+02   4.71638E+01   5.48093E+02   0.00000E+00   0.00000E+00   0.00000E+00
 10003            2.27093E+03   2.33743E+03   5.44595E+02   4.71637E+01   5.48093E+02   0.00000E+00   0.00000E+00   0.00000E+00
 10004            2.27081E+03   2.33743E+03   5.44595E+02   4.71637E+01   5.48093E+02   0.00000E+00   0.00000E+00   0.00000E+00
    10            2.27069E+03   2.33743E+03   5.44595E+02   4.71636E+01   5.48092E+02   0.00000E+00   0.00000E+00   0.00000E+00
    11            2.26902E+03   3.72537E+04   5.44595E+02   4.71626E+01   5.48089E+02   0.00000E+00   0.00000E+00   0.00000E+00
    12            2.27181E+03   3.80238E+04   5.44595E+02   4.71643E+01   5.48094E+02   0.00000E+00   0.00000E+00   0.00000E+00
    13            2.25490E+03   2.01348E+03   5.44595E+02   4.71541E+01   5.48063E+02   0.00000E+00   0.00000E+00   0.00000E+00
    14            2.26077E+03   7.79190E+03   5.55984E+02   4.65466E+01   5.57062E+02   0.00000E+00   0.00000E+00   5.99937E+05
    15            2.25587E+03   7.51436E+03   5.84982E+02   4.48887E+01   5.79130E+02   0.00000E+00   0.00000E+00   9.27562E+05
    16            2.25095E+03   7.21114E+03   6.13980E+02   4.30773E+01   5.99953E+02   0.00000E+00   0.00000E+00   5.99937E+05
    17            2.27425E+03   2.39366E+02   5.44595E+02   4.71657E+01   5.48099E+02   0.00000E+00   0.00000E+00   0.00000E+00
    19            2.22673E+03   1.05516E+03   6.97712E+02   3.68938E+01   6.52093E+02   0.00000E+00   0.00000E+00   0.00000E+00
    20            8.71120E+02   9.49338E+04   6.14934E+02   1.11125E+01   5.27657E+02   1.37694E-01   7.98434E-01   2.13766E+06
   110 LIQ REG    2.22000E+03   3.10545E+04   6.98013E+02   3.67517E+01   6.52073E+02   7.13060E-04   3.52796E-01   0.00000E+00
       VAP REG                  2.78679E+03   1.12050E+03   6.12455E+00   6.52073E+02   1.00000E+00                 0.00000E+00

JUNCTION    CONNECTS      CHOK/ JUN. FLOW     JUN. ENTH.    JUN. SPVL.    P  R  E  S  S  U  R  E     D  I  F  F  E  R  E  N  T  I  A  L  S
NUMBER      VOLUMES       PATH  (LB/SEC)      (BTU/LB)      (FT3/LB)      VEL. PSI      ELEV. PSI     FRIC. PSI     ACCL. PSI     PUMP PSI
     1         1 TO    2001     2.71940E+04   6.22827E+02   2.35377E-02 -9.91017E+00   2.59650E-01 -4.21552E+00 -4.75192E-12   0.00000E+00
  2001      2001 TO    2002     2.71940E+04   6.22827E+02   2.35451E-02 -7.45088E-03   1.14016E-05 -1.34904E-01 -6.85590E-13   0.00000E+00
  2002      2002 TO    2003     2.71996E+04   6.22842E+02   2.35457E-02 -8.42693E-03   1.35469E-06 -1.34959E-01   5.77094E-13   0.00000E+00
  2003      2003 TO       2     2.71996E+04   6.22842E+02   2.35458E-02 -6.27117E-05   1.27569E-06 -1.34959E-01   2.36500E-12   0.00000E+00
     2         2 TO       3     2.71996E+04   6.22842E+02   2.35459E-02   9.76886E+00 -1.16058E+00 -7.53743E+00   1.98463E-12   0.00000E+00
     3         3 TO       4     2.71996E+04   6.22842E+02   2.35453E-02 -9.29851E-01 -2.99124E+00 -4.11326E+00   7.50808E-08   0.00000E+00
     4         4 TO       5     2.71996E+04   5.90856E+02   2.24681E-02   8.15621E-02 -4.57785E+00 -4.87483E+00   8.40893E-08   0.00000E+00
     5         5 TO       6     2.71996E+04   5.69060E+02   2.18415E-02   4.83949E-02   5.32016E-02 -5.02258E+00 -1.33765E-07   0.00000E+00
     6         6 TO       7     2.71996E+04   5.54285E+02   2.14571E-02   3.01361E-02   4.80557E+00 -4.53994E+00 -1.84363E-07   0.00000E+00
     7         7 TO       8     2.71996E+04   5.44250E+02   2.12119E-02 -5.82667E+00   5.11449E+00 -4.80671E+00 -7.57764E-08   0.00000E+00
     8         8 TO       9     2.71996E+04   5.44250E+02   2.12134E-02   6.85332E+00 -4.11241E-02 -1.21783E+00   9.16668E-08   4.36235E+01
     9         9 TO   10001     2.71996E+04   5.44595E+02   2.12083E-02 -1.10810E+01 -4.73151E-01 -1.11538E+01   2.49717E-11   4.36235E+01
 10001     10001 TO   10002     2.71996E+04   5.44595E+02   2.12027E-02   2.92548E-03   5.63335E-07 -1.20867E-01 -3.73876E-10   0.00000E+00
 10002     10002 TO   10003     2.71996E+04   5.44595E+02   2.12027E-02 -3.35622E-05   5.77475E-07 -1.20868E-01   5.63022E-13   0.00000E+00
 10003     10003 TO   10004     2.71996E+04   5.44595E+02   2.12027E-02 -3.39785E-05   5.77482E-07 -1.20868E-01 -3.10030E-13   0.00000E+00
 10004     10004 TO      10     2.71996E+04   5.44595E+02   2.12028E-02   4.50509E-03   5.55807E-07 -1.20868E-01 -1.59428E-13   0.00000E+00
    10        10 TO      11     2.71940E+04   5.44595E+02   2.12028E-02   9.13337E+00   2.13378E+00 -1.29339E+01   5.10081E-12   0.00000E+00
    11        11 TO      12     2.71940E+04   5.44595E+02   2.12032E-02   1.94314E+00   4.94882E+00 -4.10774E+00   2.00284E-12   0.00000E+00
    12        12 TO      13     8.56000E+02   5.44595E+02   2.12025E-02 -1.35346E-01 -3.57784E+00 -1.32000E+01   4.78728E-13   0.00000E+00
    13        12 TO      14     2.63380E+04   5.44595E+02   2.12025E-02 -8.51854E-01 -2.25956E+00 -7.93077E+00 -6.21725E-14   0.00000E+00
    14        14 TO      15     2.63380E+04   5.67373E+02   2.17798E-02 -6.34856E-02 -1.26993E+00 -3.56361E+00   1.88294E-13   0.00000E+00
    15        15 TO      16     2.63380E+04   6.02591E+02   2.28257E-02 -7.22735E-02 -1.22175E+00 -3.62743E+00   2.31370E-13   0.00000E+00
    16        16 TO       1     2.63380E+04   6.25369E+02   2.36276E-02   8.92761E-01 -2.30360E+00 -7.73780E+00   1.07647E-12   0.00000E+00
    17        13 TO       1     8.56000E+02   5.44595E+02   2.12071E-02   1.35317E-01 -3.67006E+00 -9.56141E+00   6.11955E-13   0.00000E+00
    18        10 TO      17     5.57113E+00   5.44595E+02   2.12028E-02   1.10697E+01 -7.46789E+00 -4.14894E-02   3.94706E-12   0.00000E+00
    19        17 TO     110     5.57113E+00   5.44595E+02   2.12018E-02   6.89376E-03 -6.79770E+00 -4.74609E+01   2.93650E-11   0.00000E+00
    21      2002 TO      19    -5.57113E+00   6.97712E+02   2.71049E-02   0.00000E+00 -1.06576E+00   7.63311E-04 -1.53211E-14   0.00000E+00
110009        19 TO     110    -5.57113E+00   6.97712E+02   2.71125E-02   1.36035E-07 -6.72684E+00   6.37925E-04   2.27374E-13   0.00000E+00
    31         0 TO      20     0.00000E+00   1.19732E+03   5.21811E-01   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
    30         0 TO      20     0.00000E+00   1.19732E+03   5.21811E-01   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
    29         0 TO      20     0.00000E+00   1.19732E+03   5.21811E-01   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
    28         0 TO      20     0.00000E+00   1.19732E+03   5.21811E-01   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
    27         0 TO      20     0.00000E+00   1.19732E+03   5.21811E-01   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
    26         0 TO     110     0.00000E+00   1.12050E+03   1.63277E-01   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
    25         0 TO     110     0.00000E+00   1.12050E+03   1.63277E-01   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
    24         0 TO   10002     0.00000E+00   5.44595E+02   2.12027E-02   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
    23         0 TO      20    -2.73979E+03   1.19732E+03   5.21811E-01   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
    22         0 TO      20     2.73979E+03   4.17089E+02   1.91099E-02   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00

  BUBL            BUBBLE        BUBBLE        MIXTURE       MIXTURE       BUBBLE
  SET    VOL.     GRADIENT      VELOCITY      LEVEL         QUALITY       MASS
  NUMB.  NUMB.    PARAMETER     (FT/SEC)      (FT)                        (LB)
     1    110     1.00000E+00   1.00000E+00   2.19500E+01   7.13060E-04   2.21437E+01
     2     20     0.00000E+00   1.41808E+01   4.95000E+01   1.04605E-01   9.56357E+03

  PUMP   VOL.     PUMP SPEED    NORM. PUMP    NORM. FRIC.   NORM. MOT.    POWER TO H2O
  NUMB.  NUMB.    (RPM)         TORQUE        TORQUE        TORQUE        (BTU/HR)
     1      9     1.18000E+03   9.94238E-01   0.00000E+00   1.00000E+00   3.37223E+07

 HEAT COND.   VOL. HT TRAN    SURF. FLUX    CRIT. FLUX    H.T. COEF.    SURF. TEMP.   MASS FLUX     STORD ENRGY   POWR TO H20   DRYOUT PNT
 NUMBER       NUM. MODE-COR   (BTU/HR-FT2)  (BTU/HR-FT2)  (BTU/H-F2-F)  (DEG. F)      (LBM/HR-FT2)  (BTU)         (BTU/HR)      ()
    1 RGHT      14    1-DB-L  1.52597E+05   9.16986E+05   5.33720E+03   5.85654E+02   2.16724E+06   6.10875E+06   2.15977E+09
    2 RGHT      15    1-DB-L  2.35930E+05   9.18223E+05   5.44056E+03   6.22495E+02   2.16724E+06   7.99299E+06   3.33922E+09
    3 RGHT      16    1-DB-L  1.52597E+05   9.19467E+05   5.55000E+03   6.27448E+02   2.16724E+06   6.36107E+06   2.15977E+09
    4 LEFT       4    1-DB-L -1.02048E+05   8.29783E+05   5.43996E+03   5.76111E+02   2.39761E+06                -3.13205E+09
      RGHT      20    2-THOM  9.03800E+04   2.51851E+05   8.33604E+03   5.38499E+02   2.90951E+05   4.49714E+06   3.13205E+09
    5 LEFT       5    1-DB-L -6.95349E+04   8.31594E+05   5.34210E+03   5.62271E+02   2.39761E+06                -2.13416E+09
      RGHT      20    2-THOM  6.15843E+04   1.38458E+05   6.88111E+03   5.36607E+02   2.90951E+05   4.43034E+06   2.13416E+09
    6 LEFT       7    1-DB-L -3.20127E+04   8.32489E+05   5.23567E+03   5.45565E+02   2.39761E+06                -9.82529E+08
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PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

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        RGHT     20   2-THOM  2.83523E+04  1.38458E+05  4.66894E+03  5.33730E+02  2.90951E+05  4.34694E+06  9.82529E+08
      7 LEFT      6   1-DB-L -4.71406E+04  8.32546E+05  5.27834E+03  5.52442E+02  2.39761E+06              -1.44683E+09
        RGHT     20   2-THOM  4.17505E+04  2.51851E+05  5.66571E+03  5.35026E+02  2.90951E+05  4.38183E+06  1.44683E+09

   CORE    COND.  DEPTH REAC.  DEPTH REAC.  HEAT GEN.    COND. HEAT-  DIR. MODER-  AVG. METAL   CENTERLINE   FUEL
   NUMB.   NUMB.  EXT. ZR-H2O  INT. ZR-H2O  ZR-H2O       ING RATE     ATOR HT RT   TEMPERATURE  TEMPERATURE  ENTHALPY
                  (FT)         (FT)         (BTU/HR)     (BTU/HR)     (BTU/HR)     (DEG. F)     (DEG. F)     (CAL/GM)
      1       1  0.00000E+00  0.00000E+00  0.00000E+00  2.15977E+09  0.00000E+00  1.24439E+03  1.58917E+03  0.00000E+00
      2       2  0.00000E+00  0.00000E+00  0.00000E+00  3.33922E+09  0.00000E+00  1.61721E+03  2.25170E+03  0.00000E+00
      3       3  0.00000E+00  0.00000E+00  0.00000E+00  2.15977E+09  0.00000E+00  1.28877E+03  1.64093E+03  0.00000E+00
0        AVERAGE CORE           MINIMUM  HEIGHT              HOT  SPOT                    MINUMUM DNBR POSITION
           (RETRAN)              (HOT CHANNEL)              (HOT CHANNEL)                    (HOT CHANNEL)
   LHGR(KW/FT)     DNBR      LHGR(KW/FT)     DNBR      LHGR(KW/FT)     DNBR      POS. (FT)    LHGR(KW/FT)  MDNBR
   5.99613E+00  5.09065E+00  1.43439E+01  2.91240E+00  1.82291E+01  1.63188E+00  8.50000E+00  1.49336E+01  1.46116E+00

  REACTOR      FISSION      DECAY HEAT   TOTAL        CONTROL      COOL. TEMP.  VOID         FUEL TEMP.   DOPPLER
  PERIOD       POWER        POWER        REACTIVITY   REACTIVITY   REACTIVITY   REACTIVITY   REACTIVITY   REACTIVITY
  (SEC)                                  ($)          ($)          ($)          ($)          ($)          ($)
  0.00000E+00  1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00

  HEAT EXCGR.   VOLUME   POWR TO H2O
  NUMBER        NUMBER   (BTU/HR)
      1           110    0.00000E+00
      2           110    3.07093E+06
      3           110    0.00000E+00


  DATA RECORD NUMBER     1 WAS WRITTEN TO UNIT 14
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PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE -- NRC APPROVED VERSION 29/08/14 Page 54
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis 11:57:27
UNCONTROLLED ROD WITHDRAWAL - RETRAN-3D SAMPLE PROBLEM CPU TIME = 0.281
* *

NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	ENERGY BALANCE (BTU)	TOTAL MASS BALANCE (LBM)	NCG MASS BALANCE (LBM)	AVERAGE TIME STEP (SEC)	CURRENT TIME STEP (SEC)	ELAPSED TIME (SEC)	TIME STEP NUM STANDRD/ACTUL
8.09849E-01	1.81730E+03	6.23618E+09	2.84359E+08	4.88511E+05	0.00000E+00	2.08333E-02	1.94230E-02	3.00000E+00	120 / 131

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	VOID FRAC.	POWR TO H2O (BTU/SEC)
1	2.26364E+03	4.16898E+04	6.25086E+02	4.23548E+01	6.07618E+02	0.00000E+00	0.00000E+00	0.00000E+00
2001	2.24970E+03	3.12534E+03	6.24972E+02	4.23488E+01	6.07501E+02	0.00000E+00	0.00000E+00	0.00000E+00
2002	2.24975E+03	3.12628E+03	6.24784E+02	4.23616E+01	6.07374E+02	0.00000E+00	0.00000E+00	0.00000E+00
2003	2.24962E+03	3.12733E+03	6.24571E+02	4.23757E+01	6.07229E+02	0.00000E+00	0.00000E+00	0.00000E+00
2	2.24949E+03	3.12826E+03	6.24382E+02	4.23883E+01	6.07100E+02	0.00000E+00	0.00000E+00	0.00000E+00
3	2.25056E+03	1.72266E+04	6.23619E+02	4.24405E+01	6.06585E+02	0.00000E+00	0.00000E+00	0.00000E+00
4	2.24256E+03	2.64171E+04	6.07543E+02	4.34850E+01	5.95419E+02	0.00000E+00	0.00000E+00	-8.50011E+05
5	2.23321E+03	2.74217E+04	5.80479E+02	4.51386E+01	5.75728E+02	0.00000E+00	0.00000E+00	-5.71742E+05
6	2.22830E+03	2.80575E+04	5.62156E+02	4.61851E+01	5.61793E+02	0.00000E+00	0.00000E+00	-3.80985E+05
7	2.22860E+03	2.84702E+04	5.49737E+02	4.68645E+01	5.52092E+02	0.00000E+00	0.00000E+00	-2.52472E+05
8	2.22307E+03	3.77919E+04	5.44396E+02	4.71456E+01	5.47847E+02	0.00000E+00	0.00000E+00	0.00000E+00
9	2.27227E+03	2.71643E+04	5.44677E+02	4.71602E+01	5.48161E+02	0.00000E+00	0.00000E+00	9.36825E+03
10001	2.29313E+03	2.33788E+03	5.44677E+02	4.71726E+01	5.48199E+02	0.00000E+00	0.00000E+00	0.00000E+00
10002	2.29301E+03	2.33787E+03	5.44678E+02	4.71725E+01	5.48200E+02	0.00000E+00	0.00000E+00	0.00000E+00
10003	2.29289E+03	2.33787E+03	5.44679E+02	4.71724E+01	5.48200E+02	0.00000E+00	0.00000E+00	0.00000E+00
10004	2.29276E+03	2.33786E+03	5.44680E+02	4.71723E+01	5.48200E+02	0.00000E+00	0.00000E+00	0.00000E+00
10	2.29264E+03	2.33785E+03	5.44681E+02	4.71722E+01	5.48201E+02	0.00000E+00	0.00000E+00	0.00000E+00
11	2.29095E+03	3.72604E+04	5.44682E+02	4.71711E+01	5.48199E+02	0.00000E+00	0.00000E+00	0.00000E+00
12	2.29372E+03	3.80308E+04	5.44679E+02	4.71729E+01	5.48202E+02	0.00000E+00	0.00000E+00	0.00000E+00
13	2.27676E+03	2.01384E+03	5.44682E+02	4.71626E+01	5.48173E+02	0.00000E+00	0.00000E+00	0.00000E+00
14	2.28266E+03	7.78728E+03	5.56745E+02	4.65190E+01	5.57701E+02	0.00000E+00	0.00000E+00	6.31025E+05
15	2.27776E+03	7.49031E+03	5.87663E+02	4.47450E+01	5.81163E+02	0.00000E+00	0.00000E+00	9.77174E+05
16	2.27282E+03	7.16357E+03	6.18628E+02	4.27931E+01	6.03231E+02	0.00000E+00	0.00000E+00	6.28146E+05
17	2.24714E+03	2.39310E+02	5.44495E+02	4.71548E+01	5.47970E+02	0.00000E+00	0.00000E+00	0.00000E+00
19	2.24797E+03	1.09238E+03	6.81893E+02	3.81951E+01	6.43275E+02	0.00000E+00	0.00000E+00	0.00000E+00
20	8.86796E+02	9.49338E+04	6.18895E+02	1.11125E+01	5.29743E+02	1.40381E-01	7.98517E-01	2.05434E+06
110001	2.24553E+03	4.79903E+03	6.97800E+02	3.69156E+01	6.52198E+02	0.00000E+00	0.00000E+00	0.00000E+00
110002	2.24467E+03	4.79573E+03	6.98094E+02	3.68902E+01	6.52357E+02	0.00000E+00	0.00000E+00	0.00000E+00
110003	2.24380E+03	4.79560E+03	6.98090E+02	3.68893E+01	6.52351E+02	0.00000E+00	0.00000E+00	0.00000E+00
110004	2.24294E+03	4.79548E+03	6.98085E+02	3.68883E+01	6.52346E+02	0.00000E+00	0.00000E+00	0.00000E+00
110005	2.24207E+03	4.79536E+03	6.98080E+02	3.68874E+01	6.52341E+02	0.00000E+00	0.00000E+00	0.00000E+00
110006	2.24121E+03	4.79524E+03	6.98075E+02	3.68864E+01	6.52336E+02	0.00000E+00	0.00000E+00	0.00000E+00
110 LIQ REG	2.24031E+03	2.49804E+03	6.98065E+02	3.68858E+01	6.52328E+02	0.00000E+00	8.69763E-01	0.00000E+00
VAP REG		2.78972E+03	1.12112E+03	6.16818E+00	6.54026E+02	1.00000E+00		0.00000E+00

JUNCTION NUMBER	CONNECTS VOLUMES	CHOK/ PATH	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E VEL. PSI	ELEV. PSI	D I F F E R E N T I A L S FRIC. PSI	ACCL. PSI	PUMP PSI
1	1 TO 2001		2.72899E+04	6.25051E+02	2.36088E-02	-1.00150E+01	2.58857E-01	-4.25892E+00	-7.01277E-02	0.00000E+00
2001	2001 TO 2002		2.72986E+04	6.24877E+02	2.36099E-02	1.68322E-01	-1.25150E-04	-1.36217E-01	-5.74650E-03	0.00000E+00
2002	2002 TO 2003		2.70638E+04	6.24662E+02	2.36018E-02	-6.10330E-03	-1.37044E-04	-1.33992E-01	-2.04707E-03	0.00000E+00
2003	2003 TO 2		2.70720E+04	6.24461E+02	2.35944E-02	-4.89166E-03	-1.20779E-04	-1.34025E-01	-7.09209E-03	0.00000E+00
2	2 TO 3		2.70793E+04	6.24279E+02	2.35877E-02	9.69749E+00	-1.15928E+00	-7.48511E+00	-3.14679E-02	0.00000E+00
3	3 TO 4		2.71055E+04	6.23619E+02	2.35617E-02	-9.26328E-01	-2.98947E+00	-4.08880E+00	-4.46128E-03	0.00000E+00
4	4 TO 5		2.71374E+04	5.91409E+02	2.24764E-02	7.69838E-02	-4.57590E+00	-4.85579E+00	-6.02607E-03	0.00000E+00
5	5 TO 6		2.71646E+04	5.69519E+02	2.18467E-02	4.45318E-02	5.32997E-02	-5.01165E+00	-4.39241E-03	0.00000E+00
6	6 TO 7		2.71878E+04	5.54732E+02	2.14619E-02	2.67181E-02	4.80441E+00	-4.53716E+00	-3.76286E-03	0.00000E+00
7	7 TO 8		2.72099E+04	5.44682E+02	2.12163E-02	-5.83511E+00	5.11426E+00	-4.81115E+00	-1.01440E-02	0.00000E+00
8	8 TO 9		2.72183E+04	5.44333E+02	2.12095E-02	6.86002E+00	-4.11838E-02	-1.21921E+00	1.58634E-02	4.36132E+01
9	9 TO 10001		2.72167E+04	5.44677E+02	2.12044E-02	-1.10921E+01	-4.73239E-01	-1.11651E+01	1.37930E-02	4.36132E+01
10001	10001 TO 10002		2.72166E+04	5.44677E+02	2.11988E-02	3.18020E-03	8.53274E-07	-1.20983E-01	3.53920E-03	0.00000E+00
10002	10002 TO 10003		2.72164E+04	5.44678E+02	2.11988E-02	2.41456E-04	8.48575E-07	-1.20982E-01	3.72771E-03	0.00000E+00
10003	10003 TO 10004		2.72163E+04	5.44678E+02	2.11988E-02	2.78702E-04	1.21010E-06	-1.20981E-01	3.92425E-03	0.00000E+00
10004	10004 TO 10		2.72161E+04	5.44679E+02	2.11989E-02	4.22522E-04	1.16197E-06	-1.20979E-01	3.77617E-03	0.00000E+00
10	10 TO 11		2.72158E+04	5.44682E+02	2.11990E-02	9.14617E+00	2.13416E+00	-1.29512E+01	1.97895E-02	0.00000E+00
11	11 TO 12		2.72136E+04	5.44680E+02	2.11994E-02	1.94575E+00	4.94971E+00	-4.11246E+00	1.00543E-02	0.00000E+00
12	12 TO 13		8.57516E+02	5.44678E+02	2.11986E-02	-1.35761E-01	-3.57848E+00	-1.32447E+01	-3.04172E-04	0.00000E+00
13	12 TO 14		2.63540E+04	5.44679E+02	2.11986E-02	-8.53589E-01	-2.25946E+00	-7.93769E+00	4.25666E-03	0.00000E+00
14	14 TO 15		2.63462E+04	5.68863E+02	2.18127E-02	-6.67264E-02	-1.26751E+00	-3.57022E+00	1.31341E-03	0.00000E+00
15	15 TO 16		2.63271E+04	6.06490E+02	2.29450E-02	-7.65438E-02	-1.21576E+00	-3.64187E+00	5.91889E-04	0.00000E+00
16	16 TO 1		2.63172E+04	6.30580E+02	2.38141E-02	8.96718E-01	-2.29450E+00	-7.78711E+00	-2.10807E-03	0.00000E+00
17	13 TO 1		8.57398E+02	5.44681E+02	2.12033E-02	1.35778E-01	-3.66527E+00	-9.59055E+00	-3.36826E-04	0.00000E+00
18	10 TO 17		1.65878E-01	5.44682E+02	2.11990E-02	1.10916E+01	-7.46627E+00	-4.95835E+01	-3.11599E-03	0.00000E+00
19	17 TO 110		1.05223E-01	5.44418E+02	2.12051E-02	-7.79367E-06	-6.79659E+00	-1.70603E-02	1.61083E-02	0.00000E+00
20	19 TO 110001		2.14496E+02	6.82140E+02	2.61950E-02	7.41435E-05	-1.59665E+00	-1.06069E+00	-6.42857E-03	0.00000E+00
21	2002 TO 19		2.43824E+02	6.24662E+02	2.36018E-02	0.00000E+00	-1.10497E+00	-1.02618E+00	-1.24593E-01	0.00000E+00
110001	110001 TO 110002		2.02369E+02	6.98011E+02	2.71021E-02	1.05480E-05	-8.65396E-01	-4.83671E-07	1.39847E-04	0.00000E+00
110002	110002 TO 110003		1.97880E+02	6.98010E+02	2.71031E-02	7.09036E-06	-8.65100E-01	-4.64228E-07	-2.03429E-04	0.00000E+00
110003	110003 TO 110004		1.93387E+02	6.98010E+02	2.71040E-02	6.93590E-06	-8.65077E-01	-4.45126E-07	-2.01379E-04	0.00000E+00
110004	110004 TO 110005		1.88890E+02	6.98007E+02	2.71049E-02	6.78109E-06	-8.65055E-01	-4.26374E-07	-1.99608E-04	0.00000E+00
110005	110005 TO 110006		1.84389E+02	6.98007E+02	2.71058E-02	6.62593E-06	-8.65033E-01	-4.07971E-07	-1.98095E-04	0.00000E+00
110009	110006 TO 110		1.79884E+02	6.98007E+02	2.71068E-02	6.77359E-05	-8.82515E-01	-9.74806E-07	1.68242E-02	0.00000E+00
31	0 TO 20		0.00000E+00	6.17307E+02	8.88171E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
30	0 TO 20		0.00000E+00	6.17307E+02	8.88171E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
29	0 TO 20		0.00000E+00	6.17307E+02	8.88171E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
28	0 TO 20		0.00000E+00	6.17307E+02	8.88171E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
27	0 TO 20		0.00000E+00	6.17307E+02	8.88171E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
26	0 TO 110		0.00000E+00	1.12110E+03	1.62156E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
25	0 TO 110		0.00000E+00	1.12110E+03	1.62156E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
24	0 TO 10002		0.00000E+00	5.44678E+02	2.11988E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
23	0 TO 20		-2.73979E+03	1.19682E+03	5.11832E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
22	0 TO 20		2.73979E+03	4.17089E+02	1.91099E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

BUBL SET NUMB.	VOL. NUMB.	BUBBLE GRADIENT PARAMETER	BUBBLE VELOCITY (FT/SEC)	MIXTURE LEVEL (FT)	MIXTURE QUALITY	BUBBLE MASS (LB)
1	110	1.00000E+00	1.00000E+00	1.75925E+00	0.00000E+00	0.00000E+00
2	20	0.00000E+00	1.41808E+01	6.19890E+01	1.37949E-01	1.30591E+04

PUMP NUMB.	VOL. NUMB.	PUMP SPEED (RPM)	NORM. PUMP TORQUE	NORM. FRIC. TORQUE	NORM. MOT. TORQUE	POWER TO H2O (BTU/HR)

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


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      1      9   1.18000E+03  9.94337E-01  0.00000E+00  0.00000E+00  3.37257E+07

  HEAT COND.   VOL. HT TRAN   SURF. FLUX   CRIT. FLUX   H.T. COEF.   SURF. TEMP.  MASS FLUX    STORD ENRGY  POWR TO H20  DRYOUT PNT
  NUMBER       NUM. MODE-COR  (BTU/HR-FT2) (BTU/HR-FT2) (BTU/H-F2-F) (DEG. F)     (LBM/HR-FT2) (BTU)        (BTU/HR)     ()
      1 RGHT     14   1-DB-L  1.60504E+05  9.11599E+05  5.34107E+03  5.87764E+02  2.16808E+06  6.25935E+06  2.27169E+09
      2 RGHT     15   1-DB-L  2.48549E+05  9.12722E+05  5.44979E+03  6.26796E+02  2.16706E+06  8.21940E+06  3.51783E+09
      3 RGHT     16   1-DB-L  1.59772E+05  9.13857E+05  5.56603E+03  6.31946E+02  2.16605E+06  6.51631E+06  2.26132E+09
      4 LEFT      4   1-DB-L -9.97020E+04  8.25021E+05  5.42992E+03  5.77045E+02  2.39076E+06               -3.06004E+09
        RGHT     20   2-THOM  8.82971E+04  2.54639E+05  8.34298E+03  5.40336E+02  2.90951E+05  4.50938E+06  3.05987E+09
      5 LEFT      5   1-DB-L -6.70625E+04  8.27033E+05  5.33594E+03  5.63147E+02  2.39336E+06               -2.05827E+09
        RGHT     20   2-THOM  5.93822E+04  1.40568E+05  6.84188E+03  5.38432E+02  2.90951E+05  4.44231E+06  2.05785E+09
      6 LEFT      7   1-DB-L -2.96137E+04  8.28257E+05  5.23663E+03  5.46425E+02  2.39758E+06               -9.08899E+08
        RGHT     20   2-THOM  2.61767E+04  1.40568E+05  4.54257E+03  5.35515E+02  2.90951E+05  4.35868E+06  9.07135E+08
      7 LEFT      6   1-DB-L -4.46876E+04  8.28156E+05  5.27590E+03  5.53311E+02  2.39558E+06               -1.37155E+09
        RGHT     20   2-THOM  3.95554E+04  2.54639E+05  5.58404E+03  5.36837E+02  2.90951E+05  4.39372E+06  1.37076E+09

    CORE   COND.  DEPTH REAC.  DEPTH REAC.  HEAT GEN.    COND. HEAT-  DIR. MODER-  AVG. METAL   CENTERLINE   FUEL
    NUMB.  NUMB.  EXT. ZR-H2O  INT. ZR-H2O  ZR-H2O       ING RATE     ATOR HT RT   TEMPERATURE  TEMPERATURE  ENTHALPY
                  (FT)         (FT)         (BTU/HR)     (BTU/HR)     (BTU/HR)     (DEG. F)     (DEG. F)     (CAL/GM)
       1      1   0.00000E+00  0.00000E+00  0.00000E+00  1.74909E+09  0.00000E+00  1.27484E+03  1.63271E+03  0.00000E+00
       2      2   0.00000E+00  0.00000E+00  0.00000E+00  2.70427E+09  0.00000E+00  1.66099E+03  2.31756E+03  0.00000E+00
       3      3   0.00000E+00  0.00000E+00  0.00000E+00  1.74909E+09  0.00000E+00  1.31963E+03  1.68433E+03  0.00000E+00
0         AVERAGE CORE            MINIMUM  HEIGHT              HOT  SPOT                    MINUMUM DNBR POSITION
            (RETRAN)              (HOT CHANNEL)             (HOT CHANNEL)                  (HOT CHANNEL)
    LHGR(KW/FT)      DNBR      LHGR(KW/FT)      DNBR      LHGR(KW/FT)      DNBR      POS. (FT)    LHGR(KW/FT)  MDNBR
    6.38641E+00  4.75600E+00  1.53658E+01  2.68786E+00  1.95004E+01  1.46471E+00  9.00000E+00  1.39638E+01  1.27071E+00

  REACTOR      FISSION      DECAY HEAT   TOTAL        CONTROL      COOL. TEMP.  VOID         FUEL TEMP.   DOPPLER
  PERIOD       POWER        POWER        REACTIVITY   REACTIVITY   REACTIVITY   REACTIVITY   REACTIVITY   REACTIVITY
  (SEC)                                  ($)          ($)          ($)          ($)          ($)          ($)
 -1.14316E+00  8.09849E-01  0.00000E+00 -2.94725E-01 -2.70785E-01  0.00000E+00  0.00000E+00  0.00000E+00 -2.39405E-02

  HEAT EXCGR.   VOLUME   POWR TO H2O
  NUMBER        NUMBER   (BTU/HR)
      1        110001    0.00000E+00
      2        110001    0.00000E+00
      3        110001    0.00000E+00


  DATA RECORD NUMBER    41 WAS WRITTEN TO UNIT 14

  TRAILER LABEL WRITTEN ON UNIT 14
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PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   55
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:27
 UNCONTROLLED ROD WITHDRAWAL - RETRAN-3D SAMPLE PROBLEM                                                         CPU TIME =     0.281
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *
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SYSTEM ELAPSED TIME (SEC)	SYSTEM ELAPSED TIME (SEC)	TIME STP ACTUAL	VOL 1 AVG. PRESS. (PSIA)	VOL 2 AVG. PRESS. (PSIA)	VOL 19 AVG. PRESS. (PSIA)	VOL 110 AVG. PRESS. (PSIA)	SYSTEM NORM. POWER	VOL 2 AVG. TEMP. (DEG F)
0.00000E+00	0.00000E+00	0.00000E+00	2.24180E+03	2.22751E+03	2.22673E+03	2.22000E+03	1.00000E+00	6.05991E+02
1.00000E-02	1.00000E-02	1.00000E+00	2.24180E+03	2.22751E+03	2.22673E+03	2.22000E+03	1.00059E+00	6.05991E+02
2.00000E-02	2.00000E-02	2.00000E+00	2.24182E+03	2.22752E+03	2.22673E+03	2.22000E+03	1.00137E+00	6.05991E+02
3.00000E-02	3.00000E-02	3.00000E+00	2.24183E+03	2.22753E+03	2.22673E+03	2.21999E+03	1.00216E+00	6.05991E+02
4.00000E-02	4.00000E-02	4.00000E+00	2.24185E+03	2.22754E+03	2.22673E+03	2.21999E+03	1.00296E+00	6.05992E+02
5.00000E-02	5.00000E-02	5.00000E+00	2.24187E+03	2.22755E+03	2.22674E+03	2.21999E+03	1.00375E+00	6.05992E+02
6.00000E-02	6.00000E-02	6.00000E+00	2.24188E+03	2.22757E+03	2.22675E+03	2.21999E+03	1.00455E+00	6.05992E+02
7.00000E-02	7.00000E-02	7.00000E+00	2.24189E+03	2.22759E+03	2.22676E+03	2.21999E+03	1.00536E+00	6.05992E+02
8.00000E-02	8.00000E-02	8.00000E+00	2.24190E+03	2.22760E+03	2.22677E+03	2.21999E+03	1.00617E+00	6.05992E+02
9.00000E-02	9.00000E-02	9.00000E+00	2.24191E+03	2.22762E+03	2.22677E+03	2.21999E+03	1.00698E+00	6.05992E+02
1.00000E-01	1.00000E-01	1.00000E+01	2.24191E+03	2.22763E+03	2.22678E+03	2.21999E+03	1.00779E+00	6.05992E+02
1.10000E-01	1.10000E-01	1.10000E+01	2.24192E+03	2.22764E+03	2.22678E+03	2.21999E+03	1.00861E+00	6.05992E+02
1.20000E-01	1.20000E-01	1.20000E+01	2.24193E+03	2.22765E+03	2.22679E+03	2.21999E+03	1.00943E+00	6.05992E+02
1.30000E-01	1.30000E-01	1.30000E+01	2.24195E+03	2.22766E+03	2.22679E+03	2.21999E+03	1.01026E+00	6.05992E+02
1.40000E-01	1.40000E-01	1.40000E+01	2.24196E+03	2.22767E+03	2.22680E+03	2.21999E+03	1.01109E+00	6.05992E+02
1.50000E-01	1.50000E-01	1.50000E+01	2.24197E+03	2.22768E+03	2.22680E+03	2.21999E+03	1.01192E+00	6.05993E+02
1.60000E-01	1.60000E-01	1.60000E+01	2.24198E+03	2.22769E+03	2.22681E+03	2.21999E+03	1.01276E+00	6.05993E+02
1.70000E-01	1.70000E-01	1.70000E+01	2.24200E+03	2.22770E+03	2.22681E+03	2.21998E+03	1.01360E+00	6.05993E+02
1.80000E-01	1.80000E-01	1.80000E+01	2.24201E+03	2.22771E+03	2.22682E+03	2.21998E+03	1.01444E+00	6.05993E+02
1.90000E-01	1.90000E-01	1.90000E+01	2.24202E+03	2.22772E+03	2.22682E+03	2.21998E+03	1.01529E+00	6.05994E+02
2.00000E-01	2.00000E-01	2.00000E+01	2.24203E+03	2.22773E+03	2.22683E+03	2.21998E+03	1.01614E+00	6.05994E+02
2.10000E-01	2.10000E-01	2.10000E+01	2.24204E+03	2.22774E+03	2.22683E+03	2.21998E+03	1.01699E+00	6.05995E+02
2.20000E-01	2.20000E-01	2.20000E+01	2.24205E+03	2.22775E+03	2.22684E+03	2.21998E+03	1.01785E+00	6.05995E+02
2.30000E-01	2.30000E-01	2.30000E+01	2.24206E+03	2.22776E+03	2.22684E+03	2.21998E+03	1.01871E+00	6.05996E+02
2.40000E-01	2.40000E-01	2.40000E+01	2.24206E+03	2.22777E+03	2.22684E+03	2.21998E+03	1.01957E+00	6.05997E+02
2.50000E-01	2.50000E-01	2.50000E+01	2.24207E+03	2.22778E+03	2.22685E+03	2.21998E+03	1.02044E+00	6.05997E+02
3.00000E-01	3.00000E-01	3.00000E+01	2.24211E+03	2.22782E+03	2.22687E+03	2.21998E+03	1.02482E+00	6.05996E+02
3.50000E-01	3.50000E-01	3.50000E+01	2.24214E+03	2.22785E+03	2.22688E+03	2.21999E+03	1.02928E+00	6.05992E+02
4.00000E-01	4.00000E-01	4.00000E+01	2.24217E+03	2.22787E+03	2.22688E+03	2.21999E+03	1.03382E+00	6.05991E+02
4.50000E-01	4.50000E-01	4.50000E+01	2.24219E+03	2.22790E+03	2.22689E+03	2.21999E+03	1.03844E+00	6.05989E+02
5.00000E-01	5.00000E-01	5.00000E+01	2.24221E+03	2.22792E+03	2.22691E+03	2.22000E+03	1.04313E+00	6.05987E+02
5.50000E-01	5.50000E-01	5.50000E+01	2.24224E+03	2.22794E+03	2.22692E+03	2.22001E+03	1.04790E+00	6.05985E+02
6.00000E-01	6.00000E-01	6.00000E+01	2.24226E+03	2.22796E+03	2.22694E+03	2.22002E+03	1.05275E+00	6.05984E+02
6.50000E-01	6.50000E-01	6.50000E+01	2.24228E+03	2.22798E+03	2.22695E+03	2.22003E+03	1.05767E+00	6.05984E+02
7.00000E-01	7.00000E-01	7.00000E+01	2.24231E+03	2.22801E+03	2.22698E+03	2.22005E+03	1.06266E+00	6.05984E+02
7.50000E-01	7.50000E-01	7.50000E+01	2.24235E+03	2.22805E+03	2.22700E+03	2.22007E+03	1.06773E+00	6.05984E+02
1.25000E+00	1.25000E+00	8.50000E+01	2.24319E+03	2.22886E+03	2.22757E+03	2.22039E+03	1.12279E+00	6.06006E+02
1.75000E+00	1.75000E+00	9.50000E+01	2.24458E+03	2.23023E+03	2.22863E+03	2.22112E+03	1.18467E+00	6.06101E+02
2.25000E+00	2.25000E+00	1.05000E+02	2.24672E+03	2.23235E+03	2.23037E+03	2.22273E+03	1.25363E+00	6.06340E+02
2.75000E+00	2.75000E+00	1.19000E+02	2.25934E+03	2.24504E+03	2.24193E+03	2.23294E+03	1.02476E+00	6.06814E+02
3.00000E+00	3.00000E+00	1.31000E+02	2.26364E+03	2.24949E+03	2.24797E+03	2.24031E+03	8.09849E-01	6.07100E+02

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   56
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:27
 UNCONTROLLED ROD WITHDRAWAL - RETRAN-3D SAMPLE PROBLEM                                                         CPU TIME =     0.281
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *
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SYSTEM ELAPSED TIME (SEC)	VOL 19 AVG. TEMP. (DEG F)	VOL 17 AVG. TEMP. (DEG F)	JUN 13 FLOW (LB/SEC)	JUN 1 FLOW (LB/SEC)	JUN 19 FLOW (LB/SEC)	JUN 21 FLOW (LB/SEC)	JUN 20 FLOW (LB/SEC)	JUN 2 FLOW (LB/SEC)
0.00000E+00	6.52093E+02	5.48099E+02	2.63380E+04	2.71940E+04	5.57113E+00	-5.57113E+00	-5.57113E+00	2.71996E+04
1.00000E-02	6.52093E+02	5.48042E+02	2.63385E+04	2.71941E+04	5.05902E+00	-5.56822E+00	-5.56729E+00	2.71996E+04
2.00000E-02	6.52093E+02	5.47972E+02	2.63394E+04	2.71942E+04	4.22413E+00	-5.55787E+00	-5.55994E+00	2.71997E+04
3.00000E-02	6.52093E+02	5.47909E+02	2.63401E+04	2.71945E+04	3.22720E+00	-5.53625E+00	-5.54558E+00	2.71998E+04
4.00000E-02	6.52093E+02	5.47864E+02	2.63405E+04	2.71949E+04	2.18021E+00	-5.50236E+00	-5.52021E+00	2.72001E+04
5.00000E-02	6.52094E+02	5.47840E+02	2.63407E+04	2.71952E+04	1.17744E+00	-5.45487E+00	-5.48029E+00	2.72003E+04
6.00000E-02	6.52094E+02	5.47836E+02	2.63407E+04	2.71955E+04	3.25153E-01	-5.39584E+00	-5.42448E+00	2.72006E+04
7.00000E-02	6.52094E+02	5.47847E+02	2.63407E+04	2.71957E+04	-2.41596E-01	-5.32432E+00	-5.35296E+00	2.72007E+04
8.00000E-02	6.52094E+02	5.47865E+02	2.63406E+04	2.71958E+04	-2.36582E-01	-5.24195E+00	-5.26691E+00	2.72007E+04
9.00000E-02	6.52094E+02	5.47874E+02	2.63406E+04	2.71958E+04	-9.05929E-02	-5.14773E+00	-5.16883E+00	2.72007E+04
1.00000E-01	6.52094E+02	5.47874E+02	2.63405E+04	2.71958E+04	7.40410E-02	-5.04314E+00	-5.06087E+00	2.72005E+04
1.10000E-01	6.52094E+02	5.47873E+02	2.63405E+04	2.71957E+04	2.22036E-01	-4.92951E+00	-4.94427E+00	2.72004E+04
1.20000E-01	6.52094E+02	5.47870E+02	2.63405E+04	2.71957E+04	2.63468E-01	-4.80566E+00	-4.81954E+00	2.72002E+04
1.30000E-01	6.52094E+02	5.47868E+02	2.63405E+04	2.71956E+04	2.38016E-01	-4.67007E+00	-4.68581E+00	2.72000E+04
1.40000E-01	6.52094E+02	5.47867E+02	2.63405E+04	2.71957E+04	1.92058E-01	-4.52845E+00	-4.54349E+00	2.71999E+04
1.50000E-01	6.52094E+02	5.47868E+02	2.63406E+04	2.71957E+04	1.56434E-01	-4.37787E+00	-4.39275E+00	2.71998E+04
1.60000E-01	6.52094E+02	5.47868E+02	2.63406E+04	2.71958E+04	1.42112E-01	-4.21747E+00	-4.23321E+00	2.71997E+04
1.70000E-01	6.52094E+02	5.47869E+02	2.63406E+04	2.71960E+04	1.45002E-01	-4.04788E+00	-4.06449E+00	2.71997E+04
1.80000E-01	6.52094E+02	5.47869E+02	2.63406E+04	2.71962E+04	1.55028E-01	-3.87044E+00	-3.88679E+00	2.71996E+04
1.90000E-01	6.52094E+02	5.47869E+02	2.63406E+04	2.71964E+04	1.63868E-01	-3.68444E+00	-3.70039E+00	2.71996E+04
2.00000E-01	6.52094E+02	5.47869E+02	2.63406E+04	2.71966E+04	1.68034E-01	-3.49099E+00	-3.50589E+00	2.71996E+04
2.10000E-01	6.52094E+02	5.47869E+02	2.63406E+04	2.71968E+04	1.68006E-01	-3.28945E+00	-3.30371E+00	2.71996E+04
2.20000E-01	6.52094E+02	5.47869E+02	2.63407E+04	2.71970E+04	1.65953E-01	-3.08076E+00	-3.09429E+00	2.71996E+04
2.30000E-01	6.52094E+02	5.47869E+02	2.63407E+04	2.71972E+04	1.63859E-01	-2.86473E+00	-2.87790E+00	2.71996E+04
2.40000E-01	6.52094E+02	5.47869E+02	2.63407E+04	2.71974E+04	1.62712E-01	-2.64174E+00	-2.65473E+00	2.71995E+04
2.50000E-01	6.52094E+02	5.47869E+02	2.63407E+04	2.71976E+04	1.62559E-01	-2.41048E+00	-2.42438E+00	2.71994E+04
3.00000E-01	6.52094E+02	5.47869E+02	2.63407E+04	2.71986E+04	1.63764E-01	-1.17388E+00	-1.18480E+00	2.71989E+04
3.50000E-01	6.52094E+02	5.47869E+02	2.63407E+04	2.71998E+04	1.63574E-01	1.89341E-01	1.79377E-01	2.71984E+04
4.00000E-01	6.52092E+02	5.47869E+02	2.63406E+04	2.72011E+04	1.63572E-01	1.81636E+00	1.49724E+00	2.71986E+04
4.50000E-01	6.52087E+02	5.47869E+02	2.63405E+04	2.72025E+04	1.63537E-01	3.49759E+00	2.90974E+00	2.71985E+04
5.00000E-01	6.52078E+02	5.47869E+02	2.63404E+04	2.72040E+04	1.63473E-01	5.24946E+00	4.36766E+00	2.71983E+04
5.50000E-01	6.52066E+02	5.47869E+02	2.63401E+04	2.72055E+04	1.63425E-01	7.04827E+00	5.86733E+00	2.71983E+04
6.00000E-01	6.52050E+02	5.47869E+02	2.63398E+04	2.72072E+04	1.63369E-01	8.88876E+00	7.40238E+00	2.71982E+04
6.50000E-01	6.52031E+02	5.47869E+02	2.63395E+04	2.72089E+04	1.63314E-01	1.07734E+01	8.97314E+00	2.71982E+04
7.00000E-01	6.52008E+02	5.47869E+02	2.63391E+04	2.72107E+04	1.63263E-01	1.27094E+01	1.05872E+01	2.71982E+04
7.50000E-01	6.51981E+02	5.47869E+02	2.63387E+04	2.72126E+04	1.63216E-01	1.47132E+01	1.22579E+01	2.71982E+04
1.25000E+00	6.51422E+02	5.47871E+02	2.63335E+04	2.72379E+04	1.62890E-01	4.42616E+01	3.70133E+01	2.71969E+04
1.75000E+00	6.50109E+02	5.47874E+02	2.63281E+04	2.72741E+04	1.62065E-01	9.39998E+01	7.93196E+01	2.71905E+04
2.25000E+00	6.47847E+02	5.47881E+02	2.63212E+04	2.73151E+04	1.61329E-01	1.55923E+02	1.33519E+02	2.71794E+04
2.75000E+00	6.45073E+02	5.47933E+02	2.63248E+04	2.73009E+04	1.18986E-01	2.12170E+02	1.84350E+02	2.71112E+04
3.00000E+00	6.43275E+02	5.47970E+02	2.63540E+04	2.72899E+04	1.05223E-01	2.43824E+02	2.14496E+02	2.70793E+04

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   57
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis             11:57:27
 UNCONTROLLED ROD WITHDRAWAL - RETRAN-3D SAMPLE PROBLEM                                                         CPU TIME =    0.281
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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SYSTEM ELAPSED TIME (SEC)	BUBL 110 MIX. LEVEL (FEET)	VOL 110 AVG ENTHALPY (BTU/LB)	BUBL 110 BUBBLE MASS (LB)	NEQV 110 CUM.MIX LVL (FEET)
0.00000E+00	2.19500E+01	7.32804E+02	2.21437E+01	2.19500E+01
1.00000E-02	2.19500E+01	7.32804E+02	2.21419E+01	2.19500E+01
2.00000E-02	2.19499E+01	7.32804E+02	2.21386E+01	2.19500E+01
3.00000E-02	2.19499E+01	7.32804E+02	2.21337E+01	2.19499E+01
4.00000E-02	2.19498E+01	7.32804E+02	2.21271E+01	2.19499E+01
5.00000E-02	2.19498E+01	7.32804E+02	2.21189E+01	2.19498E+01
6.00000E-02	2.19497E+01	7.32804E+02	2.21093E+01	2.19498E+01
7.00000E-02	2.19496E+01	7.32804E+02	2.20989E+01	2.19497E+01
8.00000E-02	2.19495E+01	7.32804E+02	2.20918E+01	2.19496E+01
9.00000E-02	2.19494E+01	7.32804E+02	2.20826E+01	2.19495E+01
1.00000E-01	2.19493E+01	7.32804E+02	2.20713E+01	2.19494E+01
1.10000E-01	2.19492E+01	7.32804E+02	2.20613E+01	2.19493E+01
1.20000E-01	2.19492E+01	7.32805E+02	2.20511E+01	2.19492E+01
1.30000E-01	2.19491E+01	7.32805E+02	2.20406E+01	2.19492E+01
1.40000E-01	2.19490E+01	7.32805E+02	2.20297E+01	2.19491E+01
1.50000E-01	2.19489E+01	7.32805E+02	2.20184E+01	2.19490E+01
1.60000E-01	2.19488E+01	7.32805E+02	2.20069E+01	2.19489E+01
1.70000E-01	2.19487E+01	7.32805E+02	2.19951E+01	2.19488E+01
1.80000E-01	2.19486E+01	7.32805E+02	2.19830E+01	2.19487E+01
1.90000E-01	2.19486E+01	7.32805E+02	2.19705E+01	2.19486E+01
2.00000E-01	2.19485E+01	7.32805E+02	2.19577E+01	2.19486E+01
2.10000E-01	2.19484E+01	7.32805E+02	2.19445E+01	2.19485E+01
2.20000E-01	2.19483E+01	7.32805E+02	2.19309E+01	2.19484E+01
2.30000E-01	2.19482E+01	7.32805E+02	2.19169E+01	2.19483E+01
2.40000E-01	2.19481E+01	7.32806E+02	2.19025E+01	2.19482E+01
2.50000E-01	2.19481E+01	7.32806E+02	2.18877E+01	2.19481E+01
3.00000E-01	2.19477E+01	7.32806E+02	2.18067E+01	2.19477E+01
3.50000E-01	2.19473E+01	7.32806E+02	2.17135E+01	2.19473E+01
4.00000E-01	2.19469E+01	7.32806E+02	2.16079E+01	2.19469E+01
4.50000E-01	2.19465E+01	7.32807E+02	2.14896E+01	2.19466E+01
5.00000E-01	2.19461E+01	7.32807E+02	2.13549E+01	2.19462E+01
5.50000E-01	2.19458E+01	7.32807E+02	2.12054E+01	2.19458E+01
6.00000E-01	2.19454E+01	7.32807E+02	2.10412E+01	2.19455E+01
6.50000E-01	2.19451E+01	7.32807E+02	2.08619E+01	2.19451E+01
7.00000E-01	2.19448E+01	7.32806E+02	2.06672E+01	2.19448E+01
7.50000E-01	2.19444E+01	7.32806E+02	2.04566E+01	2.19445E+01
1.25000E+00	2.19423E+01	7.32798E+02	1.71354E+01	2.19424E+01
1.75000E+00	2.19428E+01	7.32773E+02	1.05161E+01	2.19426E+01
2.25000E+00	2.19491E+01	7.32721E+02	0.00000E+00	2.19467E+01
2.75000E+00	1.72899E+00	9.22980E+02	0.00000E+00	2.19909E+01
3.00000E+00	1.75925E+00	9.21261E+02	0.00000E+00	2.20188E+01

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7.0 TWO-DIMENSIONAL FLOW FIELD

The sample problem is a symmetric model to illustrate a usage of the vector momentum feature in RETRAN-3D. The model is of a rectangular region with three sources (fills) and one sink (time-dependent volume). A schematic diagram of the model is given in Figure VII.7-1.

Initially, the system is filled with subcooled water and is at a constant pressure with zero junction flows. Three identical fills are tripped after time zero. The fill flows force flows and pressure increases throughout the system. A transient is run to achieve a new steady-state pressure and flow distribution.

Input for the Two-Dimensional Flow Field sample problem and selected portions of the output are shown below.

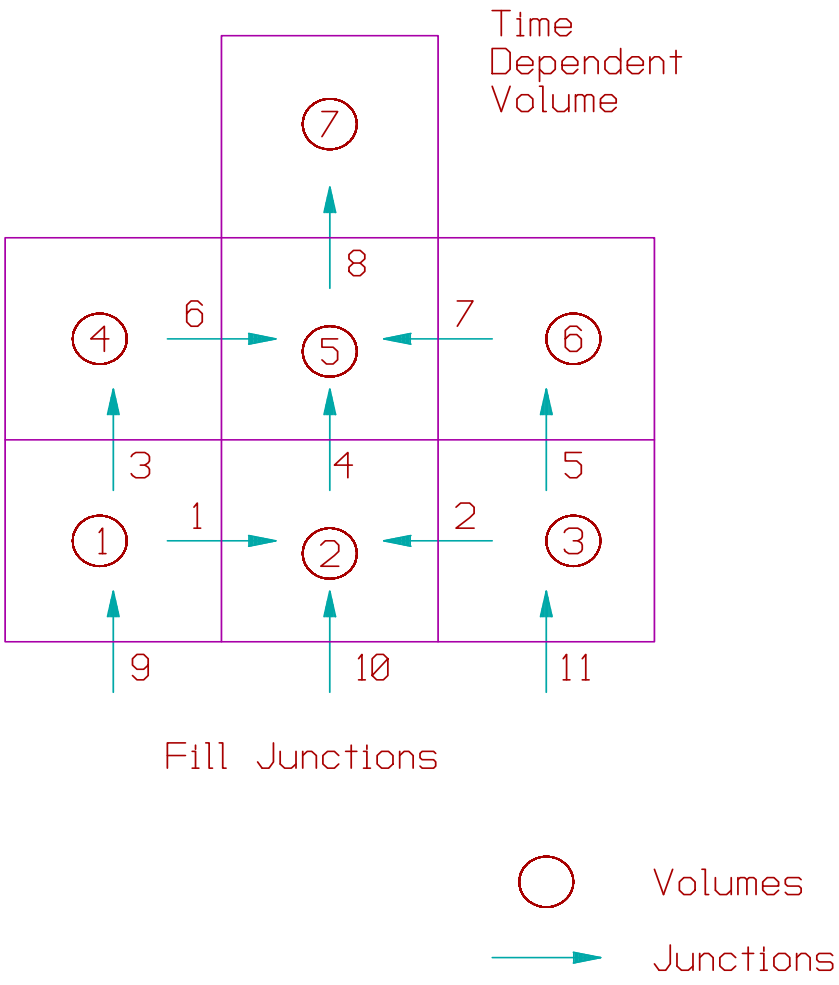


Figure VII.7-1. Schematic Diagram of the Two-Dimensional Flow Field

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


```
 LISTING OF INPUT DATA FOR CASE  1

    1    =TWO-DIMENSIONAL FLOW FIELD - RETRAN-3D SAMPLE PROBLEM
    2    *
    3    ********************************************************************************
    4    *
    5    *  PROBLEM DIMENSIONS
    6    *
    7    *        1     2     3     4     5     6     7     8     9    10    11    12
    8    *      TAPE PRNPLT  POW    SS  NVOID GENTRN HTMAP SLIP  5EQ  NCOND  NSOL  PNMTH
    9    010001   0     0     0     1     0     0     0     0     0     0     2     0
   10    *
   11    *
   12    *      POWER
   13    010005   0.0
   14    *
   15    *
   16    020000 TIMX  0 NTTS  0
   17    020001 PRES  4 PRES  6
   18    020002 WP**  1 WP**  2
   19    020002 WP**  3 WP**  4 WP**  5
+                                                                                *** THIS CARD IS A REPLACEMENT CARD. ***
   20    *
   21    *
   22    * FORMAT FOR TAPE60
   23    *
   24    025000 1
   25    025001 '(5(1X,1P,E15.7))'
   26    *
   27    *
   28    *  TIME STEP DATA
   29    *       RTG  MIN   RST   MAJ  DMP  NCHK  DELTM  TLAST
   30    030010  0.   0.002 0.002 0.05 0.05   0   0.001  0.02
   31    030020  0.   0.01  0.01  0.1  0.1    0   0.002  10.0
   32    *
   33    *
   34    *   TRIP CONTROL DATA
   35    *     IDTRP IDSIG IX1 IX2  SETPT  DELAY   DESCRIPTION
   36    040010  1     1    0   0    .10     0    "PROBLEM END TRIP"
   37    040020  2     1    0   0   0.00     0    "FILL TRIP"
   38    *
   39    *
   40    *  VOLUME DATA
   41    *        1     2    3    4     5      6         7
   42    *     IBUB  IREAD  P   TEMP   X      V       ZVOL
   43    050011  0     0   0.0   0.0  0.0  5.787-4  8.333-2
   44    050021  0     0   0.0   0.0  0.0  5.787-4  8.333-2
   45    050031  0     0   0.0   0.0  0.0  5.787-4  8.333-2
   46    050041  0     0   0.0   0.0  0.0  5.787-4  8.333-2
   47    050051  0     0   0.0   0.0  0.0  5.787-4  8.333-2
   48    050061  0     0   0.0   0.0  0.0  5.787-4  8.333-2
   49    050071  0     1   0.0   0.0  0.0  5.787-4  8.333-2
   50    *
   51    *          8       9        10     11    12
   52    *        FLOWL    FLOWA   DIAMV  ELEV  EOVRD
   53    050012    0.0    6.944-3  1.0+9  0.0    0.0
   54    050022    0.0    6.944-3  1.0+9  0.0    0.0
   55    050032    0.0    6.944-3  1.0+9  0.0    0.0
   56    050042    0.0    6.944-3  1.0+9  0.0    0.0
   57    050052    0.0    6.944-3  1.0+9  0.0    0.0
   58    050062    0.0    6.944-3  1.0+9  0.0    0.0
   59    050072    0.0    6.944-3  1.0+9  0.0    0.0
   60    *
   61    *
   62    *  TIME DEPENDENT VOLUME DATA
   63    *    IRIN  TIMTBL  PTABL  TTABL  XTABL  ZTABL
   64    070100  1   0.0    70.0   91.80   0.0   0.08333
   65    *
   66    *
   67    *  JUNCTION DATA CARDS
   68    *       IW1  IW2  IPUMP IVALVE WP   AJUN     ZJUN     INERTA  FJUNF FJUNR
   69    080011   1    2     0     0    0.0  6.944-3  4.167-2  0.0     0.0   0.0
   70    080021   3    2     0     0    0.0  6.944-3  4.167-2  0.0     0.0   0.0
   71    080031   1    4     0     0    0.0  6.944-3  4.167-2  0.0     0.0   0.0
   72    080041   2    5     0     0    0.0  6.944-3  4.167-2  0.0     0.0   0.0
   73    080051   3    6     0     0    0.0  6.944-3  4.167-2  0.0     0.0   0.0
   74    080061   4    5     0     0    0.0  6.944-3  4.167-2  0.0     0.0   0.0
   75    080071   6    5     0     0    0.0  6.944-3  4.167-2  0.0     0.0   0.0
   76    080081   5    7     0     0    0.0  6.944-3  4.167-2  0.0     0.0   0.0
   77    080091   0    1     1     0    0.0  6.944-3  4.167-2  0.0     0.0   0.0
   78    080101   0    2     1     0    0.0  6.944-3  4.167-2  0.0     0.0   0.0
   79    080111   0    3     1     0    0.0  6.944-3  4.167-2  0.0     0.0   0.0
   80    *
   81    *      JVERT JCHOK JCALC MVMIX DIAMJ CONCO IFRJ JTPMJ IHQCOR ISP ANGLJ1 ANGLJ2
   82    080012   1     -1     2     3     0    0.6   0    0      0      0   90.    90.
   83    080022   1     -1     2     3     0    0.6   0    0      0      0   90.    90.
   84    080032   1     -1     2     0     0    0.6   0    0      0      0
   85    080042   1     -1     2     0     0    0.6   0    0      0      0
   86    080052   1     -1     2     0     0    0.6   0    0      0      0
   87    080062   1     -1     2     3     0    0.6   0    0      0      0   90.    90.
   88    080072   1     -1     2     3     0    0.6   0    0      0      0   90.    90.
   89    080082   1     -1     2     0     0    0.6   0    0      0      0
   90    080092   1     -1     2     0     0    0.6   0    0      0      0
   91    080102   1     -1     2     0     0    0.6   0    0      0      0
   92    080112   1     -1     2     0     0    0.6   0    0      0      0
   93    *
   94    *
   95    *  FILL TABLE DATA
   96    130100  -3  2  0  -1   0.0   0.0      60.0  70.0
   97    +                     0.01 21.66528  60.0  70.0
   98    +                   100.0  21.66528  60.0  70.0
   99    *
```


PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

```
100    *
101    *  VOLUME INITIAL CONDITIONS
102    *
103    *       LVOL    PRES      TEMP       ENTH       X    XNC
104    231001   1     70.0       0.        60.0      0.0  0.0
105    231002   2     70.0       0.        60.0      0.0  0.0
106    231003   3     70.0       0.        60.0      0.0  0.0
107    231004   4     70.0       0.        60.0      0.0  0.0
108    231005   5     70.0       0.        60.0      0.0  0.0
109    231006   6     70.0       0.        60.0      0.0  0.0
110    231007   7     70.0       0.        60.0      0.0  0.0
111    *
112    *
113    . END
```

```
RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page    1
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:35
 TWO-DIMENSIONAL FLOW FIELD - RETRAN-3D SAMPLE PROBLEM                                                          CPU TIME =     0.000
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

RETRAN PROBLEM CONTROL AND DESCRIPTION DATA.

    WORD  DESCRIPTION
    ====  ======================================================================
      1   RESTART FILE OPTION (SAVE=-1 / NO SAVE=0) .................... =    0
      2   PRINTER PLOT OPTION (YES=1 / NO=0) ........................... =    0
      3   POWER OPTION (TAPE OPTNS<0 / NO/TBL=0 / PT KIN=1 / 1D=2 / 3D=3) =    0
      4   USE STEADY-STATE SOLUTION (YES=0 / NO=1) ..................... =    1
      5   USE NEUTRON VOID MODEL (YES=1 / NO=0) ........................ =    0
      6   USE GENERALIZED TRANSPORT MODEL (NO=0 / VAP=1 / LIQ=-1) ....... =    0
      7   HEAT TRANSFER MAP OPTION (FORCED=0 / NAT CONV=1) ............. =    0
      8   SLIP OPTION (DYN=1 / Z-L=2 / C-L=3 / Z-L TAUGL=4 / C-L TAUGL=5) =    0
      9   FIVE-EQUATION OPTION (NO= 0 / YES=1) ......................... =    0
     10   NONCONDENSABLE GAS FLOW OPTION (NO=0 / YES=1) ................ =    0
     11   TH MATRIX DIRECT SOLVER OPTION (4-EQ=2 / 6-EQ=3) ............. =    2
     12   TH MATRIX ITERATIVE SOLVER OPTION (NO<=1 / YES=2) ............ =    0

    (DIMENSIONS AND OPTIONS AUTOMATICALLY DETERMINED BY CONTENT OF INPUT DATA)

          NUMBER OF MINOR EDIT SETS (0200XX DATA )...................... =    7
          NUMBER OF TIME-STEP CONTROL SETS (03XXX0 DATA )............... =    2
          NUMBER OF TRIP CONTROL SETS (04XXX0 DATA )..................... =    2
          NUMBER OF CONTROL VOLUME DESCRIPTIONS (05XXXY DATA )........... =    7
          NUMBER OF BUBBLE RISE DESCRIPTIONS (060XXY DATA) ............. =    0
          NUMBER OF TIME DEPENDENT VOLUMES FORM CARDS (07XXYY DATA) ..... =    1
          NUMBER OF JUNCTION DESCRIPTIONS (08XXXY DATA) ................ =   11
          NUMBER OF CENTRIFUGAL PUMP DESCRIPTIONS (090XXY DATA )......... =    0
          NUMBER OF VALVE DESCRIPTIONS (11XXXY DATA) ................... =    0
          NUMBER OF GENERAL DATA TABLE DESCRIPTIONS (12XXYY DATA) ....... =    0
          NUMBER OF FILL DESCRIPTIONS (13XXYY DATA )..................... =    1
          NUMBER OF HEAT CONDUCTOR DESCRIPTIONS (15XXXY DATA) .......... =    0
          NUMBER OF HEAT CONDUCTOR GEOMETRY DESCRIPTIONS (17XXYY DATA) .. =    0
          NUMBER OF HEAT CONDUCTOR MATERIAL DESCRIPTIONS (18XXYY DATA) .. =    0
          NUMBER OF CORE SECTION DESCRIPTIONS (16XXXY DATA) ............ =    0
          NUMBER OF NON-CONDUCTNG HEAT EXCHNGR DESCRIPTIONS (21XXYY DATA) =    0
          NUMBER OF TIME DEP BCS FROM TAPE (IREAD<0 ON 05XXXY DATA) ..... =    0
          NUMBER OF SPECIFIED HEAT TRAN COEF DESCRIPTIONS (015XXX DATA) . =    0
          TWO-REGION NONEQ VOL DESCRIPTIONS (610XXX OR 611XXX DATA) ..... =    0
          TEMP. TRANSPORT DELAY OPTION (MESH>0 ON 05XXXY DATA) ......... =    0
          AUXILIARY DNB MODEL (8001XX DATA INCLUDED) ................... =    0
          CONTROL SYSTEM MODEL (702XXX OR 702XXXX DATA) ................ =    0
          ACCUMULATOR MODEL DESCRIPTIONS (620XXX OR 621XXX DATA)......... =    0
          DYNAMIC GAP CONDUCTANCE MODEL DESCRIPTIONS (225XX0 DATA) ...... =    0
          NUMBER OF HT CONDUCTOR STACK DESCRIPTIONS (2200XY DATA) ....... =    0
          NUMBER OF TURBINE SHAFT DESCRIPTIONS (500XXY DATA) ........... =    0
          NUMBER OF PROFILE FIT DESCRIPTIONS (061XX1 DATA) ............. =    0
          NUMBER OF STEAM-WATER SEPARATOR DESCRIPTIONS (60XXX0 DATA) .... =    0


                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * *                                                * * *
                   * * *          STEADY-STATE OPTION    =   1          * * *
                   * * *                                                * * *
                   * * *          SLIP OPTION            =   0          * * *
                   * * *                                                * * *
                   * * *          NUMERICS OPTION        =   2          * * *
                   * * *                                                * * *
                   * * *          HEAT TRANSFER OPTION   =   0          * * *
                   * * *                                                * * *
                   * * *          NEW EQUATIONS OPTION   =   0          * * *
                   * * *                                                * * *
                   * * *         USING THE 4-EQ SOLVER - SOLVE3         * * *
                   * * *                                                * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *


INITIAL THERMAL POWER (MEGAWATTS) =  0.00000E+00


AIR IS THE DEFAULT NONCONDENSABLE GAS.
```

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


```
RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   14
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis           11:57:35
 TWO-DIMENSIONAL FLOW FIELD - RETRAN-3D SAMPLE PROBLEM                                                        CPU TIME =    0.016
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
```

NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	ENERGY BALANCE (BTU)	TOTAL MASS BALANCE (LBM)	NCG MASS BALANCE (LBM)	AVERAGE TIME STEP (SEC)	CURRENT TIME STEP (SEC)	ELAPSED TIME (SEC)	TIME STEP NUM STANDRD/ACTUL
0.00000E+00	0.00000E+00	0.00000E+00	1.50328E+01	2.51513E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0 0

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	VOID FRAC.	POWR TO H2O (BTU/SEC)
1	7.00000E+01	3.59303E-02	6.00000E+01	6.20880E+01	9.19512E+01	0.00000E+00	0.00000E+00	0.00000E+00
2	7.00000E+01	3.59303E-02	6.00000E+01	6.20880E+01	9.19512E+01	0.00000E+00	0.00000E+00	0.00000E+00
3	7.00000E+01	3.59303E-02	6.00000E+01	6.20880E+01	9.19512E+01	0.00000E+00	0.00000E+00	0.00000E+00
4	7.00000E+01	3.59303E-02	6.00000E+01	6.20880E+01	9.19512E+01	0.00000E+00	0.00000E+00	0.00000E+00
5	7.00000E+01	3.59303E-02	6.00000E+01	6.20880E+01	9.19512E+01	0.00000E+00	0.00000E+00	0.00000E+00
6	7.00000E+01	3.59303E-02	6.00000E+01	6.20880E+01	9.19512E+01	0.00000E+00	0.00000E+00	0.00000E+00
7	7.00000E+01	3.59313E-02	5.98474E+01	6.20897E+01	9.18000E+01	0.00000E+00	0.00000E+00	0.00000E+00

JUNCTION NUMBER	CONNECTS VOLUMES	CHOK/ PATH	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E D I F F E R E N T I A L S VEL. PSI	ELEV. PSI	FRIC. PSI	ACCL. PSI	PUMP PSI
1	1 TO 2		0.00000E+00	6.00000E+01	1.61062E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
2	3 TO 2		0.00000E+00	6.00000E+01	1.61062E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3	1 TO 4		0.00000E+00	6.00000E+01	1.61062E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
4	2 TO 5		0.00000E+00	6.00000E+01	1.61062E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
5	3 TO 6		0.00000E+00	6.00000E+01	1.61062E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
6	4 TO 5		0.00000E+00	6.00000E+01	1.61062E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
7	6 TO 5		0.00000E+00	6.00000E+01	1.61062E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
8	5 TO 7		0.00000E+00	6.00000E+01	1.61062E-02	0.00000E+00	5.89674E-11	0.00000E+00	5.89674E-11	0.00000E+00
11	0 TO 3		0.00000E+00	6.00000E+01	1.61062E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
10	0 TO 2		0.00000E+00	6.00000E+01	1.61062E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
9	0 TO 1		0.00000E+00	6.00000E+01	1.61062E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   17
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis           11:57:35
 TWO-DIMENSIONAL FLOW FIELD - RETRAN-3D SAMPLE PROBLEM                                                        CPU TIME =    0.078
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	ENERGY BALANCE (BTU)	TOTAL MASS BALANCE (LBM)	NCG MASS BALANCE (LBM)	AVERAGE TIME STEP (SEC)	CURRENT TIME STEP (SEC)	ELAPSED TIME (SEC)	TIME STEP NUM STANDRD/ACTUL
0.00000E+00	0.00000E+00	0.00000E+00	1.49492E+01	2.51619E-01	0.00000E+00	2.00000E-03	2.00000E-03	1.00000E-01	60 301

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	VOID FRAC.	POWR TO H2O (BTU/SEC)
1	2.05278E+02	3.59474E-02	6.00000E+01	6.21175E+01	9.20271E+01	0.00000E+00	0.00000E+00	0.00000E+00
2	2.05278E+02	3.59474E-02	6.00000E+01	6.21175E+01	9.20271E+01	0.00000E+00	0.00000E+00	0.00000E+00
3	2.05278E+02	3.59474E-02	6.00000E+01	6.21175E+01	9.20271E+01	0.00000E+00	0.00000E+00	0.00000E+00
4	2.14904E+02	3.59486E-02	6.00000E+01	6.21196E+01	9.20325E+01	0.00000E+00	0.00000E+00	0.00000E+00
5	2.14904E+02	3.59486E-02	6.00000E+01	6.21196E+01	9.20325E+01	0.00000E+00	0.00000E+00	0.00000E+00
6	2.14904E+02	3.59486E-02	6.00000E+01	6.21196E+01	9.20325E+01	0.00000E+00	0.00000E+00	0.00000E+00
7	7.00000E+01	3.59313E-02	5.98474E+01	6.20897E+01	9.18000E+01	0.00000E+00	0.00000E+00	0.00000E+00

JUNCTION NUMBER	CONNECTS VOLUMES	CHOK/ PATH	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E VEL. PSI	ELEV. PSI	D I F F E R E N T I A L S FRIC. PSI	ACCL. PSI	PUMP PSI
1	1 TO 2	2	-3.71601E+00	6.00000E+01	1.60985E-02	0.00000E+00	-9.73830E-17	6.05737E-14	-2.47888E-14	0.00000E+00
2	3 TO 2	2	-3.71601E+00	6.00000E+01	1.60985E-02	0.00000E+00	-9.73830E-17	6.05737E-14	3.20546E-14	0.00000E+00
3	1 TO 4	2	2.53813E+01	6.00000E+01	1.60985E-02	9.62604E+00	7.29696E-11	-2.50935E-12	-8.24465E-14	0.00000E+00
4	2 TO 5	2	1.42333E+01	6.00000E+01	1.60985E-02	9.62604E+00	7.29698E-11	-8.17270E-13	-1.02298E-14	0.00000E+00
5	3 TO 6	2	2.53813E+01	6.00000E+01	1.60985E-02	9.62604E+00	7.29696E-11	-2.50935E-12	5.96621E-14	0.00000E+00
6	4 TO 5	2	2.53813E+01	6.00000E+01	1.60980E-02	0.00000E+00	8.06884E-17	-2.50925E-12	2.03611E-14	0.00000E+00
7	6 TO 5	2	2.53813E+01	6.00000E+01	1.60980E-02	0.00000E+00	8.06884E-17	-2.50925E-12	-8.06064E-15	0.00000E+00
8	5 TO 7	2	6.49958E+01	6.00000E+01	1.60980E-02	-1.44904E+02	-1.03883E-09	-1.55625E-11	-1.06802E-15	0.00000E+00
11	0 TO 3	2	2.16653E+01	6.00000E+01	1.61062E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
10	0 TO 2	2	2.16653E+01	6.00000E+01	1.61062E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
9	0 TO 1	2	2.16653E+01	6.00000E+01	1.61062E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   18
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:35
 TWO-DIMENSIONAL FLOW FIELD - RETRAN-3D SAMPLE PROBLEM                                                          CPU TIME =     0.078
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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SYSTEM ELAPSED TIME (SEC)	SYSTEM ELAPSED TIME (SEC)	TIME STP ACTUAL	VOL 4 AVG. PRESS. (PSIA)	VOL 6 AVG. PRESS. (PSIA)	JUN 3 FLOW (LB/SEC)	JUN 4 FLOW (LB/SEC)	JUN 5 FLOW (LB/SEC)
0.00000E+00	0.00000E+00	0.00000E+00	7.00000E+01	7.00000E+01	0.00000E+00	0.00000E+00	0.00000E+00
2.00000E-03	2.00000E-03	1.48000E+02	9.63342E+01	9.63342E+01	3.52450E+00	5.94893E+00	3.52450E+00
4.00000E-03	4.00000E-03	1.59000E+02	1.11887E+02	1.11887E+02	7.36820E+00	1.12593E+01	7.36820E+00
6.00000E-03	6.00000E-03	1.74000E+02	1.38893E+02	1.38893E+02	1.17244E+01	1.55433E+01	1.17244E+01
8.00000E-03	8.00000E-03	1.92000E+02	1.78611E+02	1.78611E+02	1.66932E+01	1.86041E+01	1.66932E+01
1.00000E-02	1.00000E-02	2.10000E+02	2.31180E+02	2.31180E+02	2.22556E+01	2.04746E+01	2.22556E+01
1.20000E-02	1.20000E-02	2.53000E+02	2.12762E+02	2.12762E+02	2.38368E+01	1.73204E+01	2.38368E+01
1.40000E-02	1.40000E-02	2.55000E+02	2.14304E+02	2.14304E+02	2.46823E+01	1.56308E+01	2.46823E+01
1.60000E-02	1.60000E-02	2.57000E+02	2.14656E+02	2.14656E+02	2.50690E+01	1.48577E+01	2.50690E+01
1.80000E-02	1.80000E-02	2.59000E+02	2.14798E+02	2.14798E+02	2.52426E+01	1.45106E+01	2.52426E+01
2.00000E-02	2.00000E-02	2.61000E+02	2.14858E+02	2.14858E+02	2.53199E+01	1.43561E+01	2.53199E+01
3.00000E-02	3.00000E-02	2.66000E+02	2.14905E+02	2.14905E+02	2.53810E+01	1.42338E+01	2.53810E+01
4.00000E-02	4.00000E-02	2.71000E+02	2.14904E+02	2.14904E+02	2.53813E+01	1.42333E+01	2.53813E+01
5.00000E-02	5.00000E-02	2.76000E+02	2.14904E+02	2.14904E+02	2.53813E+01	1.42333E+01	2.53813E+01
6.00000E-02	6.00000E-02	2.81000E+02	2.14904E+02	2.14904E+02	2.53813E+01	1.42333E+01	2.53813E+01
7.00000E-02	7.00000E-02	2.86000E+02	2.14904E+02	2.14904E+02	2.53813E+01	1.42333E+01	2.53813E+01
8.00000E-02	8.00000E-02	2.91000E+02	2.14904E+02	2.14904E+02	2.53813E+01	1.42333E+01	2.53813E+01
9.00000E-02	9.00000E-02	2.96000E+02	2.14904E+02	2.14904E+02	2.53813E+01	1.42333E+01	2.53813E+01
1.00000E-01	1.00000E-01	3.01000E+02	2.14904E+02	2.14904E+02	2.53813E+01	1.42333E+01	2.53813E+01

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

8.0 SECONDARY-SIDE SAMPLE PROBLEM

The Secondary-Side Sample Problem is a simplified representation of the secondary side of a pressurized water reactor. The model (Figure VII.8-1) contains most of the components present on a secondary side such as high pressure turbine, low pressure turbine, moisture separator, reheater, condenser, condensate pump, feedwater heater, and feedwater pump. The energy transferred from the primary to the secondary side and the energy transferred into the reheater are modeled with nonconducting heat exchangers. The model is initialized using the steady-state initialization option. A null transient is run for a short time then the throttle valve is shut in Junction 3.

The input listing for the Secondary-Side Sample Problem and selected output from the RETRAN program module are given below.

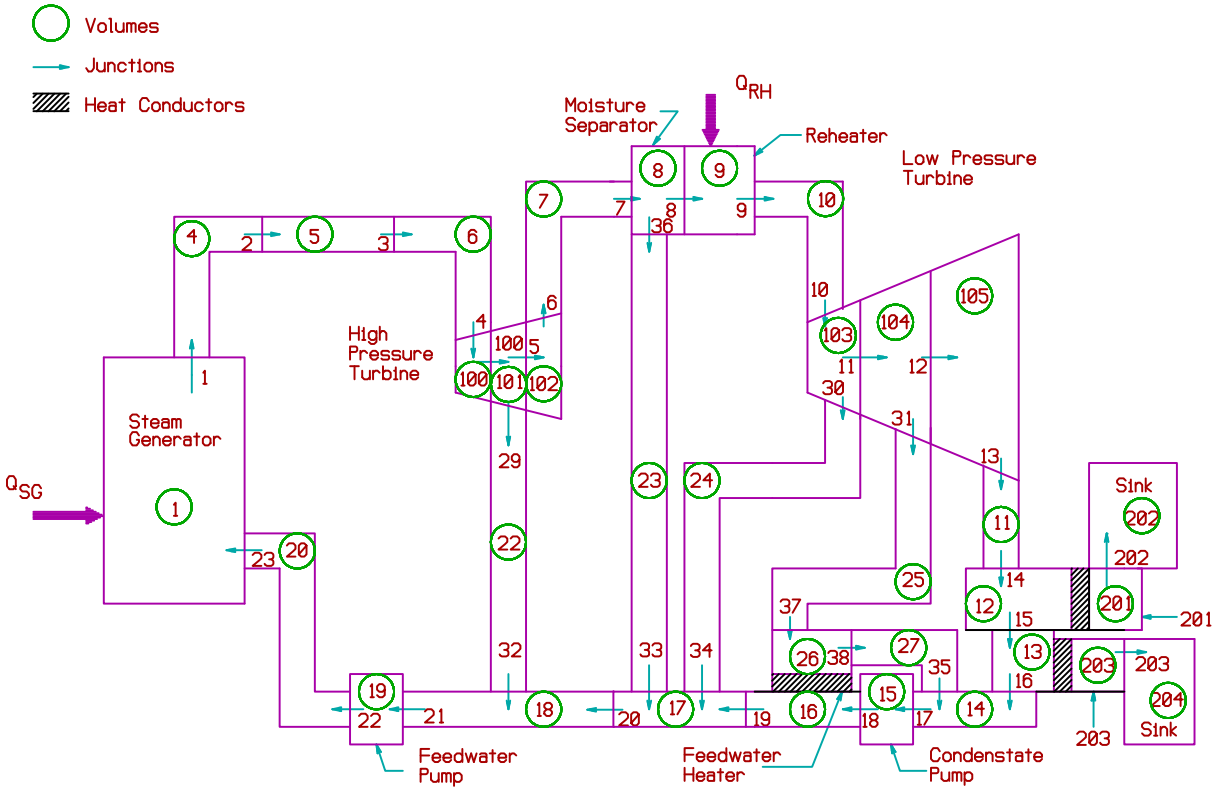


Figure VII.8-1. Schematic Diagram of the Secondary-Side Sample Problem

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LISTING OF INPUT DATA FOR CASE  1

    1    =SECONDARY SYSTEM SAMPLE PROBLEM - RETRAN-3D SAMPLE PROBLEM
    2    *
    3    ********************************************************************************
    4    *
    5    *  PROBLEM DIMENSIONS
    6    *
    7    *        1     2     3     4     5     6     7     8     9    10    11    12
    8    *      TAPE PRNPLT  POW    SS  NVOID GENTRN HTMAP SLIP  5EQ  NCOND  NSOL  PNMTH
    9    010001   0     0     0     0     0     0     1     0     0     0     2     0
   10    *
   11    *
   12    *10005     POWER
   13    010005      0.0
   14    *
   15    *  MINOR EDIT REQUESTS
   16    *
   17    020000 TIMX  0 NTTS  0
   18    020001 PRES  8 PRES 12 PRES 16
   19    020002 WP** 20 WP** 29
   20    *
   21    *
   22    * FORMAT FOR TAPE60
   23    *
   24    025000 1
   25    025001 '(5(1X,1P,E15.7))'
   26    *
   27    *
   28    *  TIME STEP DATA CARDS
   29    *30010  RST  MIN  RST  MAJ  DMP  NCHK DELTM  TLAST
   30    030010  0.   .01  0.   0.25 0.25   0   .001   0.375
   31    030020  0.   .015 0.   1.5  1.5    0   .001   5.0
   32    *
   33    *
   34    *  TIME STEP CONSTANTS
   35    *3XXX1  EPSP  EPSIMP  COUR
   36    030011   0.03    1.0
   37    030021   0.03    1.0
   38    *
   39    *
   40    *  TRIP CONTROL DATA CARDS
   41    *      IDTRP IDSIG IX1 IX2 SETPT DELAY  DESCRIPTION
   42    040010   1     1    0   0   0.5    0.0  "END OF PROBLEM TIME  "
   43    040020   2     1    0   0   0.01   0.0  "VALVE TRIP           "
   44    040030   3     1    0   0 100.0    0.0  "PUMP TRIP            "
   45    040040   4     1    0   0   0.0    0.0  "TIME DEP HTX TRIP    "
   46    040050   5     1    0   0   0.0    0.0  "FILL TRIP            "
   47    *
   48    *
   49    *  VOLUME DATA CARDS
   50    *5XXXY IBUB IRD   P    TEMP    X       V     ZVOL    FLOWL
   51    050011   0   0    0.    0.    0.0    15000.  60.17     0.
   52    050041   0   0    0.    0.    0.0     8600.  60.17     0.
   53    050051   0   0    0.    0.    0.0     5000.   4.50     0.
   54    050061   0   0    0.    0.    0.0     5000.  20.       0.
   55    050071   0   0    0.    0.    0.0     4000.  25.       0.
   56    050081   1   0    0.    0.    0.0    2500.    5.       0.
   57    050091   0   0    0.    0.    0.0   30000.    5.       0.
   58    050101   0   0    0.    0.    0.0    5000.   20.       0.
   59    050111   0   0    0.    0.    0.0    3000.   40.       0.
   60    050121   0   0    0.    0.    0.0    5000.0  10.       0.
   61    050131   0   0    0.    0.    0.0    2000.   11.       0.
   62    050141   0   0    0.    0.    0.0    1000.    4.       0.
   63    050151   0   0    0.    0.    0.0    1000.    5.       0.
   64    050161   0   0    0.    0.    0.0    1500.    2.       0.
   65    050171   0   0    0.    0.    0.0    1500.    2.       0.
   66    050181   0   0    0.    0.    0.0    1500.    2.       0.
   67    050191   0   0    0.    0.    0.0    1000.    5.       0.
   68    050201   0   0    0.    0.    0.0    2000.   50.       0.
   69    050221   0   0    0.    0.    0.0    1000.   55.       0.
   70    050231   0   0    0.    0.    0.0    1000.   79.4      0.
   71    050241   0   0    0.    0.    0.0    1000.   55.       0.
   72    050251   0   0    0.    0.    0.0    1000.   56.       0.
   73    050261   0   0    0.    0.    0.0    1500.    2.       0.
   74    050271   0   0    0.    0.    0.0     500.   4.        0.
   75    051001   0   0    0.    0.    0.0       2.0  5.        0.5
   76    051011   0   0    0.    0.    0.0       5.0  5.        0.5
   77    051021   0   0    0.    0.    0.0      10.0  5.        0.5
   78    051031   0   0    0.    0.    0.0      10.7  5.        0.5
   79    051041   0   0    0.    0.    0.0     162.3  5.        0.5
   80    051051   0   0    0.    0.    0.0     492.0  5.        0.5
   81    052011   0   0    0.    0.    0.0    1790.0  6.75      0.
   82    052021   0   0    0.    0.    0.0     1E+15  6.75      0.
   83    052031   0   0    0.    0.    0.0    1790.0  6.75      0.
   84    052041   0   0    0.    0.    0.0     1E+15  6.75      0.
   85    *
   86    *  VOLUME DATA CARDS (CARD 2)
   87    *5XXXY   FLOWA       DIAMV       ELEV  EOVRD
   88    050012     36.        0.0        0.0
   89    050042     20.        2.5       60.17
   90    050052     20.        2.5       60.17
   91    050062     20.        2.5       40.17
   92    050072     40.       10.0       40.17
   93    050082     40.       10.0       60.17
   94    050092     40.       10.0       60.17
   95    050102     40.       10.0       40.17
   96    050112   3000.      250.0        0.17
   97    050122   1500.        0.0       -9.
   98    050132    200.        0.0      -20.
   99    050142    100.      250.0      -24.
  100    050152     30.        0.0      -24.
```

```
050162     30.        0.0      -20.
050172    100.        0.0      -20.
050182     30.        0.0      -20.
050192     30.        0.0      -20.
050202     30.        0.0      -16.
050222     30.        0.0      -19.
050232     30.        0.0      -19.
050242    100.        0.0      -19.
050252     30.        0.0      -20.
050262     30.        0.0      -18.
050272     30.        0.0      -20.
051002     40.        0.0       35.2
051012     40.        0.0       35.2
051022     40.        0.0       35.2
051032     40.        0.0       35.2
051042    156.        0.0       35.2
051052   1500.        0.0       35.2
052012    160.        6.75E+6    0.0
052022   3580.        6.75E+6    0.0
052032     35.80      6.75E+6    0.0
052042   3580.        6.75E+6    0.0
*
*
*  BUBBLE DATA CARDS
*6XXX1    ALPH    VBUB    ZM     WILSON
060011     .8     0.0    1.0      1
*
*
*  JUNCTION DATA CARDS
*8XXXY  IW1 IW2 IP IV  WP      AJUN    ZJUN   INERTA   FJUNF  FJUNR
080011   1   4  0  0     0.     20.    60.17    4.      .7    1.4
080021   4   5  0  0     0.     20.    60.17    8.      .7     .7
080031   5   6  0  2     0.     15.    60.17    8.     0.      .5
080041   6  100 0  0     0.      5.    40.17    6.     0.      .3
080051  101 102 0  0     0.      5.    40.17    2.     0.      .2
080061  102  7  0  0     0.      5.    40.17    4.     0.      .7
080071   7   8  0  0     0.     20.    60.17    4.      .05    .1
080081   8   9  0  0     0.     40.    65.17    2.      .05    .1
080091   9   10 0  0     0.     20.    60.17    5.      .05    .7
080101   10 103 0  0     0.     20.    40.17    4.     0.      .1
080111  103 104 0  0     0.     20.6   40.17    2.     0.      .1
080121  104 105 0  0     0.    156.    40.17    5.     0.      .7
080131  105  11 0  0     0.   3000.    40.17     .1    0.      .7
080141   11  12 0  0     0.   3000.     0.2      .1     .05    .2
080151   12  13 0  0     0.   1000.    -9.      2.     0.     1.
080161   13  14 0  0     0.    100.   -20.      5.      .05    .8
080171   14  15 -1 0     0.    100.   -24.      4.     0.      .1
080181   15  16 1  0     0.     30.   -19.      4.      .1     .1
080191   16  17 0  0     0.     30.   -19.     16.     0.     0.
080201   17  18 0  0     0.     30.   -19.     16.     0.     0.
080211   18  19 -2 0     0.     30.   -19.      8.     0.      .1
080221   19  20 2  0     0.     30.   -15.      8.     0.      .1
080231   20  1  0  0     0.     30.    33.      8.     1.3     .1
080291  101  22 0  0     0.      5.    36.     10.      .3    1.
080301  103  24 0  0     0.      5.    36.     10.      .3    1.
080311  104  25 0  0     0.     20.    36.     10.      .3    1.
080321   22  18 0  0     0.      5.   -19.     10.     0.      .2
080331   23  17 0  0     0.      5.   -19.     10.     0.      .2
080341   24  17 0  0     0.      5.   -19.     10.     0.      .2
080351   27  14 0  0     0.     20.   -20.     10.     0.      .2
080361   8   23 0  0     0.      5.    60.4    10.      .2    1.
080371   25  26 0  0     0.     20.    -17.    10.      .05    .05
080381   26  27 0  0     0.     20.    -17.    10.      .05    .05
081001  100 101 0  0     0.      1.52   40.17   2.     0.      .2
082011   0  201 1  0     0.    160.      3.0    1.40   0.0    0.0
082021  201 202 0  0     0.    160.      3.0    1.40   -1.0    0.0
082031   0  203 1  0     0.     16.      3.0    1.40   0.0    0.0
082041  203 204 0  0     0.     16.      3.0    1.40   -1.0    0.0
*
*8XXXY JVET JCHK JCALC MVMIX DIAMJ CONCO  IFRJ JTPM IHQCOR
080012   0    -1   0      0    0.0    1.    0    0     1
080022   0    -1   0      0    0.0    1.    0    0     0
080032   0    -1   0      0    0.0    1.    0    0     0
080042   0    -1   0      0    0.0    1.    0    0     0
080052   0    -1   0      0    0.0    1.    0    0     0
080062   0    -1   0      0    0.0    1.    0    0     0
080072   0    -1   0      0    0.0    1.    0    0     0
080082   0    -1   0      0    0.0    1.    0    0     0
080092   0    -1   0      0    0.0    1.    0    0     0
080102   0    -1   0      0    0.0    1.    0    0     0
080112   0    -1   0      0    0.0    1.    0    0     0
080122   0    -1   0      0    0.0    1.    0    0     0
080132   0    -1   0      3    0.0    1.    0    0     0
080142   0    -1   0      3    0.0    1.    0    0     1
080152   0    -1   0      3    0.0    1.    0    0     0
080162   0    -1   0      0    0.0    1.    0    0     1
080172   0    -1   0      0    0.0    1.    0    0     0
080182   0    -1   0      0    0.0    1.    0    0     1
080192   0    -1   0      0    0.0    1.    0    0     1
080202   0    -1   0      0    0.0    1.    0    0     0
080212   0    -1   0      0    0.0    1.    0    0     0
080222   0    -1   0      0    0.0    1.    0    0     0
080232   0    -1   0      0    0.0    1.    0    0     0
080292   0    -1   0      3    0.0    1.    0    0     0
080302   0    -1   0      3    0.0    1.    0    0     0
080312   0    -1   0      3    0.0    1.    0    0     0
080322   0    -1   0      3    0.0    1.    0    0     0
080332   0    -1   0      3    0.0    1.    0    0     0
080342   0    -1   0      3    0.0    1.    0    0     0
080352   0    -1   0      3    0.0    1.    0    0     0
080362   0    -1   0      3    0.0    1.    0    0     0
080372   0    -1   0      0    0.0    1.    0    0     0
```

```
080382   0    -1   0      0    0.0    1.    0    0     0
081002   0    -1   0      0    0.0    1.    0    0     0
082012   1    -1   0      3    0.0    0.    0    0     1
082022   1    -1   0      3    0.0    0.    0    1     1
082032   1    -1   0      3    0.0    0.    0    0     1
082042   1    -1   0      3    0.0    0.    0    1     1
*
*
*  PUMPS
*90XXY IPC ITP IRP IPM IMT POMGR PSRT PFLOWR PHEDR PTR PINRTA VRHOI TORKF--
090011  1   3   0   0   0  3600.  1.  20320.  235.  1.  2000.  0.0   0.  0.
090021  2   3   0   0   0  3600.  1. 370250. 8380.  1. 20000.  0.0   0.  0.
100000  1  0  1  0
*
*
*  VALVES
*11XXX0 ITCV IACV IACV2 PCV CV1 CV2 CV3
110010  -2    0     0    0.  0.  0.  0.
110020   2    0     0    0.  0.  0.  0.
*
*
*  FILL DATA CARDS
*13XXYY  NFLL TFLL JX   JY   FILTBL1   FILTBL2   FILENT1   FILPRS1
130101   -2   5    0    0    0.0       400.0     43.3      101.0
130102                      100.0     400.0     43.3      101.0
*
*
*  HEAT CONDUCTOR DATA CARDS 15XXXY
*15XXXY IVSL IVSR IGOM CELV IMCL IMCR   AHTL      AHTR     VOLS
150011   12  201   1    0    0    0    126087.   139770.   369.
150021   13  203   1    0    0    0     14009.    15530.    41.
150031   26   16   1    0    0    0     10000.    13000.   100.
*
*15XXX2  HDML      HDMR      DHEL      DHER      CHNL      CHNR     IHXQF
150012   .0376     .1189     0.0       0.0       50.0      50.0      1
150022   .0376     .1189     0.0       0.0       50.0      50.0      2
150032   .022      .067      0.0       0.0        0.0       0.0      0
*
*
*  CONDUCTOR GEOMETRY DATA CARDS 17XXYY
*17XXYY  IG   NR   IM   NDX    XO        XR       PF
170101   2    1    1    10   .0376     .00408    0.0
*
*
*  THERMAL CONDUCTIVITY DATA CARDS 18XXYY
*18XXYY  NKP       TPK1      TPK2
180101   1         500.0     85.0
*
*
*  VOLUMETRIC HEAT CAPACITY DATA CARDS 19XXYY
*19XXYY  NCP       TPC1      TPC2
190101   1         500.0     48.94
*
*
*  TIME DEPENDENT HEAT EXCHANGERS
*210101  IHTX ITHTXQ JVOL IHTYPE   HTXTBL---
210101    -2    4     1     4       0.0 -3200.     100.   -3200.
210201    -2    4     9     4       0.0  -270.     100.    -270.
*
*
*  STEADY STATE CONVERGENCE CARD
*      LCOUNT
230000   -50
*
*  STEADY STATE POWER REMOVAL
*
*230XXY ISGNUM JBIAS JBAL POWF
230011     1    201  202  .95
230021     2    203  204  .05
*
*
*  VOLUME INITIAL CONDITIONS
*
*       LVOL   PRES  TEMP    HW     X      XNC
231001    1   900.0   0.0  815.06  0.0    0.0
231006    6   844.8   0.0    0.0   0.0    0.0
231010   10   167.9   0.0    0.0   0.0    0.0
231012   12     1.0   0.0    0.0   0.0    0.0
231013   13     3.0   0.0    0.0   0.0    0.0
231015   15    45.0   0.0    0.0   0.0    0.0
231019   19   500.0   0.0    0.0   0.0    0.0
231100  100   625.5   0.0    0.0   0.0    0.0
231101  101   287.7   0.0    0.0   0.0    0.0
231102  102   175.9   0.0    0.0   0.0    0.0
231103  103    98.8   0.0    0.0   0.0    0.0
231104  104     8.4   0.0    0.0   0.0    0.0
231105  105     1.5   0.0    0.0   0.0    0.0
231201  201   100.0   0.0   53.0   0.0    0.0
231202  202    90.0   0.0   60.0   0.0    0.0
231203  203   100.0   0.0   53.0   0.0    0.0
231204  204    90.0   0.0   60.0   0.0    0.0
*
*
*  INITIAL JUNCTION FLOWS
*
*       JUN JESTW    WP    SPLTV1    SPLTV2
232001    1   0  4187.
232002    2   0  4187.
232003    3   1  4187.
232004    4   1  4187.
232005    5   1  3735.
232006    6   1  3735.
```

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```
232007    7   0  3735.
232008    8   0  3275.
232009    9   0  3275.
232010   10   1  3275.
232011   11   1  2630.
232012   12   1  2406.
232013   13   1  2406.
232014   14   0  2406.
232015   15   1  2406.
232016   16   0  2406.
232017   17   1  2630.
232018   18   0  2630.
232019   19   0  2630.
232020   20   0  3735.
232021   21   1  4187.
232022   22   1  4187.
232023   23   0  4187.
232029   29   0   452.
232030   30   0   645.
232031   31   0   224.
232032   32   1   452.
232033   33   1   460.
232034   34   1   645.
232035   35   1   224.
232036   36   0   460.
232037   37   0   224.
232038   38   0   224.
232100  100   1  4187.
*
*
*  TURBINE MODEL
*500XXY NTURS ISIN SHRPM SHPOW   SHIR
500011    2    0   1800. 1206. 4517570.
*
*5010XY  ITSHA NG JINTUR  CN   TINH   TINP   TINW
501011     1   3    4    .98  1194.3  844.8  4187.
501021     1   3   10    .98  1274.4  160.6  3275.
*
*51XYYZ NS IVOLSG IJUNSG GBLC GRLC GNA GEA  DTP   DTH    DWP    GXE
511011   1  100     4     0    0    0   0  625.5 1173.1 4187.   0.5
511021   3  101    100    0    0    0   0  287.7 1120.2 4187.   0.5
511031   2  102     5     0    0    0   0  175.9 1091.1 3735.   0.5
512011   1  103    10     0    0    0   0   98.8 1231.  3275.   0.5
512021   4  104    11     0    0    0   0   9.12 1070.  2630.   0.5
512031   2  105    12     0    0    0   0   1.5  1004.5 2406.   0.5
*
*
*  SEPARATOR MODEL INPUT
*     ISEV JIN JSTM JRSC IUDC ZVAN COVI XIND  ZMD  ICO1 ICO2 ICU1 ICU2
600010 8    7   8    36    8  0.0  0.06 0.85  1.0    0    0    0    0
*
*
*  NON-EQUILIBRIUM VOLUME DATA
*61XXXY  NEQVOL  SEPFG  VRAIN  IHTC  VLHTC
610080      8      1     0.0     0     0.0
*
*
. END
```


PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page    1
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis             11:57:37
 SECONDARY SYSTEM SAMPLE PROBLEM - RETRAN-3D SAMPLE PROBLEM                                                      CPU TIME =    0.000
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

RETRAN PROBLEM CONTROL AND DESCRIPTION DATA.

    WORD  DESCRIPTION
    ====  ==================================================================
      1   RESTART FILE OPTION (SAVE=-1 / NO SAVE=0) .................... =    0
      2   PRINTER PLOT OPTION (YES=1 / NO=0) ........................... =    0
      3   POWER OPTION (TAPE OPTNS<0 / NO/TBL=0 / PT KIN=1 / 1D=2 / 3D=3) =    0
      4   USE STEADY-STATE SOLUTION (YES=0 / NO=1) ..................... =    0
      5   USE NEUTRON VOID MODEL (YES=1 / NO=0) ........................ =    0
      6   USE GENERALIZED TRANSPORT MODEL (NO=0 / VAP=1 / LIQ=-1) ....... =    0
      7   HEAT TRANSFER MAP OPTION (FORCED=0 / NAT CONV=1) ............. =    1
      8   SLIP OPTION (DYN=1 / Z-L=2 / C-L=3 / Z-L TAUGL=4 / C-L TAUGL=5) =    0
      9   FIVE-EQUATION OPTION (NO= 0 / YES=1) ......................... =    0
     10   NONCONDENSABLE GAS FLOW OPTION (NO=0 / YES=1) ................ =    0
     11   TH MATRIX DIRECT SOLVER OPTION (4-EQ=2 / 6-EQ=3) ............. =    2
     12   TH MATRIX ITERATIVE SOLVER OPTION (NO<=1 / YES=2) ............ =    0

    (DIMENSIONS AND OPTIONS AUTOMATICALLY DETERMINED BY CONTENT OF INPUT DATA)

          NUMBER OF MINOR EDIT SETS (0200XX DATA )...................... =    7
          NUMBER OF TIME-STEP CONTROL SETS (03XXX0 DATA )............... =    2
          NUMBER OF TRIP CONTROL SETS (04XXX0 DATA )..................... =    5
          NUMBER OF CONTROL VOLUME DESCRIPTIONS (05XXXY DATA )........... =   34
          NUMBER OF BUBBLE RISE DESCRIPTIONS (060XXY DATA) ............. =    1
          NUMBER OF TIME DEPENDENT VOLUMES FORM CARDS (07XXYY DATA) ..... =    0
          NUMBER OF JUNCTION DESCRIPTIONS (08XXXY DATA) ................ =   38
          NUMBER OF CENTRIFUGAL PUMP DESCRIPTIONS (090XXY DATA )......... =    2
          NUMBER OF VALVE DESCRIPTIONS (11XXXY DATA) ................... =    2
          NUMBER OF GENERAL DATA TABLE DESCRIPTIONS (12XXYY DATA) ....... =    0
          NUMBER OF FILL DESCRIPTIONS (13XXYY DATA )..................... =    1
          NUMBER OF HEAT CONDUCTOR DESCRIPTIONS (15XXXY DATA) ........... =    3
          NUMBER OF HEAT CONDUCTOR GEOMETRY DESCRIPTIONS (17XXYY DATA) .. =    1
          NUMBER OF HEAT CONDUCTOR MATERIAL DESCRIPTIONS (18XXYY DATA) .. =    1
          NUMBER OF CORE SECTION DESCRIPTIONS (16XXXY DATA) ............ =    0
          NUMBER OF NON-CONDUCTNG HEAT EXCHNGR DESCRIPTIONS (21XXYY DATA) =    2
          NUMBER OF TIME DEP BCS FROM TAPE (IREAD<0 ON 05XXXY DATA) ..... =    0
          NUMBER OF SPECIFIED HEAT TRAN COEF DESCRIPTIONS (015XXX DATA) . =    0
          TWO-REGION NONEQ VOL DESCRIPTIONS (610XXX OR 611XXX DATA) ..... =    1
          TEMP. TRANSPORT DELAY OPTION (MESH>0 ON 05XXXY DATA) .......... =    0
          AUXILIARY DNB MODEL (8001XX DATA INCLUDED) .................... =    0
          CONTROL SYSTEM MODEL (702XXX OR 702XXXX DATA) ................ =    0
          ACCUMULATOR MODEL DESCRIPTIONS (620XXX OR 621XXX DATA)......... =    0
          DYNAMIC GAP CONDUCTANCE MODEL DESCRIPTIONS (225XX0 DATA) ...... =    0
          NUMBER OF HT CONDUCTOR STACK DESCRIPTIONS (2200XY DATA) ....... =    0
          NUMBER OF TURBINE SHAFT DESCRIPTIONS (500XXY DATA) ........... =    1
          NUMBER OF PROFILE FIT DESCRIPTIONS (061XX1 DATA) ............. =    0
          NUMBER OF STEAM-WATER SEPARATOR DESCRIPTIONS (60XXX0 DATA) .... =    1


                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * *                                                 * * *
                   * * *          STEADY-STATE OPTION    =   0           * * *
                   * * *                                                 * * *
                   * * *          SLIP OPTION            =   0           * * *
                   * * *                                                 * * *
                   * * *          NUMERICS OPTION        =   2           * * *
                   * * *                                                 * * *
                   * * *          HEAT TRANSFER OPTION   =   1           * * *
                   * * *                                                 * * *
                   * * *          NEW EQUATIONS OPTION   =   0           * * *
                   * * *                                                 * * *
                   * * *         USING THE 4-EQ SOLVER - SOLVE3          * * *
                   * * *                                                 * * *
                   * * *      USING STANDARD STEADY-STATE SOLUTION       * * *
                   * * *                                                 * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *


INITIAL THERMAL POWER (MEGAWATTS) =  0.00000E+00


AIR IS THE DEFAULT NONCONDENSABLE GAS.
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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE -- NRC APPROVED VERSION 29/08/14 Page 33
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis 11:57:37
SECONDARY SYSTEM SAMPLE PROBLEM - RETRAN-3D SAMPLE PROBLEM CPU TIME = 0.062
* *

NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	ENERGY BALANCE (BTU)	TOTAL MASS BALANCE (LBM)	NCG MASS BALANCE (LBM)	AVERAGE TIME STEP (SEC)	CURRENT TIME STEP (SEC)	ELAPSED TIME (SEC)	TIME STEP NUM STANDRD/ACTUL
0.00000E+00	0.00000E+00	1.18431E+10	7.41778E+17	1.24185E+16	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0 0

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	VOID FRAC.	POWR TO H2O (BTU/SEC)
1	9.00000E+02	6.55125E+04	8.15060E+02	4.36750E+00	5.31480E+02	4.30611E-01	9.47428E-01	3.03378E+06
4	8.93316E+02	1.74136E+04	1.17735E+03	2.02484E+00	5.30603E+02	9.71285E-01	9.98772E-01	0.00000E+00
5	8.89996E+02	1.00849E+04	1.17735E+03	2.01698E+00	5.30166E+02	9.71154E-01	9.98772E-01	0.00000E+00
6	8.44800E+02	9.55183E+03	1.17735E+03	1.91037E+00	5.24078E+02	9.69477E-01	9.98779E-01	0.00000E+00
7	1.70054E+02	1.76842E+03	1.06601E+03	4.42105E-01	3.68729E+02	8.47904E-01	9.98772E-01	0.00000E+00
8 LIQ REG	1.69692E+02	7.16131E+02	5.60315E+02	1.43226E+00	3.68557E+02	2.56429E-01	9.95761E-01	0.00000E+00
VAP REG		7.96583E+02	1.14468E+03	3.98291E-01	3.68557E+02	9.40000E-01		0.00000E+00
9	1.69144E+02	1.04100E+04	1.22284E+03	3.46999E-01	4.15734E+02	1.00000E+00	1.00000E+00	2.55975E+05
10	1.67900E+02	1.72222E+03	1.22284E+03	3.44445E-01	4.15406E+02	1.00000E+00	1.00000E+00	0.00000E+00
11	9.98644E-01	1.05513E+01	9.51025E+02	3.51710E-03	1.01523E+02	8.50609E-01	9.99992E-01	0.00000E+00
12	1.00000E+00	3.18569E+02	1.18375E+02	6.37138E-02	1.01568E+02	4.69694E-02	9.99020E-01	-2.00336E+06
13	3.00000E+00	1.23172E+05	9.64633E+01	6.15861E+01	1.28252E+02	0.00000E+00	0.00000E+00	-1.05440E+05
14	5.21999E+00	5.33892E+02	1.58341E+02	5.33892E-01	1.63836E+02	2.63044E-02	9.91470E-01	0.00000E+00
15	4.50000E+01	6.03699E+04	1.58341E+02	6.03699E+01	1.90072E+02	0.00000E+00	0.00000E+00	4.85837E-01
16	9.56790E+01	9.06335E+04	1.56656E+02	6.04224E+01	1.88293E+02	0.00000E+00	0.00000E+00	-8.86232E+03
17	9.56291E+01	3.51039E+03	3.74740E+02	2.34026E+00	3.24934E+02	8.92388E-02	9.62132E-01	0.00000E+00
18	9.39973E+01	1.76822E+03	4.52775E+02	1.17881E+00	3.23701E+02	1.78045E-01	9.82798E-01	0.00000E+00
19	5.00000E+02	4.23553E+04	4.52775E+02	4.23553E+01	4.66743E+02	4.31834E-03	1.69784E-01	3.87647E-01
20	9.09113E+02	1.01680E+05	4.52775E+02	5.08401E+01	4.69675E+02	0.00000E+00	0.00000E+00	0.00000E+00
22	2.87474E+02	7.14069E+02	1.09760E+03	7.14069E-01	4.13515E+02	8.70962E-01	9.98264E-01	0.00000E+00
23	1.70127E+02	1.89575E+03	5.05870E+02	1.89575E+00	3.68764E+02	1.92525E-01	9.72042E-01	0.00000E+00
24	9.64642E+01	2.21137E+02	1.17733E+03	2.21137E-01	3.25559E+02	9.89640E-01	9.99959E-01	0.00000E+00
25	8.23909E+00	2.47657E+01	1.01876E+03	2.47657E-02	1.84035E+02	8.77420E-01	9.99950E-01	0.00000E+00
26	7.94020E+00	3.42895E+01	1.05833E+03	2.28597E-02	1.82343E+02	9.18234E-01	9.99969E-01	8.86232E+03
27	8.14400E+00	1.17112E+01	1.05833E+03	2.34224E-02	1.83502E+02	9.17718E-01	9.99968E-01	0.00000E+00
100	6.25500E+02	2.89552E+00	1.15447E+03	1.44776E+00	4.90331E+02	9.32784E-01	9.98040E-01	-9.57868E+04
101	2.87700E+02	3.57316E+00	1.09760E+03	7.14633E-01	4.13586E+02	8.70942E-01	9.98262E-01	-2.38120E+05
102	1.75900E+02	4.57174E+00	1.06601E+03	4.57174E-01	3.71464E+02	8.46888E-01	9.98719E-01	-1.17985E+05
103	9.88000E+01	2.42158E+00	1.17733E+03	2.26316E-01	3.27283E+02	9.89140E-01	9.99956E-01	-1.49055E+05
104	8.40000E+00	4.09497E+00	1.01876E+03	2.52308E-02	1.84924E+02	8.77001E-01	9.99949E-01	-4.17032E+05
105	1.50000E+00	2.55928E+00	9.51025E+02	5.20179E-03	1.15445E+02	8.43633E-01	9.99987E-01	-1.62978E+05
201	1.00000E+02	1.11284E+05	5.30000E+01	6.21697E+01	8.50452E+01	0.00000E+00	0.00000E+00	2.00336E+06
202	9.00000E+01	6.20924E+15	6.00000E+01	6.20924E+01	9.19624E+01	0.00000E+00	0.00000E+00	0.00000E+00
203	1.00000E+02	1.11284E+05	5.30000E+01	6.21697E+01	8.50452E+01	0.00000E+00	0.00000E+00	1.05440E+05
204	9.00000E+01	6.20924E+15	6.00000E+01	6.20924E+01	9.19624E+01	0.00000E+00	0.00000E+00	0.00000E+00

JUNCTION NUMBER	CONNECTS VOLUMES	CHOK/ PATH	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E D I F F E R E N T I A L S VEL. PSI	ELEV. PSI	FRIC. PSI	ACCL. PSI	PUMP PSI
1	1 TO 4		4.18700E+03	1.17735E+03	4.90036E-01	-2.30720E+00	-1.33551E+00	-3.04100E+00	-2.22045E-14	0.00000E+00
2	4 TO 5		4.18700E+03	1.17735E+03	4.93866E-01	-2.72202E-02	3.91521E-01	-3.68507E+00	7.72715E-14	0.00000E+00
3	5 TO 6		4.18700E+03	1.17735E+03	4.95791E-01	-1.39975E-01	1.64180E-01	-4.52197E+01	-5.73430E-14	0.00000E+00
4	6 TO 100		4.18700E+03	1.17735E+03	5.23460E-01	1.52827E+00	1.57497E-01	-2.20986E+02	3.99680E-15	0.00000E+00
5	101 TO 102		3.73500E+03	1.09760E+03	1.39932E+00	-1.57939E+00	-4.41613E-03	-1.10216E+02	6.50001E-15	0.00000E+00
6	102 TO 7		3.73500E+03	1.06601E+03	2.18735E+00	-8.11646E-01	-4.62190E-02	-4.98778E+00	-2.84495E-16	0.00000E+00
7	7 TO 8		3.73500E+03	1.06601E+03	2.26191E+00	2.41805E-01	-3.71214E-02	-5.67152E-01	-2.52576E-15	0.00000E+00
8	8 TO 9		3.27500E+03	1.14468E+03	2.51072E+00	4.34670E-02	-8.90497E-04	-5.90058E-01	-1.16678E-14	0.00000E+00
9	9 TO 10		3.27500E+03	1.22284E+03	2.88185E+00	-2.83950E-01	2.99441E-02	-9.90402E-01	1.33990E-14	0.00000E+00
10	10 TO 103		3.27500E+03	1.22284E+03	2.90322E+00	2.33858E-02	2.78017E-02	-6.91512E+01	4.94743E-15	0.00000E+00
11	103 TO 104		2.63000E+03	1.17733E+03	4.41859E+00	-5.22616E-02	-3.44917E-03	-9.03443E+01	1.44030E-14	0.00000E+00
12	104 TO 105		2.40600E+03	1.01876E+03	3.96340E+01	-6.27350E-02	-3.43554E-04	-6.83692E+00	-3.11383E-16	0.00000E+00
13	105 TO 11		2.40600E+03	9.51025E+02	1.92242E+02	0.00000E+00	3.99261E-04	-5.01755E-01	-4.99817E-17	0.00000E+00
14	11 TO 12		2.40600E+03	9.51025E+02	2.84325E+02	0.00000E+00	2.34607E-03	-9.90336E-04	-4.33681E-18	0.00000E+00
15	12 TO 13		2.40600E+03	1.18375E+02	1.56952E+01	0.00000E+00	2.35446E+00	-3.54458E-01	4.44089E-16	0.00000E+00
16	13 TO 14		2.40600E+03	7.45514E+01	1.61554E-02	-1.39620E-01	2.35966E+00	-5.16593E-05	-3.34948E-09	0.00000E+00
17	14 TO 15		2.63000E+03	1.58341E+02	1.87304E+00	-1.27296E-02	-1.04067E+00	-9.35616E+00	-1.95595E-07	5.01896E+01
18	15 TO 16		2.63000E+03	1.58341E+02	1.65645E-02	1.53981E+00	-1.04809E+00	-2.31816E-03	2.27129E-08	5.01896E+01
19	16 TO 17		2.63000E+03	1.54971E+02	1.65393E-02	-4.93366E-02	0.00000E+00	-5.76131E-04	4.26118E-11	0.00000E+00
20	17 TO 18		3.73500E+03	3.74740E+02	4.27303E-01	-1.59858E+00	0.00000E+00	-3.31444E-02	8.66496E-10	0.00000E+00
21	18 TO 19		4.18700E+03	4.52775E+02	8.48311E-01	6.65156E-01	-4.41202E-01	-1.29496E+03	5.23482E-07	1.70074E+03
22	19 TO 20		4.18700E+03	4.52775E+02	2.36098E-02	1.74194E+00	-9.20869E+00	-1.28416E+03	-8.59066E-10	1.70074E+03
23	20 TO 1		4.18700E+03	4.52775E+02	1.96695E-02	-6.65739E-01	-8.38494E+00	-6.27830E-02	3.90799E-14	0.00000E+00
29	101 TO 22		4.52000E+02	1.09760E+03	1.39932E+00	0.00000E+00	1.44804E-01	-3.71274E-01	-8.90954E-15	0.00000E+00
30	103 TO 24		6.45000E+02	1.17733E+03	4.41859E+00	0.00000E+00	4.49029E-02	-2.38071E+00	-4.82253E-15	0.00000E+00
31	104 TO 25		2.24000E+02	1.01876E+03	3.96340E+01	0.00000E+00	5.11342E-03	-1.66026E-01	-5.41234E-16	0.00000E+00
32	22 TO 18		4.52000E+02	1.09760E+03	1.40042E+00	0.00000E+00	1.36367E-01	-1.93613E+02	3.27238E-14	0.00000E+00
33	23 TO 17		4.60000E+02	5.05870E+02	5.27495E-01	0.00000E+00	5.22649E-01	-7.50211E+01	-1.72085E-14	0.00000E+00
34	24 TO 17		6.45000E+02	1.17733E+03	4.52208E+00	0.00000E+00	4.22311E-02	-8.77367E-01	2.08167E-16	0.00000E+00
35	27 TO 14		2.24000E+02	1.05833E+03	4.26942E+01	0.00000E+00	7.74048E-03	-2.93175E+00	-1.80252E-08	0.00000E+00
36	8 TO 23		4.60000E+02	5.05870E+02	5.29327E-01	0.00000E+00	5.33416E-01	-9.78137E-02	2.66454E-15	0.00000E+00
37	25 TO 26		2.24000E+02	1.01876E+03	4.03784E+01	-2.63200E-01	4.29961E-03	-3.99885E-02	-1.94913E-09	0.00000E+00
38	26 TO 27		2.24000E+02	1.05833E+03	4.37452E+01	2.42943E-01	1.62656E-04	-3.93050E-02	-1.02174E-10	0.00000E+00
100	100 TO 101		4.18700E+03	1.15447E+03	6.90721E-01	-6.97708E-01	-1.25752E-02	-3.37090E+02	4.40273E-15	0.00000E+00
202	201 TO 202		6.40000E+04	6.86512E+01	1.61306E-02	0.00000E+00	2.01340E-04	-1.00002E+01	5.55112E-16	0.00000E+00
204	203 TO 204		6.40000E+03	6.12375E+01	1.61081E-02	0.00000E+00	2.01340E-04	-1.00002E+01	-1.22125E-15	0.00000E+00
203	0 TO 203		6.40000E+03	4.47625E+01	1.60604E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
201	0 TO 201		6.40000E+04	3.73488E+01	1.60604E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

BUBL SET NUMB.	VOL. NUMB.	BUBBLE GRADIENT PARAMETER	BUBBLE VELOCITY (FT/SEC)	MIXTURE LEVEL (FT)	MIXTURE QUALITY	BUBBLE MASS (LB)
1	8	8.00000E-01	0.00000E+00	1.00000E+00	2.56429E-01	1.83636E+02

PUMP NUMB.	VOL. NUMB.	PUMP SPEED (RPM)	NORM. PUMP TORQUE	NORM. FRIC. TORQUE	NORM. MOT. TORQUE	POWER TO H2O (BTU/HR)
1	15	3.60000E+03	1.00263E+00	0.00000E+00	1.00000E+00	1.74901E+03
2	19	3.60000E+03	7.99991E-01	0.00000E+00	1.00000E+00	1.39553E+03

HEAT COND. NUMBER	VOL. NUM.	HT TRAN MODE-COR	SURF. FLUX (BTU/HR-FT2)	CRIT. FLUX (BTU/HR-FT2)	H.T. COEF. (BTU/H-F2-F)	SURF. TEMP. (DEG. F)	MASS FLUX (LBM/HR-FT2)	STORD ENRGY (BTU)	POWR TO H20 (BTU/HR)	DRYOUT PNT ()
1 LEFT	12	22-CH-S	-4.35573E+03	9.00000E+04	3.31848E+02	8.84423E+01	5.77440E+03		-7.21208E+09	

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      RGHT    201   1-DB-L  3.92935E+03  2.35590E+05  1.22846E+03  8.82438E+01  1.44000E+06  1.59531E+06  7.21208E+09
    2 LEFT     13   1-DB-L -4.25395E+03  9.00000E+04  1.14777E+02  9.11889E+01  4.33080E+04              -3.79583E+08
      RGHT    203   1-DB-L  3.83761E+03  1.39360E+05  6.44985E+02  9.09951E+01  6.43575E+05  1.82773E+05  3.79583E+08
    3 LEFT     26   3-SG    3.19044E+03  1.36913E+05  2.80493E+03  1.83481E+02  2.68800E+04                3.19044E+07
      RGHT     16   1-DB-L -2.87813E+03  7.82628E+05  6.16716E+02  1.83626E+02  3.15600E+05  8.98322E+05 -3.19044E+07

HEAT EXCGR.   VOLUME   POWR TO H2O
NUMBER        NUMBER   (BTU/HR)
    1            1    1.09216E+10
    2            9    9.21510E+08
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PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   38
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis             11:57:37
 SECONDARY SYSTEM SAMPLE PROBLEM - RETRAN-3D SAMPLE PROBLEM                                                      CPU TIME =     0.421
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *
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NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	ENERGY BALANCE (BTU)	TOTAL MASS BALANCE (LBM)	NCG MASS BALANCE (LBM)	AVERAGE TIME STEP (SEC)	CURRENT TIME STEP (SEC)	ELAPSED TIME (SEC)	TIME STEP NUM STANDRD/ACTUL
									500
0.00000E+00	0.00000E+00	1.18431E+10	7.41778E+17	1.24185E+16	0.00000E+00	7.14286E-04	6.49755E-04	5.00000E-01	726

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	VOID FRAC.	POWR TO H2O (BTU/SEC)
1	9.26647E+02	6.65078E+04	8.21793E+02	4.43386E+00	5.34939E+02	4.37631E-01	9.47044E-01	3.03378E+06
4	9.32699E+02	1.81231E+04	1.18087E+03	2.10733E+00	5.35717E+02	9.78227E-01	9.99025E-01	0.00000E+00
5	9.21444E+02	1.04163E+04	1.18004E+03	2.08326E+00	5.34268E+02	9.76486E-01	9.98961E-01	0.00000E+00
6	6.70794E+02	7.73114E+03	1.15865E+03	1.54623E+00	4.97961E+02	9.38840E-01	9.98079E-01	0.00000E+00
7	1.66543E+02	1.73634E+03	1.06428E+03	4.34085E-01	3.67050E+02	8.46507E-01	9.98784E-01	0.00000E+00
8 LIQ REG	1.68048E+02	7.19507E+02	5.60175E+02	1.41599E+00	3.67773E+02	2.57035E-01	9.95751E-01	0.00000E+00
VAP REG		7.86295E+02	1.14418E+03	3.94752E-01	3.67773E+02	9.39633E-01		0.00000E+00
9	1.67904E+02	1.03344E+04	1.22282E+03	3.44478E-01	4.15355E+02	1.00000E+00	1.00000E+00	2.55975E+05
10	1.66659E+02	1.71205E+03	1.22227E+03	3.42411E-01	4.14053E+02	1.00000E+00	1.00000E+00	0.00000E+00
11	9.94537E-01	1.05129E+01	9.50749E+02	3.50429E-03	1.01386E+02	8.50411E-01	9.99992E-01	0.00000E+00
12	9.97622E-01	3.17633E+02	1.18332E+02	6.35266E-02	1.01489E+02	4.70023E-02	9.99023E-01	-1.99428E+06
13	2.99731E+00	1.23172E+05	9.64632E+01	6.15861E+01	1.28252E+02	0.00000E+00	0.00000E+00	-1.05435E+05
14	5.21872E+00	5.33708E+02	1.58334E+02	5.33708E-01	1.63825E+02	2.63076E-02	9.91473E-01	0.00000E+00
15	4.49310E+01	6.03699E+04	1.58341E+02	6.03699E+01	1.90072E+02	0.00000E+00	0.00000E+00	4.85924E-01
16	9.55646E+01	9.06335E+04	1.56656E+02	6.04223E+01	1.88293E+02	0.00000E+00	0.00000E+00	-8.90171E+03
17	9.53962E+01	3.50048E+03	3.74621E+02	2.33365E+00	3.24759E+02	8.92957E-02	9.62245E-01	0.00000E+00
18	9.19723E+01	1.76589E+03	4.48335E+02	1.17726E+00	3.22147E+02	1.74640E-01	9.82766E-01	0.00000E+00
19	4.99738E+02	4.23577E+04	4.52711E+02	4.23577E+01	4.66689E+02	4.31565E-03	1.69777E-01	3.87668E-01
20	9.34529E+02	1.01695E+05	4.52866E+02	5.08475E+01	4.69761E+02	0.00000E+00	0.00000E+00	0.00000E+00
22	2.52631E+02	6.35863E+02	1.08807E+03	6.35863E-01	4.02019E+02	8.62739E-01	9.98369E-01	0.00000E+00
23	1.69098E+02	1.88172E+03	5.05737E+02	1.88172E+00	3.68274E+02	1.92882E-01	9.72270E-01	0.00000E+00
24	9.61191E+01	2.20453E+02	1.17700E+03	2.20453E-01	3.25301E+02	9.89348E-01	9.99958E-01	0.00000E+00
25	8.18882E+00	2.46349E+01	1.01825E+03	2.46349E-02	1.83754E+02	8.77034E-01	9.99950E-01	0.00000E+00
26	7.92237E+00	3.41908E+01	1.05899E+03	2.27939E-02	1.82241E+02	9.18946E-01	9.99969E-01	9.44752E+03
27	8.13558E+00	1.16955E+01	1.05865E+03	2.33909E-02	1.83455E+02	9.18063E-01	9.99968E-01	0.00000E+00
100	5.04583E+02	2.38105E+00	1.13780E+03	1.19052E+00	4.67679E+02	9.11339E-01	9.97920E-01	-6.84442E+04
101	2.52769E+02	3.17605E+00	1.08920E+03	6.35210E-01	4.02067E+02	8.64099E-01	9.98387E-01	-1.59538E+05
102	1.69103E+02	4.40896E+00	1.06395E+03	4.40896E-01	3.68277E+02	8.45663E-01	9.98758E-01	-7.73488E+04
103	9.82202E+01	2.40890E+00	1.17694E+03	2.25131E-01	3.26858E+02	9.88822E-01	9.99955E-01	-1.47375E+05
104	8.31002E+00	4.05539E+00	1.01820E+03	2.49870E-02	1.84428E+02	8.76666E-01	9.99949E-01	-4.15352E+05
105	1.49213E+00	2.54716E+00	9.50749E+02	5.17716E-03	1.15260E+02	8.43458E-01	9.99987E-01	-1.61575E+05
201	9.99995E+01	1.11284E+05	5.29994E+01	6.21697E+01	8.50446E+01	0.00000E+00	0.00000E+00	2.00245E+06
202	9.00000E+01	6.20924E+15	6.00000E+01	6.20924E+01	9.19624E+01	0.00000E+00	0.00000E+00	0.00000E+00
203	1.00000E+02	1.11284E+05	5.30000E+01	6.21697E+01	8.50452E+01	0.00000E+00	0.00000E+00	1.05439E+05
204	9.00000E+01	6.20924E+15	6.00000E+01	6.20924E+01	9.19624E+01	0.00000E+00	0.00000E+00	0.00000E+00

JUNCTION NUMBER	CONNECTS VOLUMES	CHOK/ PATH	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E VEL. PSI	ELEV. PSI	D I F F E R E N T I A L S FRIC. PSI	ACCL. PSI	PUMP PSI
1	1 TO 4		-2.25308E+03	1.18087E+03	4.74515E-01	-1.56020E-01	-1.36657E+00	1.33660E+00	-6.38681E+00	0.00000E+00
2	4 TO 5		-1.18337E+03	1.18005E+03	4.79982E-01	6.47171E-01	4.07735E-01	3.20964E-01	1.25959E+01	0.00000E+00
3	5 TO 6		0.00000E+00	1.18005E+03	4.79982E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
4	6 TO 100		3.28215E+03	1.15868E+03	6.46557E-01	-6.11165E-01	1.27833E-01	-1.67905E+02	-2.11664E+00	0.00000E+00
5	101 TO 102		3.06366E+03	1.08921E+03	1.57400E+00	-9.74748E-01	-3.33480E-03	-8.34723E+01	-7.38662E-01	0.00000E+00
6	102 TO 7		3.06380E+03	1.06395E+03	2.26806E+00	-4.79803E-01	-4.52439E-02	-3.48406E+00	-1.44694E+00	0.00000E+00
7	7 TO 8		3.08157E+03	1.06428E+03	2.30368E+00	1.72505E-01	-3.66693E-02	-3.96338E-01	-1.76644E+00	0.00000E+00
8	8 TO 9		2.71925E+03	1.14418E+03	2.53320E+00	-5.00108E-01	-8.72729E-04	-4.20343E-01	-7.79358E-01	0.00000E+00
9	9 TO 10		3.17728E+03	1.22281E+03	2.90286E+00	-8.17498E-01	2.97599E-02	-9.41220E-01	-4.85171E-01	0.00000E+00
10	10 TO 103		3.25102E+03	1.22227E+03	2.92039E+00	-7.44262E-02	2.76409E-02	-6.85501E-01	-1.55085E-01	0.00000E+00
11	103 TO 104		2.61664E+03	1.17694E+03	4.44175E+00	-5.18604E-02	-3.43310E-03	-8.99021E+01	-4.49027E-02	0.00000E+00
12	104 TO 105		2.39539E+03	1.01820E+03	4.00194E+01	-6.21865E-02	-3.39807E-04	-6.84298E+00	-8.73301E-02	0.00000E+00
13	105 TO 11		2.39548E+03	9.50750E+02	1.93152E+02	0.00000E+00	3.97910E-04	-4.99753E-01	-1.74873E-03	0.00000E+00
14	11 TO 12		2.39575E+03	9.50749E+02	2.85360E+02	0.00000E+00	2.33888E-03	-9.85527E-04	-1.72654E-03	0.00000E+00
15	12 TO 13		2.40586E+03	1.18332E+02	1.57411E+01	0.00000E+00	2.35445E+00	-3.55455E-01	-6.93019E-04	0.00000E+00
16	13 TO 14		2.40585E+03	7.45515E+01	1.61554E-02	-1.39921E-01	2.35966E+00	-5.16527E-05	-1.72742E-03	0.00000E+00
17	14 TO 15		2.63239E+03	1.58334E+02	1.87368E+00	-1.27507E-02	-1.04068E+00	-9.37626E+00	2.51312E-02	5.01676E+01
18	15 TO 16		2.63252E+03	1.58341E+02	1.65646E-02	1.54311E+00	-1.04809E+00	-2.32244E-03	2.63436E-02	5.01676E+01
19	16 TO 17		2.63285E+03	1.54971E+02	1.65393E-02	-5.23822E-02	0.00000E+00	-5.77270E-04	1.14756E-01	0.00000E+00
20	17 TO 18		3.81784E+03	3.74622E+02	4.28506E-01	-1.61928E+00	0.00000E+00	-3.44774E-02	1.76673E+00	0.00000E+00
21	18 TO 19		4.18151E+03	4.48347E+02	8.49440E-01	7.00137E-01	-4.41226E-01	-1.29328E+03	5.35519E-02	1.70084E+03
22	19 TO 20		4.14604E+03	4.52711E+02	2.36085E-02	1.74246E+00	-9.20995E+00	-1.25921E+03	-5.09615E-01	1.70084E+03
23	20 TO 1		4.04143E+03	4.52866E+02	1.96667E-02	-1.51077E-01	-8.38482E+00	-5.85359E-02	-7.20341E-01	0.00000E+00
29	101 TO 22		2.20301E+02	1.08921E+03	1.57400E+00	0.00000E+00	1.28953E-01	-9.92003E-02	1.68330E-01	0.00000E+00
30	103 TO 24		6.34467E+02	1.17694E+03	4.44175E+00	0.00000E+00	4.47591E-02	-2.31604E+00	-1.69509E-01	0.00000E+00
31	104 TO 25		2.21467E+02	1.01820E+03	4.00194E+01	0.00000E+00	5.08523E-03	-1.63853E-01	-3.74781E-02	0.00000E+00
32	22 TO 18		3.89070E+02	1.08808E+03	1.57240E+00	2.84217E-14	1.21453E-01	-1.61142E+02	-3.18469E-01	0.00000E+00
33	23 TO 17		4.55995E+02	5.05737E+02	5.31412E-01	0.00000E+00	5.18796E-01	-7.42726E-01	-4.98212E-02	0.00000E+00
34	24 TO 17		6.40429E+02	1.17701E+03	4.53603E+00	0.00000E+00	4.21012E-02	-8.67727E-01	-1.02274E-01	0.00000E+00
35	27 TO 14		2.23817E+02	1.05864E+03	4.27511E+01	0.00000E+00	7.73751E-03	-2.93091E+00	-6.25490E-03	0.00000E+00
36	8 TO 23		3.70622E+02	5.05046E+02	5.33744E-01	0.00000E+00	5.29562E-01	-6.41142E-02	-5.85942E-01	0.00000E+00
37	25 TO 26		2.22408E+02	1.01825E+03	4.05918E+01	-2.62984E-01	4.27699E-03	-3.95925E-02	-3.17486E-02	0.00000E+00
38	26 TO 27		2.23587E+02	1.05898E+03	4.38704E+01	2.40783E-01	1.62439E-04	-3.92400E-02	-1.14518E-02	0.00000E+00
100	100 TO 101		3.28309E+03	1.13782E+03	8.39751E-01	-5.27047E-01	-9.52849E-03	-2.52133E+02	-7.62750E-01	0.00000E+00
202	201 TO 202		6.39999E+04	6.86506E+01	1.61306E-02	0.00000E+00	2.01356E-04	-1.00002E+01	-4.24801E-04	0.00000E+00
204	203 TO 204		6.40000E+03	6.12375E+01	1.61081E-02	0.00000E+00	2.01340E-04	-1.00002E+01	-2.65969E-07	0.00000E+00
203	0 TO 203		6.40000E+03	4.47625E+01	1.60604E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
201	0 TO 201		6.40000E+04	3.73488E+01	1.60604E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

BUBL SET NUMB.	VOL. NUMB.	BUBBLE GRADIENT PARAMETER	BUBBLE VELOCITY (FT/SEC)	MIXTURE LEVEL (FT)	MIXTURE QUALITY	BUBBLE MASS (LB)
1	8	8.00000E-01	2.76567E+01	1.01626E+00	2.57035E-01	1.84938E+02

PUMP NUMB.	VOL. NUMB.	PUMP SPEED (RPM)	NORM. PUMP TORQUE	NORM. FRIC. TORQUE	NORM. MOT. TORQUE	POWER TO H2O (BTU/HR)
1	15	3.60000E+03	1.00281E+00	0.00000E+00	0.00000E+00	1.74933E+03
2	19	3.60000E+03	8.00034E-01	0.00000E+00	0.00000E+00	1.39561E+03

HEAT COND. NUMBER	VOL. NUM.	HT TRAN MODE-COR	SURF. FLUX (BTU/HR-FT2)	CRIT. FLUX (BTU/HR-FT2)	H.T. COEF. (BTU/H-F2-F)	SURF. TEMP. (DEG. F)	MASS FLUX (LBM/HR-FT2)	STORD ENRGY (BTU)	POWR TO H20 (BTU/HR)	DRYOUT PNT ()
1 LEFT	12	22-CH-S	-4.33599E+03	9.00000E+04	3.32271E+02	8.84397E+01	5.76200E+03		-7.17941E+09	

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

```
      RGHT    201   1-DB-L  3.92757E+03  2.35589E+05  1.22845E+03  8.82417E+01  1.44000E+06  1.59527E+06  7.20881E+09
    2 LEFT     13   1-DB-L -4.25374E+03  9.00000E+04  1.14771E+02  9.11889E+01  4.33054E+04              -3.79565E+08
      RGHT    203   1-DB-L  3.83758E+03  1.39360E+05  6.44985E+02  9.09950E+01  6.43575E+05  1.82773E+05  3.79580E+08
    3 LEFT     26   3-SG    3.40111E+03  1.36548E+05  2.79457E+03  1.83458E+02  2.67605E+04                3.40111E+07
      RGHT     16   1-DB-L -2.89092E+03  7.82906E+05  6.17215E+02  1.83609E+02  3.15920E+05  8.98230E+05 -3.20462E+07

HEAT EXCGR.   VOLUME   POWR TO H2O
NUMBER        NUMBER   (BTU/HR)
    1            1    1.09216E+10
    2            9    9.21510E+08
```

```
RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   39
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:37
 SECONDARY SYSTEM SAMPLE PROBLEM - RETRAN-3D SAMPLE PROBLEM                                                     CPU TIME =     0.421
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *
```

SYSTEM ELAPSED TIME (SEC)	SYSTEM ELAPSED TIME (SEC)	TIME STP ACTUAL	VOL 8 AVG. PRESS. (PSIA)	VOL 12 AVG. PRESS. (PSIA)	VOL 16 AVG. PRESS. (PSIA)	JUN 20 FLOW (LB/SEC)	JUN 29 FLOW (LB/SEC)
0.00000E+00	0.00000E+00	0.00000E+00	1.69692E+02	1.00000E+00	9.56790E+01	3.73500E+03	4.52000E+02
1.00000E-02	1.00000E-02	1.40000E+01	1.69692E+02	1.00000E+00	9.56790E+01	3.73500E+03	4.51999E+02
2.00000E-02	2.00000E-02	2.90000E+01	1.69692E+02	1.00000E+00	9.56790E+01	3.73500E+03	4.47760E+02
3.00000E-02	3.00000E-02	4.40000E+01	1.69692E+02	1.00000E+00	9.56790E+01	3.73500E+03	4.37362E+02
4.00000E-02	4.00000E-02	5.90000E+01	1.69691E+02	1.00000E+00	9.56790E+01	3.73500E+03	4.27980E+02
5.00000E-02	5.00000E-02	7.40000E+01	1.69688E+02	1.00000E+00	9.56790E+01	3.73500E+03	4.16603E+02
6.00000E-02	6.00000E-02	8.90000E+01	1.69683E+02	1.00000E+00	9.56790E+01	3.73501E+03	4.03230E+02
7.00000E-02	7.00000E-02	1.04000E+02	1.69674E+02	1.00000E+00	9.56790E+01	3.73502E+03	3.90680E+02
8.00000E-02	8.00000E-02	1.19000E+02	1.69662E+02	1.00000E+00	9.56790E+01	3.73503E+03	3.76908E+02
9.00000E-02	9.00000E-02	1.34000E+02	1.69646E+02	1.00000E+00	9.56790E+01	3.73506E+03	3.62968E+02
1.00000E-01	1.00000E-01	1.49000E+02	1.69625E+02	1.00000E+00	9.56790E+01	3.73510E+03	3.49647E+02
1.10000E-01	1.10000E-01	1.64000E+02	1.69600E+02	1.00000E+00	9.56790E+01	3.73516E+03	3.36040E+02
1.20000E-01	1.20000E-01	1.79000E+02	1.69571E+02	1.00000E+00	9.56790E+01	3.73525E+03	3.23040E+02
1.30000E-01	1.30000E-01	1.94000E+02	1.69538E+02	1.00000E+00	9.56789E+01	3.73536E+03	3.10678E+02
1.40000E-01	1.40000E-01	2.09000E+02	1.69503E+02	1.00000E+00	9.56789E+01	3.73551E+03	2.98698E+02
1.50000E-01	1.50000E-01	2.24000E+02	1.69465E+02	1.00000E+00	9.56789E+01	3.73571E+03	2.87595E+02
1.60000E-01	1.60000E-01	2.39000E+02	1.69426E+02	1.00000E+00	9.56789E+01	3.73595E+03	2.77214E+02
1.70000E-01	1.70000E-01	2.54000E+02	1.69387E+02	1.00000E+00	9.56788E+01	3.73624E+03	2.67548E+02
1.80000E-01	1.80000E-01	2.69000E+02	1.69348E+02	9.99998E-01	9.56787E+01	3.73661E+03	2.58799E+02
1.90000E-01	1.90000E-01	2.84000E+02	1.69311E+02	9.99995E-01	9.56786E+01	3.73704E+03	2.50805E+02
2.00000E-01	2.00000E-01	2.99000E+02	1.69275E+02	9.99992E-01	9.56785E+01	3.73755E+03	2.43613E+02
2.10000E-01	2.10000E-01	3.14000E+02	1.69241E+02	9.99987E-01	9.56783E+01	3.73814E+03	2.37261E+02
2.20000E-01	2.20000E-01	3.29000E+02	1.69209E+02	9.99981E-01	9.56781E+01	3.73883E+03	2.31625E+02
2.30000E-01	2.30000E-01	3.44000E+02	1.69180E+02	9.99972E-01	9.56778E+01	3.73963E+03	2.26732E+02
2.40000E-01	2.40000E-01	3.59000E+02	1.69152E+02	9.99962E-01	9.56774E+01	3.74053E+03	2.22534E+02
2.50000E-01	2.50000E-01	3.74000E+02	1.69125E+02	9.99949E-01	9.56770E+01	3.74154E+03	2.18959E+02
2.60000E-01	2.60000E-01	3.89000E+02	1.69099E+02	9.99934E-01	9.56765E+01	3.74268E+03	2.15991E+02
2.70000E-01	2.70000E-01	4.04000E+02	1.69073E+02	9.99915E-01	9.56759E+01	3.74395E+03	2.13563E+02
2.80000E-01	2.80000E-01	4.18000E+02	1.69045E+02	9.99892E-01	9.56751E+01	3.74536E+03	2.11625E+02
2.90000E-01	2.90000E-01	4.32000E+02	1.69016E+02	9.99865E-01	9.56742E+01	3.74691E+03	2.10142E+02
3.00000E-01	3.00000E-01	4.46000E+02	1.68985E+02	9.99834E-01	9.56731E+01	3.74860E+03	2.09053E+02
3.10000E-01	3.10000E-01	4.60000E+02	1.68950E+02	9.99798E-01	9.56719E+01	3.75045E+03	2.08315E+02
3.20000E-01	3.20000E-01	4.74000E+02	1.68912E+02	9.99756E-01	9.56704E+01	3.75246E+03	2.07889E+02
3.30000E-01	3.30000E-01	4.88000E+02	1.68871E+02	9.99709E-01	9.56687E+01	3.75463E+03	2.07735E+02
3.40000E-01	3.40000E-01	5.02000E+02	1.68826E+02	9.99655E-01	9.56668E+01	3.75696E+03	2.07808E+02
3.50000E-01	3.50000E-01	5.16000E+02	1.68777E+02	9.99595E-01	9.56645E+01	3.75946E+03	2.08082E+02
3.60000E-01	3.60000E-01	5.30000E+02	1.68725E+02	9.99528E-01	9.56619E+01	3.76214E+03	2.08521E+02
3.70000E-01	3.70000E-01	5.44000E+02	1.68671E+02	9.99454E-01	9.56589E+01	3.76499E+03	2.09096E+02
3.75000E-01	3.75000E-01	5.51000E+02	1.68644E+02	9.99413E-01	9.56573E+01	3.76648E+03	2.09428E+02
3.90000E-01	3.90000E-01	5.72000E+02	1.68560E+02	9.99280E-01	9.56517E+01	3.77121E+03	2.10557E+02
4.05000E-01	4.05000E-01	5.93000E+02	1.68475E+02	9.99127E-01	9.56450E+01	3.77635E+03	2.11834E+02
4.20000E-01	4.20000E-01	6.14000E+02	1.68394E+02	9.98951E-01	9.56370E+01	3.78188E+03	2.13200E+02
4.35000E-01	4.35000E-01	6.35000E+02	1.68317E+02	9.98755E-01	9.56275E+01	3.78781E+03	2.14604E+02
4.50000E-01	4.50000E-01	6.56000E+02	1.68246E+02	9.98536E-01	9.56163E+01	3.79412E+03	2.16003E+02
4.65000E-01	4.65000E-01	6.77000E+02	1.68181E+02	9.98293E-01	9.56033E+01	3.80082E+03	2.17370E+02
4.80000E-01	4.80000E-01	6.98000E+02	1.68122E+02	9.98024E-01	9.55882E+01	3.80788E+03	2.18677E+02
4.95000E-01	4.95000E-01	7.19000E+02	1.68066E+02	9.97727E-01	9.55709E+01	3.81529E+03	2.19909E+02
5.00000E-01	5.00000E-01	7.26000E+02	1.68048E+02	9.97622E-01	9.55646E+01	3.81784E+03	2.20301E+02

9.0 TURBINE TRIP WITHOUT BYPASS WITH SPACE-TIME KINETICS

The BWR plant modeled for the Turbine Trip Without Bypass with Space-Time Kinetics sample problem is similar to the model as described in Section VII.5.0 with the exception that this model uses the space-time kinetics option instead of the point kinetics option. The initial power level was 104% of normal, with normal core flow and 105% of normal steam flow assumed.

The geometric nodalization for the system model used for this transient analysis sample problem is shown in Figure VII.9-1. Figure VII.9-2 shows the detail of the core model, which uses the FIBWR style leakage model for the lateral and bypass leakage paths. The complete model utilizes 20 control volumes and 26 junctions. The control system requiring modeling for this sample problem includes the turbine stop valve, the safety relief valves, the feedwater control system, and the control rod movement model.

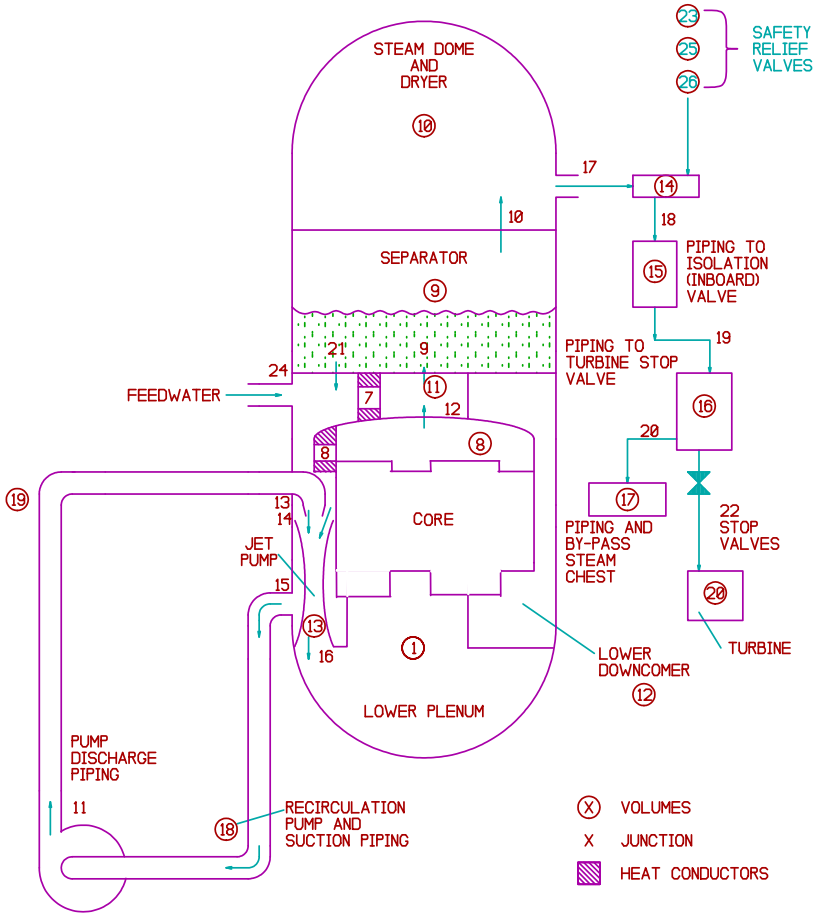


Figure VII.9-1. Schematic Diagram for TTQX1 RETRAN Model

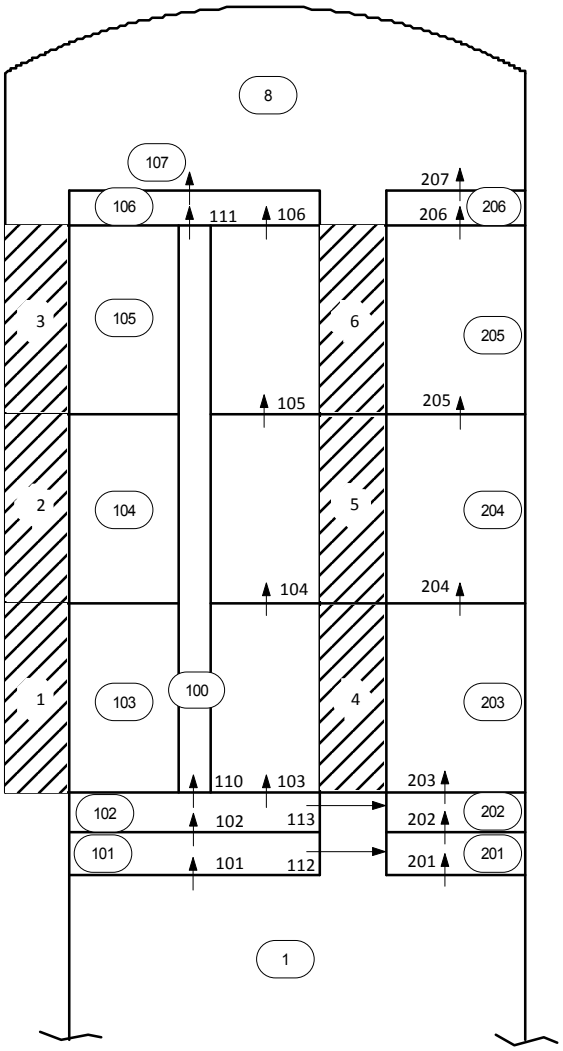


Figure VII.9-2. Core Detail

The space-time kinetics models utilize eight neutronic regions. Feedback quantities are obtained from the main channel, Volumes 103, 104, and 105 reflector regions in the lower and upper plena and Conductors 1, 2, and 3.

The space-time kinetics data satisfy the input requirements of the one-dimensional kinetics option and allow the option to be run for demonstration purposes.

The space-time kinetics data file contains a set of homogeneous cross sections for the eight neutronic regions. In order to skew the power profile toward the upper portion of the core, the control rods are partially inserted. These sample kinetics data are intended to be used for demonstration of this sample problem only. The space-time kinetics data are input on FORTRAN Unit 40.

The input and selected portions of the output are shown below.

```
 LISTING OF INPUT DATA FOR CASE  1

     1    =TTWOB WITH SPACE TIME KINETICS - RETRAN-3D SAMPLE PROBLEM
     2    *
     3    ************************************************************************
     4    *
     5    *     THIS SAMPLE PROBLEM USES THE FIVE-EQUATION OPTION,
     6    *     DYNAMIC SLIP OPTION AND THE FIBWR TOTAL CORE FLOW BC.
     7    *
     8    *  PROBLEM DIMENSIONS
     9    *
    10    *        1     2     3     4     5     6     7     8     9    10    11    12
    11    *      TAPE PRNPLT  POW   SS  NVOID GENTRN HTMAP SLIP  5EQ  NCOND  NSOL  PNMTH
    12    010001   0     0     2     0     0     0     1     1     1     0     3     0
    13    *
    14    *
    15    *10005  POWER
    16    010005  2533.4
    17    *
    18    *
    19    *  MINOR EDITS
    20    *20000  SYM  REG
    21    020000 TIMX  0 NTTS  0
    22    020001 PNRM  0 PRES 10 WP** 17 WP** 24 MIXL  9
    23    020002 RO**  0 RDRE  0 DPRE  0 VDRE  0 RSRE  0
    24    *
    25    *
    26    * FORMAT FOR TAPE60
    27    *
    28    025000 1
    29    025001 '(5(1X,1P,E15.7))'
    30    *
    31    *
    32    *  TIME STEP DATA
    33    *3XXX0  RTG  MIN   RST  MAJ  DMP  NCHK  DTMAX   TLAST  NSHAPE
    34    030010  0.   0.01  0.   1.   1.     0   0.001    0.5       5
    35    030020  0.   0.01  0.   1.   1.     0   0.0002   2.       20
    36    *
    37    *
    38    *  TIME STEP CONSTANTS
    39    *30011    EPSIMP  COURNT  EPSIU  CONDT  EPMDOT PRATE  FNPOW
    40    030021     .005    5.0    0.005  1.1892   1.0  0.015  0.01
    41    030021     .005    5.0    0.005  1.1892   1.0  0.015  0.001
+                                                                                *** THIS CARD IS A REPLACEMENT CARD. ***
    42    *
    43    *
    44    *  TRIP DATA
    45    *4XXX0   ID  IDSIG  IX1  IX2   SETPT  DELAY
    46    040010   1   1     0    0      1.0    0.0  "END OF PROBLEM TIME     "
    47    040020   1  -2     0    0      1-9    0.0  "END OF PROBLEM LOW POWER"
    48    040030   2   1     0    0       .001  0.0  "TURBINE TRIP            "
    49    040040   4   1     0    0       .700  0.12 "SCRAM TABLE            "
    50    040050   3   1     0    0      0.     0.0  "FEEDWATER               "
    51    040060   5   1     0    0      1+9    0.0  "PUMP                    "
    52    040070   6   4    14    0   1105.5    0.4  "SRV 1080PSIG +1% .4S DLY"
    53    040080   7   4    14    0   1115.6    0.4  "SRV 1090PSIG +1% .4S DLY"
    54    040090   8   4    14    0   1125.7    0.4  "SRV 1100PSIG +1% .4S DLY"
    55    *
    56    *  VOLUME DATA
    57    *5XXX1 BB RD  PRESS   TEMP    QUALITY VOLUME  HEIGHT       VOLUME DATA
    58    *5XXX1 BB RD  PRESS   ENTHAL  HUMID   VOLUME  HEIGHT       VOLUME DATA
    59    050011  0 0     0.0     0.0    0.     2672.62  17.38       * LOWER PLENUM
    60    050081  0 0     0.0     0.0    0.      812.26   5.933      * UPPER PLENUM
    61    050091  1 0     0.0     0.0   -1.0    2897.55  24.12       * SEPARATOR
    62    050101  0 0     0.0     0.0    0.     3624.1   17.29       * STEAM DOME-DRY
    63    050111  0 0     0.0     0.0    0.      211.612  5.484      * STAND PIPES
    64    050121  0 0     0.0     0.0    0.     3478.28  33.82       * LWR DWNCOMER
    65    050131  0 0     0.0     0.0    0.      195.36  16.4        * JET PUMPS
    66    050141  0 0     0.0     0.0    0.      648.3   48.544      * STM LINE TO SR9V
    67    050151  0 0     0.0     0.0    0.      444.515 17.127      * SR VV TO ISOVVV
    68    050161  0 0     0.0     0.0    0.     2322.96  42.631      * ISO TO TURB STM
    69    050171  0 0     0.0     0.0    0.      108.33   3.777      * BYPS STM CHST
    70    050181  0 0     0.0     0.0    0.      541.48  42.175      * RECIRC PMP + SUC
    71    050191  0 0     0.0     0.0    0.      593.125 51.194      * PUMP DISCHARGE
    72    050201  0 0     0.0     0.0    0.     1+9      10.         * TURBINE
    73    *
    74    *  1D CORE SECTION
    75    *
    76    051001  0 0     0.0     0.0    0.      111.87  12.2        * WAT ROD VOD
    77    051011  0 0     0.0     0.0    0.       42.25    .83333    * SP VOL
    78    051021  0 0     0.0     0.0    0.        8.45    .16667    * TP VOL
    79    051031  0 0     0.0     0.0    0.      202.81   4.0         * CORE-1
    80    051041  0 0     0.0     0.0    0.      202.81   4.0         * CORE-2
    81    051051  0 0     0.0     0.0    0.      202.81   4.0         * CORE-3
    82    051061  0 0     0.0     0.0    0.       25.35    .5         * UPPR REFL
    83    *
    84    *  BYPASS
    85    *
    86    052011  0 0     0.0     0.0    0.       42.32    .83333    * SP VOL
    87    052021  0 0     0.0     0.0    0.        8.46    .16667    * TP VOL
    88    052031  0 0     0.0     0.0    0.      203.12   4.0         * BY PASS-1
    89    052041  0 0     0.0     0.0    0.      203.12   4.0         * BY PASS-2
    90    052051  0 0     0.0     0.0    0.      203.12   4.0         * BY PASS-3
    91    052061  0 0     0.0     0.0    0.       25.39    .5         * UPPR REFL
    92    *
    93    *
    94    *5XXX2   FLOWL     FLOWA       HDIAM     ELEV
    95    050012   17.38   153.78        .69        0.          * LOWER PLENUM
    96    050082    5.933   89.67      15.29       29.88        * UPPER PLENUM
    97    050092   24.12   120.13        .552      41.294       * STM DRYER AND SEPARATOR
    98    050102    0.0    265.18      18.38       52.022       * STEAM DOME
    99    050112    0.0     32.702       .50542    35.81        * STAND PIPES
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050122    0.0    93.34       3.58         9.27        * LWR  DOWNCOMER
050132    0.0    31.52        .1833       9.27        * JET PUMPS
050142    0.0    10.1389     1.797        5.6815      * STM LINE TO SRVALVE
050152    0.0    10.1389     1.797       -9.649       * SR VV TO ISO STLN
050162    0.0    10.1389     1.797      -37.232 * STMLIN ISO VLV TO TURB STP VLV
050172    0.0     2.0         .797        5.232 * TURB STP VAL TO BYPS STM CHST
050182    0.0    7.1489      2.1333     -27.65        * RECIRC PMP + SUCT
050192    0.0    7.2131      1.0943     -23.32        * PUMP DISCHARGE
050202    0.0    1+9         1+9         -0.5         * TURBINE  2
*
*  1D CORE SECTION
*
051002   12.2      9.17       .113       17.3         * WAT ROD VOL
051012     .83333 59.869      .047612    16.38        * SP VOL
051022     .16667 59.869      .047612    17.21333     * TP VOL
051032    0.0     59.869      .047612    17.38        * CORE-1
051042    0.0     59.869      .047612    21.38        * CORE-2
051052    0.0     59.869      .047612    25.38        * CORE-3
051062    0.0     59.869      .047612    29.38        * UPPR REFL
*
*  BYPASS
*
052012    0.0     50.7801     .15208     16.38        * BY PASS (SP VOL)
052022    0.0     50.7801     .15208     17.21333     * BY PASS (TP VOL)
052032    0.0     50.7801     .15208     17.38        * BY PASS
052042    0.0     50.7801     .15208     21.38        * BY PASS-2
052052    0.0     50.7801     .15208     25.38        * BY PASS-3
052062    0.0     50.7801     .15208     29.38        * BY PASS (REFL)
*
*
*  BUBBLE SEPARATION DATA
*6XXX1  GRAD  VBUB     ZMIX
060011  .05   361.168  5.13
*
*
*  JUNCTION DATA
*8XXXY  FM  TO   PP VV   FLOW    AREA    ELEVTN  INERTIA *JUNCTION DATA-1
080091   11  9    0  0     .0   32.702   41.294   .919   *STAND PIPES-SEPARTR
080101    9 10    0  0     .0   99.75    53.      .1     *SEPARATOR TO DRYER
080111   18 19    1  0     .0    7.1489 -22.25  10.04    *RECIRC PUMP DISCHARGE
080121    8 11    0  0     .0   32.702   35.81   1.117   *UPPR PLEN-STND PIPES
080131   12 13    0  0     .0    3.9     25.67   1.57    *LWR DWNCOMR TO JET PMP
080141   19 13    0  0     .0    1.26    25.67   6.78    *RECIRC TO JET PUMPS
080151   12 18   -1  0     .0    7.1489  13.46   4.54    *LWR DWNCOMER TO RECIRC
080161   13  1    0  0     .0   31.52     9.27    .6003  *JET PUMPS TO LWR PLEN
080171   10 14    0  0     .0   10.139   53.33   3.183   *STM DOME TO STM LINE
080181   14 15    0  0     .0   10.139    6.58   5.315   *STM LINE SR TO ISO 5VV
080191   15 16    0  0     .0   10.139   -8.75  13.461   *ISO VV TO TURB STOP VV
080201   16 17    0  0     .0    2.       5.399 22.549   *STM LINE TO BYPASS STM
080211    9 12    0  0     .0   93.      41.3     .8803  *SEP TO LWR DWNCOMERR
080221   16 20    0  4     .0   10.1389   4.5   11.25    *TURB STOP VLV LEAK
080231    0 14    4  3     .0     .414   10.39   0.      *SAFETY RELIEF VLV NEGF
080241    0 12    1  0     .0    1.      40.29   0.      *FEEDWATER FILL
080251    0 14    2  1     .0     .552   10.39   0.      *SAFETY RELIEF VLV NEG
080261    0 14    3  2     .0     .552   10.39   0.      *SAFETY RELIEF VLV NEG
*
*
*
*8XXXY  FM  TO   PP VV   FLOW    AREA    ELEVTN  INERTIA *JUNCTION DATA-1
081011    1 101   0  0     .0   38.8889  16.38    .1173  *LWR PLN TO CORE SUP
081021  101 102   0  0     .0   38.8889  17.21333 .00835 *CORE SUP VOL TO TP
081031  102 103   0  0     .0   38.8889  17.38    .1433  *TP VOL TO CORE V1
081041  103 104   0  0     .0   38.8889  21.38    .066   *COREV1 TO COREV2
081051  104 105   0  0     .0   38.8889  25.38    .066   *COREV2 TO COREV3
081061  105 106   0  0     .0   38.8889  29.38    .00372 *COREV3 TO UPPR REFL
081071  106   8   0  0     .0   38.8889  29.88    .0222  *UPPR REFL TO UPR PLENM
081101  102 100   0  0     .0    9.17    17.3     .667   *TP VOL TO WAT ROD
081111  100 106   0  0     .0    9.17    29.5     .669   *WAT ROD TO UPPR REFL
081121  101 201 101  0     .0    1.      16.8            *SP FIBWR LEAKAGE PATH
081131  102 202 102  0     .0    1.      17.3            *TP FIBWR LEAKAGE PATH
*
*
082011    1 201 201  0     .0    1.      16.38           *FIBWR SUP PLATE LEAKAG
082021  201 202   0  0     .0   50.7801  17.21333 .00985 *CORE SUP VOL TO TP VOL
082031  202 203   0  0     .0   50.7801  17.38    .0410  *TP VOL TO BYPASS-1
082041  203 204   0  0     .0   50.7801  21.38    .0788  *BYPASS-1 TO BYPASS-2
082051  204 205   0  0     .0   50.7801  25.38    .0788  *BYPASS-2 TO BYPASS-3
082061  205 206   0  0     .0   50.7801  29.38    .0443  *BYPASS-3 TO UPR REFL
082071  206   8   0  0     .0   50.7801  29.88    .0229  *UPPER REFL TO UPPR PLE
*
*  JUNCTON DATA CARD 2
*8XXX2  FLOSS   RLOSS   JV JC CL MV HDIAMJ   CON  IFR JTPMJ IHQCOR ISP ANG1 ANG2
080092    .449    .254   0 -1  0  0   .50542  1.  -2    0     0     0
080102    .648    .958   0 -1  0  0  2.43     1.   0    0     0     0
080112   4.455   4.454   1 -1  0  0  2.1333   1.   0    0     0     0
080122    .364    .664   0 -1  0  0   .50542  1.  -2    0     0     0
080132    .272   1.067   0 -1  0  2   .29     1.   0    0     0     0
080142   0.365    .686   0 -1  0  2   .2833   1.   0    0     0     0
080152   1.153   1.153   0 -1  0  0  2.1333   1.   0    0     0     0
080162    .875    .605   0 -1  0  0  1.42     1.   0    0     0     0
080172    .81     .81    1 -1  0  0  1.797    1. -99    0     0     0
080182   1.152   1.152   1 -1  0  0  1.797    1. -99    0     0     0
080192  10.251   9.991   1 -1  0  0  1.797    1. -99    0     0     0
080202   2.3     2.3     0 -1  0  0  1.797    1. -99    0     0     0
080212   1.813   1.413   0 -1  0  0  0.       1. -99    0     0     0
080222   1.0      .45    1 -1  1  0  0.       1. -99    0     0     0
080232   0.      0.      1 -1  3  3  0.       1.   0    0     0     0   0. 180.
080242   0.       0.     1 -1  3  0  0.       1.   0    0     0     0
080252   0.      0.      1 -1  3  3  0.       1.   0    0     0     0   0. 180.
080262   0.      0.      1 -1  3  3  0.       1.   0    0     0     0   0. 180.
*
081012   6.44526445 5.      1 -1  0  0  0.       1.   0    0     0     0  *  +.0
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081022  30.     30.      1 -1  0  0  0.       1.   0    0     0     0
081032   0.      0.      1 -1  0  0  0.       1.   0    0     0     0
081042    .893    .893   0 -1  0  0  0.       1.   0    0     0     0
081052   1.326   1.326   0 -1  0  0  0.       1.   0    0     0     0
081062    .86     .86    0 -1  0  0  0.       1.   0    0     0     0
081072   0.      0.      0 -1  0  0  0.       1.   0    0     0     0
081102 350.    350.      0 -1  0  0  0.       1.   0    0     0     0
081112  80.     80.      0 -1  0  0  0.       1.   0    0     0     0
*
082022   0.      0.      0 -1  0  0  0.       1.   0    0     0     0
082032   0.      0.      0 -1  0  0  0.       1.   0    0     0     0
082042   6.492   6.492   0 -1  0  0  0.       1.   0    0     0     0
082052   7.151   7.151   0 -1  0  0  0.       1.   0    0     0     0
082062  96.09   95.568   0 -1  0  0  0.       1.   0    0     0     0
082072   0.      0.      0 -1  0  0  0.       1.   0    0     0     0
*
*  PUMP DATA
*
*90XXY IPC TRP REV ZPH MTQ  RPM  SRO   GPM    HEAD  TORQUE  INERTIA DENS TORKMR
090011  1   5   0   0   0  1665.  1. 90400.   530. 33200. 14059.8   47.2 0. 332.
*
*100000  PUMP CURVE INDICATOR
*100000  NPC(J)  NC(J)
100000    0       4
*
*10XYZ H/T IC NO           PUMP  HOMOLOGOUS CURVES
*10XYYZ  N  PHD(1) OR PTK(1)  PHD(2) OR PTK(2)
101011  -6  0. 1.36  .265 1.31  .531 1.24  .796 1.13  .885 1.08  1. 1. *HEAD 1
101021  -4  .752 .373  .870 .649  .943 .839  1. 1.                   *HEAD 2
101091  -6  0. 0.  .265 .182  .531 .537 .796 .874  .885 .95  1. 1.   *TORQUE 1
101101  -4  .752 .474  .870 .733  .943 .885  1. 1.                   *TORQUE 2
*
*
*  VALVE DATA
*11XXX0 ICV CV1 CV2 PCV  CV1  CV2  CV3
110010  -6   2   0   0.   0.   0.   0. * 4 S/R VALVES AT 1080 PSIG +1 PCT
110020  -7   3   0   0.   0.   0.   0. * 4 S/R VALVES AT 1090 PSIG +1 PCT
110030  -8   4   0   0.   0.   0.   0. * 3 S/R VALVES AT 1100 PSIG +1 PCT
110040   2   1   0   0.   0.   0.   0. * MSTV
*
*  LEAK - AREA VS TIME DATA        ***   STEAM LINE  MTSV  AREA CLOSURE RATE
*12XXYY PTS TRP PRES    TIME  NORM AREA
120101   3              0.  1.   .1  0.    1.+9  0. *  TURB STOP VLV
120201   3              0.  0.   .1  1.    1.+9  1. * S/R VLV STROKE TIME .1 SEC
120301   3              0.  0.   .1  1.    1.+9  1. * S/R VLV STROKE TIME .1 SEC
120401   3              0.  0.   .1  1.    1.+9  1. * S/R VLV STROKE TIME .1 SEC
120501  -6    0.0   .08333    10.0   .08333
120502   25.6  .500000  40.0 .750000    50.0 1.0       200.0  1.0
*
*
*  FILL TABLE    S/R VALVE  CAPACITY     DIA=5.030 INCH  AREA=0.138  FT*2
*13XXYY PTS TRP JX JY FILTBL(1) FILTBL(2) FILENT(1) FILPRS(1)
130101   -2   1000   -10   0
130102  100.  100.  405.708  1200.  1000.  1000.  405.708  1200.
130201   2   6   10 0  1044.7 -1547.9 1193. 1011.8 1250.7 -1851.85 1193. 1011.8
130301   2   7   10 0  1044.7 -1547.9 1193. 1011.8 1250.7 -1851.85 1193. 1011.8
130401   2   8   10 0  1044.7 -1547.9 1193. 1011.8 1250.7 -1851.85 1193. 1011.8
*
*
*  DIRECT MODERATOR HEATING CARDS
*144400X     QPMOD    QDMOD
144000    .025438  .025438
144001    .025438  .025438
144002    .025438  .025438
144003    .735     .735
144004    .732     .732
144005    .691     .691
*
*  DECAY HEAT OPTION   0 = 1979 DATA   1 = 1973 DATA
*
146000   1
*
*
*  HEAT CONDUCTOR DATA
*15XX1  IVL IVR IGM  CELEV    IMCL  IMCR  ASUL     ASUR     VOLS
150011   0  103  1  17.38    10     10     0.0  16177.86   189.7528
150021   0  104  1  21.38    10     10     0.0  16177.86   189.7528
150031   0  105  1  25.38    10     10     0.0  16177.86   189.7528
150041  103 203  2  17.38     2      2  4000.63  4000.63    26.6709
150051  104 204  2  21.38     2      2  4000.63  4000.63    26.6709
150061  105 205  2  25.38     2      2  4000.63  4000.63    26.6709
150071  11  12   3  35.81     2      2  1674.78  1822.52    40.925 * STAND PIPES
150081   8  12   4  29.38     2      2   377.1    398.2    188.87  * UPPER PLENM
*
*15XX2  HDML     HDMR     DHEL     DHER    CHNL    CHNR  IHXQF PFR HTC
150012  0.      .047612   0.      .059211  0.      4.     0
150022  0.      .047612   0.      .059211  0.      4.     0
150032  0.      .047612   0.      .059211  0.      4.     0
150042 .047612  .189472   .243067 .200100  4.      4.     0
150052 .047612  .189472   .243067 .200100  4.      4.     0
150062 .047612  .189472   .243067 .200100  4.      4.     0
150072  0.     2.657     0.      3.2      0.      0.     0
150082  0.      .2367    0.       .5169    0.      0.     0
*
*
*  CORE DATA
*                            N1 = 7  IS AT UO-2 PELLET SURFACE.
*                            N2 = 9  IS AT ZR-2 CLADDING INSIDE SURFACE.
*                            N3 = 11 IS AT A HALF DEPTH OF CLADDING.
*
* 1-D KINETICS WILL BE USED: THERE WILL BE 2 NEUTRONIC REGIONS PER CORE VOL
*
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*16XX0  ISLB   CLDTHK    QFRAC    QFRACR  IRGF IRGL  * LOCATION
160010   1     0.                .98      2    3   * CORE-1 (BOT)
160020   2     0.                .98      4    5   * CORE-2 (MID)
160030   3     0.                .98      6    7   * CORE-3 (TOP)
160040   4     0.                .02      2    3   * BYPASS-1 (BOT)
160050   5     0.                .02      4    5   * BYPASS-2 (MID)
160060   6     0.                .02      6    7   * BYPASS-3 (TOP)
*
*
*  HEAT CONDUCTOR GEOMETRY
*17XYY  IG  NR  IM  NDX   RADDIST   REGWIDTH   PFRACT
170101   2   3   1   6    0.        .02029167  1.     * UO-2 PELLET
170102       1   3   1            5.0-4       0.     * HE GAP
170103       0   2   4             .00266667  0.     * ZIRCALOY-2 CLADDING
170201  1    1   2   3    0.        .00666667  1.     * FUEL CHANNEL WALL (ZRR4)
170301  2    1   4   1     .25271   .02229     0.     * STAND PIPES
170401  2    1   4   1    7.65      .16667     0.     * UPPER PLENUM
*
* NO HEAT GENERATION IN FUEL CHANNEL WALL, USE FOR MODERATOR(CORE BY-PASS)
* DIRECT AND CONDUCTION HEATING.
*
*
*  THERMAL CONDUCTIVITY DATA
*
*        THERM COND  U02  REF  GEMP-482 FIG-13  86 W/C
*18XXYY
180101  -11                                                 * THERM COND  UO2   1
180102   212.  4.28   392.  3.47   752.  2.66  1112.  2.20 * THERM COND  U02   2
180103  1472.  1.88  1832.  1.62  2192.  1.44  2912.  1.21 * THERM COND  U02   3
180104  3632.  1.16  5072.  1.16              5500.  1.16 * THERM COND  U02   4
*
*        THERMAL COND  ZR-4  REF  BRASSFIELD(1968)GEMP-482 RECOM... LWR LOCA
180201  -8      0.   8.    1490. 12.32  2150. 17.5         * THERM COND ZR-4   1
180202  2372. 19.7   2552. 21.8   2732. 24.0   3292. 28.9  * THERM COND ZR-4   2
180203  3360. 33.1                                         * THERM COND ZR-4   3
*
*        THERMAL COND HELIUM  REF  THETA1-B EQN
180301   -6                                                * THERM COND HELIUM 1
180302   100. .0937  1100. .163   2100. .212   3100. .253  * THERM COND HELIUM 2
180303  4100. .289   5100. .322                            * THERM COND HELIUM 3
*
*        THERM CON  SS-304 9REF  NUC SYS MATLS HDBK  PROP CODE 3112 PG 1.0
180401   -2    100. 8.536   1500. 14.62                   * THERM COND  SS-304
*
*        SA-302   REF   TOULOUKIAN
180501 -5   32.  30.  212.  29.5   392.  28.3          * THERMAL COND. SA-3022 1
180502     572.  26.6  752. 24.7                        * THERMAL COND. SA-3022 2
*
*
*  VOLUMETRIC HEAT CAPACITY
*
*    SPEC HEAT  U02  REF  BRASSFIELD(1968)GEMP-482 RECOM...LWR LOCA
*    SPEC HEAT  U02  95 PCT  TH DEN AT 1000F  642 LB/FT3
*    SPEC HEAT  U02  REF  BRASSFIELD(1968)GEMP-482 TOULOUKIAN SAME TO 3750 F
*
190101  -19                                                 * VOL HT CAP U02    1
190102    77. 36.22        100. 37.12        200. 40.05    * VOL HT CAP U02    2
190103   300. 41.98        400. 43.88        600. 45.18    * VOL HT CAP U02    3
190104   800. 46.41       1000. 47.32                      * VOL HT CAP U02    4
190105                                     2400. 50.77    * VOL HT CAP U02    5
190106  2600. 51.43       2800. 52.61       3000. 54.57    * VOL HT CAP U02    6
190107  3200. 57.42       3400. 61.23       3600. 65.93    * VOL HT CAP U02    7
190108  4600. 95.15       4800. 99.31       5000. 101.57   * VOL HT CAP U02    8
190109  5074. 101.76                                       * VOL HT CAP UO2    9
*
*  ACTIVATE FUEL ENTHALPY EDIT
*
*      NRO  TEMP (F)    DENSITY      DESCRIPTION
1190101 -3   500.0       645.43     * DENSITY UO2 - LB/FT^3
1190102      1200.0      685.49
1190103      2240.0      655.77
*
*        SPEC HEAT  ZR-2   REF BMI-1803 ELDR1DGE ET AL (1967)              DEN 4
190201   15                                          * VOL HT CAP  ZR-2       1
190202    32.  28.75      932.  32.56   1112.  34.40  * VOL HT CAP  ZR-2       2
190203  1184.  35.22    1490.  35.22    1508.  49.14  * VOL HT CAP  ZR-2       3
190204  1544.  57.74    1580.  60.20    1616.  70.43  * VOL HT CAP  ZR-2       4
190205  1652.  79.85    1688.  75.35    1724.  59.38  * VOL HT CAP  ZR-2       5
190206  1760.  45.86    1787.  34.81    3300.  34.81  * VOL HT CAP  ZR-2       6
*
*        SPEC HEAT  HELIUM  REF  KREITH  AT 1 ATM  DEN 0.012 LB/FT3
190301  -2      32. .0149       3400. .0149               * VOL HT CAP HELIUM 1
*
*        SPEC HEAT  SS-304  REF  NUC SYS MATLS HDBK     DENSITY = 494 LB/FT3 AT
190401  -12                                                * VOL HT CAP SS-3UU 1
190402   100. 54.74    150. 56.51    200. 58.              * VOL HT CAP SS-3UU 2
190403   300. 54.43    400. 62.      600. 64.02            * VOL HT CAP SS-3U4 3
190404   800. 65.36   1000. 66.94   1200. 69.11            * VOL HT CAP SS-3UU 4
190405  1400. 71.63   1450. 72.27   1500. 72.87            * VOL HT CAP SS-3UU 5
*
190501 -7   130. 56.9   350. 60.8    450. 62.3         * VOL. HT. CAP. SA-302  1
190502      530. 65.2   620. 67.2    710. 70.2         * VOL. HT. CAP. SA-3022 2
190503      800. 77.5                                  * VOL. HT. CAP. SA-3022 3
*
*
*  COEF OF LINEAR THERMAL EXPANSION
*
*        THERM EXPAN COEF  U02  REF  GEMP-482
200101  -2   0. 3.72-6   4082. 11.0-6                   * EXPAN COEF  U02   1
*
*        THERM EXPAN COEF  ZR-4  REF  GEMP-482 (1968)
200201   -4                                             * THERM EXPAN ZR-4  1
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200202     0.  3.10-6   1580.  4.64-6   1584.  5.4-6       * THERM EXPAN ZR-44 2
200203  3400.  5.40-6                                      * THERM EXPAN ZR-44 3
*
*        THERM EXPAN COEF  HELIUM
200301  -2     0. 0.    1+9 0.                            * THER EXPAN  ZR-44
*
*        THERM EXPAN COEF  SS-304
200401  -2     0. 0.   2650. 0.                           * THER EXPAN  SS-T04
*
200501 -2     0.  0.       10000.  0.               * THERMAL EXP. DUMMY CSSTEL
*
*
*  STEADY STATE CONVERGENCE CARD
*      LCOUNT
230000   50
*
*
*  POWER BALANCE CARD
*    ISGNUM  JBIAS  JBAL  POWF
230011  0    24     22    1.0
*
*
*231XXX  LVOL   PRES      T      HW      X      XNC
231001     1      0.     0.   526.35
231003     8   1025.47   0.     0.
231004    20      0.     0.  1189.66
*
*
*232XXX   JUN    JESTW    WP        SPLTV1  SPLTV2
232001     21       0    18334.79                  * SEP TO DC FLOW
232002     15       0     9500.                    * RECIRC FLOW
232003     10       0     3054.1                   * SEP TO DRYER FLOW
232004     22       0     3054.1                   * TURBINE FLOW
232005    103       2    19633.69                  * ACT CORE INLET FLOW
232006    110       2      377.8                   * WATER ROD FLOW
232007    112       2      489.3                   * LEAKAGE FLOW 1
232008    113       2      144.5                   * LEAKAGE FLOW 2
232009    203       2     1377.4                   * BYPASS INLET - ACT FUEL
232010     11       1                              * RECIRC PUMP DISCHG
232011     13       1                              * RECIRC TO JET PUMP
232012     -1       0     21388.89                 * TOTAL CORE FLOW
*
*
*  CONTROL  SYSTEM
*
*        NCI   NCB
*701000    6    13
*
*702XXX    IDC    VAR    REG   GAIN    CIC
702001      1      LIQL,  9    8.00    39.78      * LIQUID  LEVEL  VOL 9
702002      2      WP**, 17    0.012   36.649     * STEAM  FLOW
702003      3      WP**, 24    0.012   36.649     * FEEDWATE FLOW
702004      4      CONS,  0    1.0      1.0       * SETPOINT CONSTANT
702006      5      CONS,  0   -6.0     -6.0       * ROD POSITION
702007      6      TRIP,  4    1.0      1.0       * SCRAM MONITOR
*
*703XXX   IDC ITYPE  INC1  INC2   CGAIN   CP1   CP2    CIC     CMIN    CMAX
703001    -1   SUM,    1    -2     1.0    1.0   1.0   39.78
703002    -2   SUM,    2     3     0.8   -1.0   1.0    0.0    -32.0    32.0
703003    -3   SUM,   -1     4     1.0    1.0 -39.78   0.0
703004    -4   LLG,   -3     0    -1.67   0.6   6.0    0.0
703005    -5   INT,   -4     0     0.025  0.0   0.0    0.0    -15.6    24.4
703006    -6   SUM,   -5    -4     1.0    1.0   1.0    0.0    -50.0    50.0
703007    -7   SUM,   -6     4     1.0    1.0  44.747 44.747   0.0     50.0
703008    -8   DLY,   -7    10     1.0    0.2   0.0   44.747   0.0     50.0
703009    -9   FNG,   -8     5  3515.81   0.0   0.0 3054.1   292.98  3515.81
703010   -10   VLM,   -9     0     1.0  732.5 732.5 3054.1   292.98  3515.81
*
*
*  AUX DNB DATA CARDS
*
800100   2   0   0   4   0   13  3
800200   1.03  1.40 1.0  1.0  1.0  5.0  11.0
800300  0.0615  0.04692  0.047612  0.0  0.956057
800400  0.0 0.0  0.08333 1.081904    0.16667 1.25934  0.25 1.267476
800401  0.3333 1.238666  0.41667 1.203747  0.5 1.166797  0.58333 1.113869
800402  0.6667 1.039859  0.75 0.934232  0.83333 0.76685  0.91667 0.498281
800403  1.0 0.0
800500  103  104  105
*
*********************************************************************
*     THE FOLLOWING CARDS ARE FOR THE 1-D KINETICS OPTION           *
*     THE MULTI TYPE ROD MODEL IS USED AND THE CROSS SECTIONS       *
*     ARE FOR SAMPLE PROBLEM PURPOSES ONLY.                         *
*                                                                   *
*     PROBLEM DESCRIPTION DATA                                      *
*                                                                   *
*      NOR  NOG  NCS  KONI  KONO  MAXI  KUDY  KUPK  NODG  NOF  NDGRP *
300001  8    2    2     1     0   200    2     0     6    1     0   *
*                                                                   *
*  NEUTRONIC REGION DATA                                            *
*                                                                   *
*      NINT  IRVOL  IRCOR   ELEVR   DELR                            *
310010  12      1     0      1.0    1.0                            *
310020  12    103     1      3.0    2.0                            *
310030  12    103     1      5.0    2.0                            *
310040  12    104     2      7.0    2.0                            *
310050  12    104     2      9.0    2.0                            *
310060  12    105     3      11.0   2.0                            *
310070  12    105     3      13.0   2.0                            *
310080  12      8     0      14.0   1.0                            *
*                                                                   *
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PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

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*  CONTROL ROD DESCRIPTION                                              *
*                                                                       *
*       IDCNTL  IBOT  FSRC                                              *
315000  -11      0    1.0                                               *
*                                                                       *
703030   -11   SUM,   5  -12  1.0   1.0   1.0   0.0                    *
703031   -12   FNG, -13    6  1.0   0.0   0.0   6.0                    *
703032   -13   INT,   6    0  1.0   0.0   0.0   0.0                    *
120601   3   0.0   6.0   .2     8.0   1.5   12.                        *
*                                                                       *
*                                                                       *
*  DELAYED NEUTRON YIELD FRACTIONS                                      *
*                                                                       *
320000  0.033  0.219  0.196  0.395  0.115  0.042                       *
*                                                                       *
*  DELAYED NEUTRON DECAY CONSTANTS                                      *
*                                                                       *
321000  0.0124  0.0305  0.1110  0.3010  1.1400  3.0100                  *
*                                                                       *
*  DELAYED NEUTRON SPECTRUM (NOG BY NODG ENTRIES)                       *
*                                                                       *
330011  1.0  1.0  1.0  1.0  1.0  1.0                                    *
330021  0.0  0.0  0.0  0.0  0.0  0.0                                    *
*                                                                       *
************************************************************************
*
*  FIBWR INPUT
*
*635000   NCHAN   NINPL   NACTFP  NOUTPL  BYP IN  CHN IN
635000      1       2       3       1      201     101
*
*
*635010    FCROC     RHOREF
635010     0.        47.4145
*
*  FIBWR LATERAL LEAKAGE COEFFICIENTS
*
*6351XX      C1             C2             C3             C4          MULTIPLIER
635101   5.367000E+05   0.000000E+00   0.000000E+00   0.000000E+00  1.000000E+00
635102   2.750000E+05   0.000000E+00   0.000000E+00   0.000000E+00  1.000000E+00
*
*  FIBWR BYPASS LEAKAGE COEFFICIENTS (CORE SUPPORT PLATE)
*
*6352XX      C1             C2             C3             C4          MULTIPLIER
635201   4.850000E+05   0.000000E+00   0.000000E+00   0.000000E+00  1.000000E+00
*
*
. END
```


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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page    1
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis             11:58:39
 TTWOB WITH SPACE TIME KINETICS - RETRAN-3D SAMPLE PROBLEM                                                      CPU TIME =    0.016
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

RETRAN PROBLEM CONTROL AND DESCRIPTION DATA.

    WORD  DESCRIPTION
    ====  ==================================================================
      1   RESTART FILE OPTION (SAVE=-1 / NO SAVE=0) .................... =    0
      2   PRINTER PLOT OPTION (YES=1 / NO=0) ........................... =    0
      3   POWER OPTION (TAPE OPTNS<0 / NO/TBL=0 / PT KIN=1 / 1D=2 / 3D=3) =    2
      4   USE STEADY-STATE SOLUTION (YES=0 / NO=1) ..................... =    0
      5   USE NEUTRON VOID MODEL (YES=1 / NO=0) ........................ =    0
      6   USE GENERALIZED TRANSPORT MODEL (NO=0 / VAP=1 / LIQ=-1) ....... =    0
      7   HEAT TRANSFER MAP OPTION (FORCED=0 / NAT CONV=1) ............. =    1
      8   SLIP OPTION (DYN=1 / Z-L=2 / C-L=3 / Z-L TAUGL=4 / C-L TAUGL=5) =    1
      9   FIVE-EQUATION OPTION (NO= 0 / YES=1) ......................... =    1
     10   NONCONDENSABLE GAS FLOW OPTION (NO=0 / YES=1) ................ =    0
     11   TH MATRIX DIRECT SOLVER OPTION (4-EQ=2 / 6-EQ=3) ............. =    3
     12   TH MATRIX ITERATIVE SOLVER OPTION (NO<=1 / YES=2) ............ =    0

    (DIMENSIONS AND OPTIONS AUTOMATICALLY DETERMINED BY CONTENT OF INPUT DATA)

          NUMBER OF MINOR EDIT SETS (0200XX DATA )...................... =   12
          NUMBER OF TIME-STEP CONTROL SETS (03XXX0 DATA )............... =    2
          NUMBER OF TRIP CONTROL SETS (04XXX0 DATA )..................... =    9
          NUMBER OF CONTROL VOLUME DESCRIPTIONS (05XXXY DATA )........... =   27
          NUMBER OF BUBBLE RISE DESCRIPTIONS (060XXY DATA) ............. =    1
          NUMBER OF TIME DEPENDENT VOLUMES FORM CARDS (07XXYY DATA) ..... =    0
          NUMBER OF JUNCTION DESCRIPTIONS (08XXXY DATA) ................ =   36
          NUMBER OF CENTRIFUGAL PUMP DESCRIPTIONS (090XXY DATA )......... =    1
          NUMBER OF VALVE DESCRIPTIONS (11XXXY DATA) ................... =    4
          NUMBER OF GENERAL DATA TABLE DESCRIPTIONS (12XXYY DATA) ....... =    6
          NUMBER OF FILL DESCRIPTIONS (13XXYY DATA )..................... =    4
          NUMBER OF HEAT CONDUCTOR DESCRIPTIONS (15XXXY DATA) .......... =    8
          NUMBER OF HEAT CONDUCTOR GEOMETRY DESCRIPTIONS (17XXYY DATA) .. =    4
          NUMBER OF HEAT CONDUCTOR MATERIAL DESCRIPTIONS (18XXYY DATA) .. =    5
          NUMBER OF CORE SECTION DESCRIPTIONS (16XXXY DATA) ............ =    6
          NUMBER OF NON-CONDUCTNG HEAT EXCHNGR DESCRIPTIONS (21XXYY DATA) =    0
          NUMBER OF TIME DEP BCS FROM TAPE (IREAD<0 ON 05XXXY DATA) ..... =    0
          NUMBER OF SPECIFIED HEAT TRAN COEF DESCRIPTIONS (015XXX DATA) . =    0
          TWO-REGION NONEQ VOL DESCRIPTIONS (610XXX OR 611XXX DATA) ..... =    0
          TEMP. TRANSPORT DELAY OPTION (MESH>0 ON 05XXXY DATA) .......... =    0
          AUXILIARY DNB MODEL (8001XX DATA INCLUDED) .................... =    1
          CONTROL SYSTEM MODEL (702XXX OR 702XXXX DATA) ................ =    1
          ACCUMULATOR MODEL DESCRIPTIONS (620XXX OR 621XXX DATA)......... =    0
          DYNAMIC GAP CONDUCTANCE MODEL DESCRIPTIONS (225XX0 DATA) ...... =    0
          NUMBER OF HT CONDUCTOR STACK DESCRIPTIONS (2200XY DATA) ....... =    0
          NUMBER OF TURBINE SHAFT DESCRIPTIONS (500XXY DATA) ........... =    0
          NUMBER OF PROFILE FIT DESCRIPTIONS (061XX1 DATA) ............. =    0
          NUMBER OF STEAM-WATER SEPARATOR DESCRIPTIONS (60XXX0 DATA) .... =    0


                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * *                                                  * * *
                   * * *          STEADY-STATE OPTION    =   0            * * *
                   * * *                                                  * * *
                   * * *          SLIP OPTION            =   1            * * *
                   * * *                                                  * * *
                   * * *          NUMERICS OPTION        =   3            * * *
                   * * *                                                  * * *
                   * * *          HEAT TRANSFER OPTION   =   1            * * *
                   * * *                                                  * * *
                   * * *          NEW EQUATIONS OPTION   =   1            * * *
                   * * *                                                  * * *
                   * * *         USING THE 6-EQ SOLVER - SOLVE4           * * *
                   * * *                                                  * * *
                   * * *      USING STANDARD STEADY-STATE SOLUTION        * * *
                   * * *                                                  * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *


INITIAL THERMAL POWER (MEGAWATTS) =  2.53340E+03


AIR IS THE DEFAULT NONCONDENSABLE GAS.
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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE -- NRC APPROVED VERSION 29/08/14 Page 43
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis 11:58:39
TTWOB WITH SPACE TIME KINETICS - RETRAN-3D SAMPLE PROBLEM CPU TIME = 0.062
* *

NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	ENERGY BALANCE (BTU)	TOTAL MASS BALANCE (LBM)	NCG MASS BALANCE (LBM)	AVERAGE TIME STEP (SEC)	CURRENT TIME STEP (SEC)	ELAPSED TIME (SEC)	TIME STEP NUM STANDRD/ACTUL
									0
1.00000E+00	2.53340E+03	8.67334E+09	2.36949E+11	2.14319E+08	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	VOID FRAC.	POWR TO H2O (BTU/SEC)
1	1.06022E+03	1.26721E+05	5.26350E+02	4.74144E+01	5.31476E+02	0.00000E+00	0.00000E+00	0.00000E+00
8	1.02547E+03	1.03500E+04	6.34908E+02	1.27422E+01	5.47260E+02	1.37019E-01	7.62389E-01	-1.01195E+02
9	1.01967E+03	3.30902E+04	6.47680E+02	1.14201E+01	5.46562E+02	1.57907E-01	7.92410E-01	0.00000E+00
10	1.01985E+03	8.24890E+03	1.19219E+03	2.27612E+00	5.46587E+02	1.00000E+00	1.00000E+00	0.00000E+00
11	1.02009E+03	2.60787E+03	6.37836E+02	1.23238E+01	5.46612E+02	1.42603E-01	7.71893E-01	-2.12980E+03
12	1.02646E+03	1.64830E+05	5.26003E+02	4.73884E+01	5.31132E+02	2.76703E-05	5.71965E-04	2.23100E+03
13	1.05795E+03	9.26244E+03	5.26350E+02	4.74122E+01	5.31472E+02	1.07893E-06	2.15755E-05	0.00000E+00
14	1.01200E+03	1.46368E+03	1.19219E+03	2.25773E+00	5.45633E+02	9.99556E-01	9.99978E-01	0.00000E+00
15	1.00664E+03	9.98010E+02	1.19219E+03	2.24517E+00	5.44981E+02	9.99249E-01	9.99964E-01	0.00000E+00
16	9.59894E+02	4.96182E+03	1.19219E+03	2.13599E+00	5.39181E+02	9.96692E-01	9.99849E-01	0.00000E+00
17	9.63934E+02	2.32411E+02	1.19219E+03	2.14540E+00	5.39690E+02	9.96905E-01	9.99858E-01	0.00000E+00
18	1.11574E+03	2.56789E+04	5.26785E+02	4.74235E+01	5.31910E+02	3.41137E-07	6.42770E-06	7.45814E+03
19	1.18106E+03	2.81509E+04	5.26785E+02	4.74619E+01	5.32011E+02	2.91080E-09	5.14489E-08	0.00000E+00
20	9.57586E+02	2.13849E+08	1.18966E+03	2.13849E+00	5.38889E+02	9.92724E-01	9.99668E-01	0.00000E+00
100	1.02960E+03	5.30224E+03	5.26350E+02	4.73964E+01	5.31428E+02	0.00000E+00	0.00000E+00	0.00000E+00
101	1.05314E+03	2.00308E+03	5.26350E+02	4.74103E+01	5.31465E+02	0.00000E+00	0.00000E+00	0.00000E+00
102	1.03449E+03	4.00524E+02	5.26350E+02	4.73993E+01	5.31436E+02	0.00000E+00	0.00000E+00	0.00000E+00
103	1.03376E+03	6.59429E+03	5.56412E+02	3.25146E+01	5.43744E+02	2.25481E-02	3.17289E-01	6.39119E+05
104	1.03148E+03	4.05362E+03	5.91800E+02	1.99873E+01	5.48003E+02	6.88968E-02	5.97426E-01	1.08181E+06
105	1.02801E+03	3.18899E+03	6.12448E+02	1.57240E+01	5.47701E+02	1.01423E-01	6.94479E-01	6.40080E+05
106	1.02550E+03	3.56714E+02	6.23356E+02	1.40715E+01	5.47241E+02	1.19163E-01	7.32181E-01	0.00000E+00
201	1.03074E+03	2.00585E+03	5.26350E+02	4.73971E+01	5.31430E+02	0.00000E+00	0.00000E+00	0.00000E+00
202	1.03057E+03	4.00979E+02	5.26350E+02	4.73970E+01	5.31430E+02	0.00000E+00	0.00000E+00	0.00000E+00
203	1.02989E+03	9.53082E+03	5.35083E+02	4.69221E+01	5.38366E+02	0.00000E+00	0.00000E+00	1.15282E+04
204	1.02860E+03	9.21114E+03	5.47662E+02	4.53483E+01	5.47678E+02	1.03969E-03	2.05184E-02	1.86989E+04
205	1.02736E+03	8.69358E+03	5.49937E+02	4.28002E+01	5.47862E+02	4.19144E-03	7.81752E-02	1.05667E+04
206	1.02653E+03	1.08355E+03	5.49575E+02	4.26762E+01	5.47484E+02	4.38208E-03	8.15673E-02	0.00000E+00

JUNCTION NUMBER	CONNECTS VOLUMES	CHOK/ PATH	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E VEL. PSI	ELEV. PSI	D I F F E R E N T I A L S FRIC. PSI	ACCL. PSI	PUMP PSI
9	11 TO 9		2.13889E+04	6.37836E+02	8.11436E-02	3.53807E+00	-1.95694E+00	-1.99423E+00	6.28002E-09	0.00000E+00
10	9 TO 10		3.05410E+03	1.19219E+03	4.39419E-01	3.26787E-01	-1.15593E-01	-3.66431E-02	3.82769E-10	0.00000E+00
11	18 TO 19		9.50000E+03	5.26785E+02	2.10866E-02	7.73961E-02	-2.91766E+00	-1.94430E+01	-5.34771E-09	8.76007E+01
12	8 TO 11		2.13889E+04	6.34908E+02	7.84791E-02	-3.35860E+00	-4.96900E-01	-1.52922E+00	-6.73507E-09	0.00000E+00
13	12 TO 13		1.18889E+04	5.26003E+02	2.11022E-02	-1.42408E+00	2.86769E+00	-5.79392E+00	8.57071E-07	3.58415E+01
14	19 TO 13		9.50000E+03	5.26785E+02	2.10695E-02	6.31294E+00	-5.01040E+00	-4.83133E+01	8.20960E-07	-7.60937E+01
15	12 TO 18		9.50000E+03	5.26003E+02	2.11022E-02	-3.98362E+00	1.07800E+01	-5.11864E+00	-1.17978E-08	8.76007E+01
16	13 TO 1		2.13889E+04	5.26350E+02	2.10916E-02	4.89297E-01	2.89083E+00	-1.11137E+00	-8.16393E-07	0.00000E+00
17	10 TO 14		3.05410E+03	1.19219E+03	4.39344E-01	-4.33098E+00	4.82484E-01	-4.00228E+00	-3.07770E-12	0.00000E+00
18	14 TO 15		3.05410E+03	1.19219E+03	4.42924E-01	-5.93201E-02	4.85981E-01	-5.78575E+00	-1.10992E-11	0.00000E+00
19	15 TO 16		3.05410E+03	1.19219E+03	4.45401E-01	-2.47193E-01	2.25803E-01	-4.67210E+01	-1.81537E-11	0.00000E+00
20	16 TO 17		0.00000E+00	1.19219E+03	4.66114E-01	4.38164E+00	-3.41826E-01	0.00000E+00	5.62600E-12	0.00000E+00
21	9 TO 12		1.83348E+04	5.46313E+02	2.20639E-02	2.78694E-01	6.69616E+00	-1.86496E-01	2.39527E-09	0.00000E+00
22	16 TO 20		3.05410E+03	1.19219E+03	4.68167E-01	4.36153E+00	-3.02843E-01	-6.36745E+00	-1.45317E-11	0.00000E+00
101	1 TO 101	CHI	2.06913E+04	5.26350E+02	2.10906E-02	-2.18532E-01	-2.66924E+00	-4.19481E+00	-3.57427E-08	0.00000E+00
102	101 TO 102		2.02199E+04	5.26350E+02	2.10925E-02	1.80906E-02	-1.64613E-01	-1.85026E+01	-4.89775E-13	0.00000E+00
103	102 TO 103	AFI	1.94962E+04	5.26350E+02	2.10973E-02	-1.10649E-01	-4.79023E-01	-1.38243E-01	-7.71322E-11	0.00000E+00
104	103 TO 104		1.94962E+04	5.56412E+02	3.07554E-02	-3.42340E-01	-7.29193E-01	-1.20855E+00	-1.24857E-09	0.00000E+00
105	104 TO 105		1.94962E+04	5.91800E+02	5.00319E-02	-3.99109E-01	-4.95990E-01	-2.57546E+00	-1.60725E-09	0.00000E+00
106	105 TO 106		1.94962E+04	6.12448E+02	6.35969E-02	-2.43220E-01	-2.42819E-01	-2.02234E+00	-7.78051E-10	0.00000E+00
107	106 TO 8	CHX	2.00687E+04	6.23356E+02	7.10654E-02	3.25853E-01	-2.86929E-01	-7.08118E-02	1.26069E-09	0.00000E+00
110	102 TO 100	WTI	5.72501E+02	5.26350E+02	2.10973E-02	2.32738E-01	-2.00886E+00	-3.11468E+00	3.27871E-12	0.00000E+00
111	100 TO 106	WTO	5.72501E+02	5.26350E+02	2.10986E-02	-1.35703E+00	-2.02047E+00	-7.18633E-01	-2.53994E-09	0.00000E+00
112	101 TO 201	LLK	4.71422E+02	5.26350E+02	2.10925E-02	2.23989E+01	-3.04572E-07	-2.23989E+01	-4.55320E-07	0.00000E+00
113	102 TO 202	LLK	1.51123E+02	5.26350E+02	2.10973E-02	3.91505E+00	-5.32635E-08	-3.91505E+00	-8.97193E-07	0.00000E+00
201	1 TO 201	BLK	6.97599E+02	5.26350E+02	2.10906E-02	2.94815E+01	-2.66921E+00	-2.68123E+01	2.30504E-05	0.00000E+00
202	201 TO 202		1.16902E+03	5.26350E+02	2.10983E-02	-6.01156E-04	-1.64573E-01	-8.27005E-05	3.35479E-12	0.00000E+00
203	202 TO 203		1.32014E+03	5.26350E+02	2.10984E-02	-3.27573E-04	-6.79125E-01	-4.27852E-04	-3.30612E-10	0.00000E+00
204	203 TO 204		1.32014E+03	5.35083E+02	2.13119E-02	-7.88802E-05	-1.28153E+00	-1.09182E-02	-4.73443E-09	0.00000E+00
205	204 TO 205		1.32014E+03	5.47662E+02	2.20516E-02	-2.02261E-04	-1.22428E+00	-1.24228E-02	-9.05190E-09	0.00000E+00
206	205 TO 206		1.32014E+03	5.49937E+02	2.33644E-02	-1.46799E-04	-6.68538E-01	-1.64332E-01	-4.01572E-09	0.00000E+00
207	206 TO 8		1.32014E+03	5.49575E+02	2.34323E-02	-7.24787E-01	-3.36590E-01	-6.58408E-05	-2.86131E-09	0.00000E+00
26	0 TO 14		0.00000E+00	1.19219E+03	4.42924E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
25	0 TO 14		0.00000E+00	1.19219E+03	4.42924E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
24	0 TO 12		3.01349E+03	4.03332E+02	1.89228E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
23	0 TO 14		0.00000E+00	1.19219E+03	4.42924E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

VOLUME NUMBER	FLOW REG.	LIQ. ENTH. (BTU/LB)	GAS ENTH. (BTU/LB)	LIQ. TEMP. (DEG. F)	GAS TEMP. (DEG. F)	IF AREA DEN (FT2/FT3)	IF HT COEFF (B/H-FT2-F)	IF MASS TRN (LB/SEC)	TOT MAS TRN (LB/SEC)	LIQ. HT RT (BTU/SEC)
8	5	5.46460E+02	1.19197E+03	5.47260E+02	5.47260E+02	2.37336E+02	8.21367E+06	-1.88351E-01	-3.45118E-01	3.10177E+02
11	5	5.45637E+02	1.19218E+03	5.46612E+02	5.46611E+02	2.32926E+02	7.82996E+06	2.23569E+01	1.90627E+01	-2.48560E+04
12	2	5.25984E+02	1.19194E+03	5.31131E+02	5.47379E+02	1.05960E+00	8.17111E+02	-2.04093E+01	-2.04093E+01	2.65576E+04
13	2	5.26349E+02	1.19072E+03	5.31472E+02	5.51113E+02	4.04554E-02	4.57562E+03	-2.96971E-01	-2.96971E-01	3.53610E+02
14	7	5.44361E+02	1.19248E+03	5.45605E+02	5.45633E+02	2.15142E-02	8.22684E+06	-1.35615E+00	-1.35615E+00	1.61718E+03
15	7	5.43551E+02	1.19268E+03	5.44964E+02	5.44981E+02	3.60730E-02	8.22096E+06	-9.36559E-01	-9.36559E-01	1.11702E+03
16	5	5.36259E+02	1.19437E+03	5.39174E+02	5.39181E+02	2.37096E+00	5.31332E+05	-7.81056E+00	-7.81056E+00	9.32871E+03
17	0	5.36906E+02	1.19423E+03	5.39690E+02	5.39690E+02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
18	2	5.26785E+02	1.18840E+03	5.31910E+02	5.57740E+02	1.23492E-02	3.11320E+03	-2.25763E-01	-2.25763E-01	7.72643E+03
19	2	5.26785E+02	1.18562E+03	5.32011E+02	5.64914E+02	1.01651E-04	3.87474E+03	-3.24081E-03	-3.24081E-03	3.84238E+00
103	3	5.41758E+02	1.19166E+03	5.43615E+02	5.48252E+02	3.36041E+02	1.04973E+03	-1.20751E+02	5.21194E+02	1.80333E+04
104	3	5.47407E+02	1.19175E+03	5.48005E+02	5.47980E+02	1.10525E+01	1.64958E+05	3.93867E+00	1.51253E+03	-7.20736E+05
105	3	5.47047E+02	1.19188E+03	5.47720E+02	5.47564E+02	4.19669E+00	4.67420E+05	2.66295E+01	1.00195E+03	-5.54117E+05
106	4	5.46431E+02	1.19197E+03	5.47237E+02	5.47263E+02	4.54227E+01	1.95923E+05	-2.53728E+00	-2.53728E+00	3.02437E+03
204	2	5.46991E+02	1.19186E+03	5.47678E+02	5.47635E+02	3.90965E+01	6.63191E+03	9.60024E-01	4.61735E+00	1.31956E+04
205	2	5.47235E+02	1.19190E+03	5.47864E+02	5.47487E+02	1.68059E+02	2.44359E+03	1.35444E+01	1.58940E+01	-8.37731E+03
206	2	5.46748E+02	1.19193E+03	5.47485E+02	5.47387E+02	1.76643E+02	5.17796E+03	9.79719E-01	9.79719E-01	-1.16776E+03

JUNCTION NUMBER	FLOW REG.	SLIP VEL. (FT/SEC)	VOID FRACTION	LIQUID FLOW (LB/SEC)	GAS FLOW (LB/SEC)	SLIP CNVCTN (BTU/SEC)	GAS VEL. (FT/SEC)	LIQ. VEL. (FT/SEC)	VG/VL	SLIP ACCEL. (FT/SEC**2)
9	-2	-4.71387E-01	7.71893E-01	1.83156E+04	3.07334E+03	1.50177E+04	5.34765E+01	5.30051E+01	1.00889E+00	-2.04463E-08

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     12     -2  -2.50818E+00  7.62389E-01  1.83346E+04  3.05428E+03  7.97752E+04  5.34941E+01  5.09860E+01  1.04919E+00 -1.36034E-08
     13      2   1.74459E+00  5.71965E-04  1.18886E+04  3.20048E-01 -5.94120E+00  6.25842E+01  6.43288E+01  9.72880E-01  1.69200E-05
     15      2   3.61269E+00  5.71965E-04  9.49977E+03  2.29003E-01 -2.25521E+01  2.44296E+01  2.80423E+01  8.71170E-01  5.04331E-08
    104      4  -2.92772E+00  3.17289E-01  1.89751E+04  5.21194E+02  5.30256E+04  1.82804E+01  1.53526E+01  1.19070E+00  1.05167E-08
    105      5  -1.38478E+01  5.97426E-01  1.74625E+04  2.03372E+03  4.44910E+05  3.79763E+01  2.41285E+01  1.57392E+00  2.59889E-08
    106      5  -1.89899E+01  6.94479E-01  1.64606E+04  3.03567E+03  6.82419E+05  4.89470E+01  2.99571E+01  1.63390E+00  4.04824E-08
    107      5  -1.11714E+01  7.32181E-01  1.70356E+04  3.03313E+03  4.14225E+05  4.65137E+01  3.53423E+01  1.31609E+00  2.92124E-08
    205      2  -1.35670E+00  2.05184E-02  1.31553E+03  4.61735E+00  2.09247E+03  1.92857E+00  5.71870E-01  3.37240E+00 -4.49844E-07
    206      2  -1.65111E+00  7.81752E-02  1.29963E+03  2.05113E+01  9.65584E+03  2.25160E+00  6.00489E-01  3.74960E+00 -4.40932E-09
    207      2  -1.66117E+00  8.15673E-02  1.29865E+03  2.14910E+01  1.01333E+04  2.26307E+00  6.01895E-01  3.75991E+00 -6.58135E-09

  BUBL          BUBBLE       BUBBLE       MIXTURE      MIXTURE      BUBBLE
  SET    VOL.   GRADIENT     VELOCITY     LEVEL        QUALITY      MASS
  NUMB.  NUMB.  PARAMETER    (FT/SEC)     (FT)                      (LB)
     1      9   5.00000E-02  4.44038E+02  5.13000E+00  1.20450E-03  3.36040E+01

  PUMP   VOL.   PUMP SPEED   NORM. PUMP   NORM. FRIC.  NORM. MOT.   POWER TO H2O
  NUMB.  NUMB.  (RPM)        TORQUE       TORQUE       TORQUE       (BTU/HR)
     1     18   1.66500E+03  1.00237E+00  1.00000E+00  1.00000E+00  2.68493E+07

 HEAT COND.    VOL. HT TRAN   SURF. FLUX   CRIT. FLUX   H.T. COEF.   SURF. TEMP.  MASS FLUX    STORD ENRGY  POWR TO H20  DRYOUT PNT
 NUMBER        NUM. MODE-COR  (BTU/HR-FT2) (BTU/HR-FT2) (BTU/H-F2-F) (DEG. F)     (LBM/HR-FT2) (BTU)        (BTU/HR)     ()
     1 RGHT     103  20-DB-T  1.38281E+05  7.77452E+05  9.71837E+03  5.57973E+02  1.17233E+06  1.03517E+07  2.23709E+09
     2 RGHT     104  20-DB-T  2.33890E+05  7.31103E+05  1.67862E+04  5.61936E+02  1.17233E+06  1.42453E+07  3.78384E+09
     3 RGHT     105  20-DB-T  1.38281E+05  6.98577E+05  1.32962E+04  5.58101E+02  1.17233E+06  1.03527E+07  2.23709E+09
     4 LEFT     103    1-DB-L  1.33604E+03  1.23956E+06  3.38698E+03  5.44139E+02  1.17233E+06               5.34501E+06
       RGHT     203    1-DB-L  1.76706E+03  1.61449E+05  3.14284E+02  5.43989E+02  9.35901E+04  4.48779E+05  7.06933E+06
     5 LEFT     104  20-DB-T  2.97974E+03  1.05924E+06  3.74953E+03  5.48797E+02  1.17233E+06               1.19208E+07
       RGHT     204  20-DB-T  2.32828E+03  1.58969E+05  1.72963E+03  5.49024E+02  9.35901E+04  4.53176E+05  9.31460E+06
     6 LEFT     105  20-DB-T  2.20122E+03  1.05924E+06  3.59125E+03  5.48314E+02  1.17233E+06               8.80629E+06
       RGHT     205  20-DB-T  1.41710E+03  1.55678E+05  1.95587E+03  5.48586E+02  9.35901E+04  4.52691E+05  5.66930E+06
     7 LEFT      11  22-CH-S -4.57809E+03  3.06876E+05  2.15701E+03  5.44489E+02  2.35460E+06              -7.66729E+06
       RGHT      12    1-DB-L  4.20701E+03  2.26403E+05  1.05109E+03  5.35134E+02  8.24941E+05  1.40062E+06  7.66729E+06
     8 LEFT       8  22-CH-S -9.66066E+02  9.00000E+04  2.97897E+03  5.46935E+02  8.58704E+05              -3.64304E+05
       RGHT      12    1-DB-L  9.45468E+02  2.11926E+05  1.70481E+03  5.31686E+02  8.24941E+05  6.45819E+06  3.64304E+05

  CORE   COND.  DEPTH REAC.  DEPTH REAC.  HEAT GEN.    COND. HEAT-  DIR. MODER-  AVG. METAL   CENTERLINE   FUEL
  NUMB.  NUMB.  EXT. ZR-H2O  INT. ZR-H2O  ZR-H2O        ING RATE     ATOR HT RT   TEMPERATURE  TEMPERATURE  ENTHALPY
                (FT)         (FT)         (BTU/HR)     (BTU/HR)     (BTU/HR)     (DEG. F)     (DEG. F)     (CAL/GM)
     1      1   0.00000E+00  0.00000E+00  0.00000E+00  2.23709E+09  5.83925E+07  1.39970E+03  1.84837E+03  5.11893E+01
     2      2   0.00000E+00  0.00000E+00  0.00000E+00  3.78384E+09  9.87656E+07  1.90106E+03  2.84549E+03  7.19639E+01
     3      3   0.00000E+00  0.00000E+00  0.00000E+00  2.23709E+09  5.83925E+07  1.39982E+03  1.84851E+03  5.11940E+01
     4      4   0.00000E+00  0.00000E+00  0.00000E+00  1.24143E+07  3.44322E+07  5.44224E+02
     5      5   0.00000E+00  0.00000E+00  0.00000E+00  2.12354E+07  5.80013E+07  5.49184E+02
     6      6   0.00000E+00  0.00000E+00  0.00000E+00  1.44756E+07  3.23710E+07  5.48636E+02
0         AVERAGE CORE            MINIMUM  HEIGHT              HOT  SPOT                    MINUMUM DNBR POSITION
           (RETRAN)                (HOT CHANNEL)               (HOT CHANNEL)                (HOT CHANNEL)
   LHGR(KW/FT)      DNBR       LHGR(KW/FT)      DNBR       LHGR(KW/FT)      DNBR       POS. (FT)    LHGR(KW/FT)  MDNBR
   7.68831E+00  4.32388E+00  1.27590E+01  1.67855E+00  1.34344E+01  0.00000E+00  8.00000E+00  1.10222E+01  1.53600E+00
       TOTAL          INVERSE    CONTROL ROD    CONTROL ROD      DENSITY       DOPPLER       RESIDUAL       PROMPT      DECAY HEA&T
     REACTIVITY        PERIOD       POSITION      REACTIVITY     REACTIVITY    REACTIVITY     REACTIVITY       POWER         POWER
       (K-1)/K         (1/SEC)         (FT)         (K-1)/K        (K-1)/K       (K-1)/K        (K-1)K
  0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00  9.300100E-01  6.999000E-02
    REGION   NORM. POWER    REGIONWISE     CHANGE IN FEEDBACK VAR. (FROM TIME = 0.0)
    NUMBER   DISTRIBUTION   REACTIVITY  NORMALIZED RHO     FUEL TEMP.     MOD. TEMP.
                              (K-1)/K                      (DEG.F)**1/2   DEG. F)


        1    0.000000E+00  0.000000E+00  0.000000E+00    0.000000E+00  0.000000E+00
        2    9.143184E-02  0.000000E+00  0.000000E+00    0.000000E+00  0.000000E+00
        3    1.794674E-01  0.000000E+00  0.000000E+00    0.000000E+00  0.000000E+00
        4    2.291008E-01  0.000000E+00  0.000000E+00    0.000000E+00  0.000000E+00
        5    2.291008E-01  0.000000E+00  0.000000E+00    0.000000E+00  0.000000E+00
        6    1.794674E-01  0.000000E+00  0.000000E+00    0.000000E+00  0.000000E+00
        7    9.143184E-02  0.000000E+00  0.000000E+00    0.000000E+00  0.000000E+00
        8    0.000000E+00  0.000000E+00  0.000000E+00    0.000000E+00  0.000000E+00
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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   44
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis             11:58:40
 TTWOB WITH SPACE TIME KINETICS - RETRAN-3D SAMPLE PROBLEM                                                      CPU TIME =    0.484
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *
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SYSTEM ELAPSED TIME (SEC)	SYSTEM ELAPSED TIME (SEC)	TIME STP ACTUAL	SYSTEM NORM. POWER	VOL 10 AVG. PRESS. (PSIA)	JUN 17 FLOW (LB/SEC)	JUN 24 FLOW (LB/SEC)	BUBL 9 MIX. LEVEL (FEET)	REACTVTY TOTAL REAC (K-1)/K
0.00000E+00	0.00000E+00	0.00000E+00	1.00000E+00	1.01985E+03	3.05410E+03	3.01349E+03	5.13000E+00	0.00000E+00
1.00000E-02	1.00000E-02	1.00000E+01	1.00000E+00	1.01985E+03	3.05410E+03	3.01349E+03	5.13000E+00	-1.44836E-09
2.00000E-02	2.00000E-02	2.00000E+01	9.99997E-01	1.01985E+03	3.05410E+03	3.01349E+03	5.12998E+00	-5.17181E-08
3.00000E-02	3.00000E-02	3.00000E+01	9.99977E-01	1.01985E+03	3.05409E+03	3.01349E+03	5.12993E+00	-3.22707E-07
4.00000E-02	4.00000E-02	4.00000E+01	9.99920E-01	1.01984E+03	3.05408E+03	3.01349E+03	5.12986E+00	-9.17229E-07
5.00000E-02	5.00000E-02	5.00000E+01	9.99831E-01	1.01984E+03	3.05405E+03	3.01349E+03	5.12978E+00	-1.67294E-06
6.00000E-02	6.00000E-02	6.00000E+01	9.99737E-01	1.01984E+03	3.05400E+03	3.01349E+03	5.12971E+00	-2.32990E-06
7.00000E-02	7.00000E-02	7.00000E+01	9.99664E-01	1.01984E+03	3.05396E+03	3.01349E+03	5.12965E+00	-2.77175E-06
8.00000E-02	8.00000E-02	8.00000E+01	9.99615E-01	1.01984E+03	3.05392E+03	3.01349E+03	5.12960E+00	-3.05172E-06
9.00000E-02	9.00000E-02	9.00000E+01	9.99580E-01	1.01984E+03	3.05390E+03	3.01349E+03	5.12957E+00	-3.27038E-06
1.00000E-01	1.00000E-01	1.00000E+02	9.99549E-01	1.01984E+03	3.05385E+03	3.01349E+03	5.12952E+00	-3.47690E-06
1.10000E-01	1.10000E-01	1.10000E+02	9.99521E-01	1.01984E+03	3.05371E+03	3.01349E+03	5.12947E+00	-3.66307E-06
1.20000E-01	1.20000E-01	1.20000E+02	9.99497E-01	1.01984E+03	3.05333E+03	3.01349E+03	5.12942E+00	-3.81056E-06
1.30000E-01	1.30000E-01	1.30000E+02	9.99478E-01	1.01984E+03	3.05238E+03	3.01349E+03	5.12937E+00	-3.92885E-06
1.40000E-01	1.40000E-01	1.40000E+02	9.99460E-01	1.01984E+03	3.05014E+03	3.01349E+03	5.12930E+00	-4.05591E-06
1.50000E-01	1.50000E-01	1.50000E+02	9.99438E-01	1.01985E+03	3.04540E+03	3.01349E+03	5.12923E+00	-4.23096E-06
1.60000E-01	1.60000E-01	1.60000E+02	9.99409E-01	1.01986E+03	3.03635E+03	3.01349E+03	5.12913E+00	-4.46481E-06
1.70000E-01	1.70000E-01	1.70000E+02	9.99374E-01	1.01988E+03	3.02052E+03	3.01349E+03	5.12898E+00	-4.73044E-06
1.80000E-01	1.80000E-01	1.80000E+02	9.99338E-01	1.01992E+03	2.99387E+03	3.01349E+03	5.12877E+00	-4.97879E-06
1.90000E-01	1.90000E-01	1.90000E+02	9.99306E-01	1.01998E+03	2.94958E+03	3.01349E+03	5.12845E+00	-5.16429E-06
2.00000E-01	2.00000E-01	2.00000E+02	9.99285E-01	1.02008E+03	2.88215E+03	3.01349E+03	5.12795E+00	-5.25643E-06
2.10000E-01	2.10000E-01	2.10000E+02	9.99278E-01	1.02024E+03	2.78913E+03	3.01613E+03	5.12720E+00	-5.22552E-06
2.20000E-01	2.20000E-01	2.20000E+02	9.99291E-01	1.02045E+03	2.67072E+03	3.01907E+03	5.12613E+00	-5.00903E-06
2.30000E-01	2.30000E-01	2.30000E+02	9.99336E-01	1.02074E+03	2.52988E+03	3.01944E+03	5.12475E+00	-4.47180E-06
2.40000E-01	2.40000E-01	2.40000E+02	9.99438E-01	1.02110E+03	2.37193E+03	3.01952E+03	5.12309E+00	-3.37952E-06
2.50000E-01	2.50000E-01	2.50000E+02	9.99634E-01	1.02154E+03	2.20379E+03	3.01960E+03	5.12123E+00	-1.40174E-06
2.60000E-01	2.60000E-01	2.60000E+02	9.99975E-01	1.02207E+03	2.03283E+03	3.01968E+03	5.11921E+00	1.89098E-06
2.70000E-01	2.70000E-01	2.70000E+02	1.00053E+00	1.02267E+03	1.86577E+03	3.01976E+03	5.11709E+00	7.07431E-06
2.80000E-01	2.80000E-01	2.80000E+02	1.00137E+00	1.02336E+03	1.70767E+03	3.01984E+03	5.11497E+00	1.48972E-05
2.90000E-01	2.90000E-01	2.90000E+02	1.00263E+00	1.02411E+03	1.56149E+03	3.01991E+03	5.11292E+00	2.62054E-05
3.00000E-01	3.00000E-01	3.00000E+02	1.00441E+00	1.02493E+03	1.42802E+03	3.01999E+03	5.11094E+00	4.18333E-05
3.10000E-01	3.10000E-01	3.10000E+02	1.00683E+00	1.02582E+03	1.30621E+03	3.02004E+03	5.10899E+00	6.25968E-05
3.20000E-01	3.20000E-01	3.20000E+02	1.01001E+00	1.02676E+03	1.19372E+03	3.02009E+03	5.10695E+00	8.92899E-05
3.30000E-01	3.30000E-01	3.30000E+02	1.01406E+00	1.02775E+03	1.08758E+03	3.01998E+03	5.10468E+00	1.22462E-04
3.40000E-01	3.40000E-01	3.40000E+02	1.01900E+00	1.02878E+03	9.84827E+02	3.01985E+03	5.10211E+00	1.61376E-04
3.50000E-01	3.50000E-01	3.50000E+02	1.02477E+00	1.02984E+03	8.83090E+02	3.01907E+03	5.09918E+00	2.05747E-04
3.60000E-01	3.60000E-01	3.60000E+02	1.03147E+00	1.03093E+03	7.80838E+02	3.01822E+03	5.09584E+00	2.56560E-04
3.70000E-01	3.70000E-01	3.70000E+02	1.03924E+00	1.03206E+03	6.77326E+02	3.01558E+03	5.09205E+00	3.14461E-04
3.80000E-01	3.80000E-01	3.80000E+02	1.04822E+00	1.03323E+03	5.72279E+02	3.01275E+03	5.08774E+00	3.80017E-04
3.90000E-01	3.90000E-01	3.90000E+02	1.05855E+00	1.03442E+03	4.65510E+02	3.00587E+03	5.08287E+00	4.53726E-04
4.00000E-01	4.00000E-01	4.00000E+02	1.07041E+00	1.03564E+03	3.56646E+02	2.99855E+03	5.07741E+00	5.36395E-04
4.10000E-01	4.10000E-01	4.10000E+02	1.08403E+00	1.03690E+03	2.45060E+02	2.99122E+03	5.07135E+00	6.28680E-04
4.20000E-01	4.20000E-01	4.20000E+02	1.09958E+00	1.03818E+03	1.29996E+02	2.98390E+03	5.06468E+00	7.30734E-04
4.30000E-01	4.30000E-01	4.30000E+02	1.11724E+00	1.03950E+03	1.08022E+01	2.97657E+03	5.05736E+00	8.42482E-04
4.40000E-01	4.40000E-01	4.40000E+02	1.13716E+00	1.04085E+03	-1.12630E+02	2.96925E+03	5.04940E+00	9.63447E-04
4.50000E-01	4.50000E-01	4.50000E+02	1.15949E+00	1.04224E+03	-2.39175E+02	2.96192E+03	5.04081E+00	1.09343E-03
4.60000E-01	4.60000E-01	4.60000E+02	1.18448E+00	1.04366E+03	-3.66413E+02	2.95460E+03	5.03167E+00	1.23241E-03
4.70000E-01	4.70000E-01	4.70000E+02	1.21243E+00	1.04512E+03	-4.90718E+02	2.94727E+03	5.02204E+00	1.38056E-03
4.80000E-01	4.80000E-01	4.80000E+02	1.24343E+00	1.04662E+03	-6.07604E+02	2.93995E+03	5.01198E+00	1.53515E-03
4.90000E-01	4.90000E-01	4.90000E+02	1.27757E+00	1.04814E+03	-7.12357E+02	2.93262E+03	5.00153E+00	1.69583E-03

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   45
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:58:40
 TTWOB WITH SPACE TIME KINETICS - RETRAN-3D SAMPLE PROBLEM                                                      CPU TIME =    0.484
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SYSTEM ELAPSED TIME (SEC)	REACTVTY ROD WORTH (K-1)/K	REACTVTY DOPPLER REAC (K-1)/K	REACTVTY DENSITY REAC (K-1)/K	REACTVTY RESIDUE REAC (K-1)/K
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
1.00000E-02	0.00000E+00	-1.68302E-11	-1.42499E-09	-6.53521E-12
2.00000E-02	0.00000E+00	-1.32924E-10	-5.08786E-08	-7.06545E-10
3.00000E-02	0.00000E+00	-1.82443E-10	-3.17924E-07	-4.60106E-09
4.00000E-02	0.00000E+00	4.84283E-10	-9.04508E-07	-1.32054E-08
5.00000E-02	0.00000E+00	2.75531E-09	-1.65151E-06	-2.41833E-08
6.00000E-02	0.00000E+00	7.12256E-09	-2.30326E-06	-3.37624E-08
7.00000E-02	0.00000E+00	1.34034E-08	-2.74491E-06	-4.02408E-08
8.00000E-02	0.00000E+00	2.10398E-08	-3.02838E-06	-4.43808E-08
9.00000E-02	0.00000E+00	2.95386E-08	-3.25227E-06	-4.76398E-08
1.00000E-01	0.00000E+00	3.86596E-08	-3.46482E-06	-5.07358E-08
1.10000E-01	0.00000E+00	4.83362E-08	-3.65785E-06	-5.35528E-08
1.20000E-01	0.00000E+00	5.85288E-08	-3.81327E-06	-5.58236E-08
1.30000E-01	0.00000E+00	6.91656E-08	-3.94033E-06	-5.76802E-08
1.40000E-01	0.00000E+00	8.01846E-08	-4.07643E-06	-5.96685E-08
1.50000E-01	0.00000E+00	9.16001E-08	-4.26021E-06	-6.23557E-08
1.60000E-01	0.00000E+00	1.03519E-07	-4.50243E-06	-6.59008E-08
1.70000E-01	0.00000E+00	1.16086E-07	-4.77661E-06	-6.99160E-08
1.80000E-01	0.00000E+00	1.29386E-07	-5.03448E-06	-7.36934E-08
1.90000E-01	0.00000E+00	1.43389E-07	-5.23110E-06	-7.65730E-08
2.00000E-01	0.00000E+00	1.57938E-07	-5.33626E-06	-7.81125E-08
2.10000E-01	0.00000E+00	1.72778E-07	-5.32042E-06	-7.78821E-08
2.20000E-01	0.00000E+00	1.87555E-07	-5.12161E-06	-7.49788E-08
2.30000E-01	0.00000E+00	2.01732E-07	-4.60608E-06	-6.74496E-08
2.40000E-01	0.00000E+00	2.14394E-07	-3.54201E-06	-5.19039E-08
2.50000E-01	0.00000E+00	2.23988E-07	-1.60217E-06	-2.35532E-08
2.60000E-01	0.00000E+00	2.28040E-07	1.63911E-06	2.38307E-08
2.70000E-01	0.00000E+00	2.22854E-07	6.75285E-06	9.86043E-08
2.80000E-01	0.00000E+00	2.03094E-07	1.44825E-05	2.11661E-07
2.90000E-01	0.00000E+00	1.61312E-07	2.56688E-05	3.75347E-07
3.00000E-01	0.00000E+00	8.76306E-08	4.11437E-05	6.01905E-07
3.10000E-01	0.00000E+00	-3.03284E-08	6.17238E-05	9.03357E-07
3.20000E-01	0.00000E+00	-2.07504E-07	8.82059E-05	1.29147E-06
3.30000E-01	0.00000E+00	-4.61363E-07	1.21149E-04	1.77451E-06
3.40000E-01	0.00000E+00	-8.11020E-07	1.59845E-04	2.34184E-06
3.50000E-01	0.00000E+00	-1.27451E-06	2.04032E-04	2.98951E-06
3.60000E-01	0.00000E+00	-1.86966E-06	2.54697E-04	3.73233E-06
3.70000E-01	0.00000E+00	-2.61684E-06	3.12498E-04	4.58022E-06
3.80000E-01	0.00000E+00	-3.53949E-06	3.78014E-04	5.54211E-06
3.90000E-01	0.00000E+00	-4.66399E-06	4.51763E-04	6.62611E-06
4.00000E-01	0.00000E+00	-6.01987E-06	5.34570E-04	7.84489E-06
4.10000E-01	0.00000E+00	-7.64076E-06	6.27112E-04	9.20921E-06
4.20000E-01	0.00000E+00	-9.56447E-06	7.29575E-04	1.07228E-05
4.30000E-01	0.00000E+00	-1.18324E-05	8.41928E-04	1.23864E-05
4.40000E-01	0.00000E+00	-1.44891E-05	9.63741E-04	1.41952E-05
4.50000E-01	0.00000E+00	-1.75819E-05	1.09486E-03	1.61484E-05
4.60000E-01	0.00000E+00	-2.11621E-05	1.23533E-03	1.82485E-05
4.70000E-01	0.00000E+00	-2.52862E-05	1.38535E-03	2.05000E-05
4.80000E-01	0.00000E+00	-3.00151E-05	1.54230E-03	2.28660E-05
4.90000E-01	0.00000E+00	-3.54096E-05	1.70590E-03	2.53457E-05

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   50
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis             11:58:43
 TTWOB WITH SPACE TIME KINETICS - RETRAN-3D SAMPLE PROBLEM                                                      CPU TIME =    2.683
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *
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NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	ENERGY BALANCE (BTU)	TOTAL MASS BALANCE (LBM)	NCG MASS BALANCE (LBM)	AVERAGE TIME STEP (SEC)	CURRENT TIME STEP (SEC)	ELAPSED TIME (SEC)	TIME STEP NUM STANDRD/ACTUL
									3000
1.07393E+00	2.72068E+03	9.31955E+09	2.36952E+11	2.14322E+08	0.00000E+00	2.00000E-04	2.00000E-04	1.00000E+00	3465

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	VOID FRAC.	POWR TO H2O (BTU/SEC)
1	1.14869E+03	1.26809E+05	5.26701E+02	4.74475E+01	5.31893E+02	0.00000E+00	0.00000E+00	0.00000E+00
8	1.11911E+03	1.16487E+04	6.40578E+02	1.43411E+01	5.58133E+02	1.27712E-01	7.25214E-01	-1.32384E+03
9	1.10382E+03	3.12478E+04	6.75621E+02	1.07842E+01	5.56396E+02	1.86249E-01	8.07754E-01	0.00000E+00
10	1.10397E+03	8.78559E+03	1.19833E+03	2.42421E+00	5.62320E+02	1.00000E+00	1.00000E+00	0.00000E+00
11	1.10790E+03	2.94757E+03	6.41733E+02	1.39291E+01	5.56860E+02	1.31733E-01	7.34865E-01	-1.82871E+04
12	1.11022E+03	1.64853E+05	5.27047E+02	4.73950E+01	5.32103E+02	1.41359E-05	2.67683E-04	1.51477E+03
13	1.14639E+03	9.26732E+03	5.26866E+02	4.74371E+01	5.32021E+02	3.34473E-07	6.11318E-06	0.00000E+00
14	1.10099E+03	1.56443E+03	1.19903E+03	2.41313E+00	5.62391E+02	1.00000E+00	1.00000E+00	0.00000E+00
15	1.10036E+03	1.06967E+03	1.19986E+03	2.40636E+00	5.62875E+02	1.00000E+00	1.00000E+00	0.00000E+00
16	1.09465E+03	5.51828E+03	1.20275E+03	2.37554E+00	5.64132E+02	1.00000E+00	1.00000E+00	0.00000E+00
17	1.10009E+03	2.58236E+02	1.20333E+03	2.38379E+00	5.65270E+02	1.00000E+00	1.00000E+00	0.00000E+00
18	1.20079E+03	2.56942E+04	5.27190E+02	4.74519E+01	5.32366E+02	1.30756E-07	2.26709E-06	7.40105E+03
19	1.26747E+03	2.81700E+04	5.27127E+02	4.74942E+01	5.32419E+02	0.00000E+00	0.00000E+00	0.00000E+00
20	9.57587E+02	2.13850E+08	1.18966E+03	2.13850E+00	5.38889E+02	9.92724E-01	9.99668E-01	0.00000E+00
100	1.12347E+03	5.30621E+03	5.26717E+02	4.74319E+01	5.31867E+02	0.00000E+00	0.00000E+00	0.00000E+00
101	1.14264E+03	2.00451E+03	5.26700E+02	4.74440E+01	5.31883E+02	0.00000E+00	0.00000E+00	0.00000E+00
102	1.12849E+03	4.00832E+02	5.26700E+02	4.74357E+01	5.31861E+02	0.00000E+00	0.00000E+00	0.00000E+00
103	1.12775E+03	7.22387E+03	5.60776E+02	3.56189E+01	5.50211E+02	1.72835E-02	2.41649E-01	7.32801E+05
104	1.12560E+03	4.12574E+03	6.06178E+02	2.03429E+01	5.58088E+02	7.32291E-02	5.86012E-01	1.35792E+06
105	1.12200E+03	3.32703E+03	6.26588E+02	1.64047E+01	5.58602E+02	1.04539E-01	6.77066E-01	7.58012E+05
106	1.11918E+03	3.76289E+02	6.36342E+02	1.48437E+01	5.57921E+02	1.21430E-01	7.13660E-01	0.00000E+00
201	1.12451E+03	2.00734E+03	5.26717E+02	4.74325E+01	5.31869E+02	0.00000E+00	0.00000E+00	0.00000E+00
202	1.12435E+03	4.01278E+02	5.26717E+02	4.74324E+01	5.31869E+02	0.00000E+00	0.00000E+00	0.00000E+00
203	1.12366E+03	9.52838E+03	5.36349E+02	4.69101E+01	5.39524E+02	0.00000E+00	0.00000E+00	9.03930E+03
204	1.12236E+03	9.30937E+03	5.49689E+02	4.58319E+01	5.49734E+02	4.31806E-04	7.81061E-03	2.15877E+04
205	1.12108E+03	9.05335E+03	5.51507E+02	4.45715E+01	5.50369E+02	2.02388E-03	3.56475E-02	1.45154E+04
206	1.12033E+03	1.12779E+03	5.49877E+02	4.44185E+01	5.48944E+02	2.36184E-03	4.14890E-02	0.00000E+00

JUNCTION NUMBER	CONNECTS VOLUMES	CHOK/ PATH	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E VEL. PSI	ELEV. PSI	D I F F E R E N T I A L S FRIC. PSI	ACCL. PSI	PUMP PSI
9	11 TO 9		2.43333E+04	6.41731E+02	7.17917E-02	4.09038E+00	-1.86328E+00	-2.26190E+00	4.05952E+00	0.00000E+00
10	9 TO 10		2.45477E+03	1.18889E+03	4.02167E-01	3.58354E-01	-1.22958E-01	-2.18433E-02	6.31940E-02	0.00000E+00
11	18 TO 19		9.31998E+03	5.27190E+02	2.10740E-02	8.61190E-02	-2.92006E+00	-1.87058E+01	5.71116E-01	8.88029E+01
12	8 TO 11		2.42849E+04	6.40576E+02	6.97274E-02	-3.85926E+00	-5.60382E-01	-1.73759E+00	5.06908E+00	0.00000E+00
13	12 TO 13		9.33959E+03	5.27046E+02	2.10992E-02	-1.07871E+00	2.86914E+00	-3.57656E+00	4.09265E-01	3.83831E+01
14	19 TO 13		9.31801E+03	5.27127E+02	2.10552E-02	6.39291E+00	-5.01422E+00	-4.64523E+01	-5.48304E-01	-7.65477E+01
15	12 TO 18		9.32973E+03	5.27046E+02	2.10992E-02	-3.83919E+00	1.07845E+01	-4.93675E+00	2.42716E-01	8.88029E+01
16	13 TO 1		1.86627E+04	5.26866E+02	2.10805E-02	3.67055E-01	2.89239E+00	-8.49012E-01	1.08240E-01	0.00000E+00
17	10 TO 14		1.71522E+03	1.19833E+03	4.12512E-01	-1.06998E+00	5.15247E-01	-1.19762E+00	1.23164E+00	0.00000E+00
18	14 TO 15		1.57095E+03	1.19902E+03	4.14408E-01	4.06532E-01	5.19775E-01	-1.47568E+00	1.02575E-01	0.00000E+00
19	15 TO 16		1.40953E+03	1.19986E+03	4.15577E-01	1.07367E+00	2.46295E-01	-9.38342E+00	-2.32653E+00	0.00000E+00
20	16 TO 17		-2.14824E+00	1.20333E+03	4.19499E-01	8.67035E-01	-3.80117E-01	1.30881E-04	-5.02775E+00	0.00000E+00
21	9 TO 12		1.59459E+04	5.58798E+02	2.23020E-02	3.13195E-01	6.57265E+00	-1.42856E-01	3.35824E-01	0.00000E+00
22	16 TO 20		0.00000E+00	1.20275E+03	4.20979E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
101	1 TO 101	CHI	1.80681E+04	5.26701E+02	2.10759E-02	-1.65316E-01	-2.67111E+00	-3.19718E+00	1.62951E-02	0.00000E+00
102	101 TO 102		1.75969E+04	5.26700E+02	2.10775E-02	1.58130E-02	-1.64731E-01	-1.40043E+01	1.12585E-03	0.00000E+00
103	102 TO 103	AFI	1.68674E+04	5.26700E+02	2.10812E-02	-1.06083E-01	-5.22180E-01	-1.06363E-01	9.97375E-04	0.00000E+00
104	103 TO 104		1.84188E+04	5.60773E+02	2.80738E-02	-4.10803E-01	-7.77287E-01	-9.77758E-01	-1.56338E-02	0.00000E+00
105	104 TO 105		1.98082E+04	6.06172E+02	4.91539E-02	-5.49342E-01	-5.10419E-01	-2.60253E-01	-6.36774E-02	0.00000E+00
106	105 TO 106		2.10437E+04	6.26582E+02	6.09538E-02	-3.31045E-01	-2.53632E-01	-2.23673E+00	-2.43274E-03	0.00000E+00
107	106 TO 8	CHX	2.17486E+04	6.36335E+02	6.73638E-02	3.11913E-01	-3.21218E-01	-7.53595E-02	-1.59026E-02	0.00000E+00
110	102 TO 100	WTI	5.74240E+02	5.26700E+02	2.10812E-02	1.71809E-01	-2.01037E+00	-3.13049E+00	4.88136E-02	0.00000E+00
111	100 TO 106	WTO	5.75700E+02	5.26717E+02	2.10828E-02	-1.49808E+00	-2.02267E+00	-7.25998E-01	3.88122E-02	0.00000E+00
112	101 TO 201	LLK	4.71659E+02	5.26700E+02	2.10775E-02	1.81233E+01	-2.66890E-07	-1.81233E+01	6.86292E-02	0.00000E+00
113	102 TO 202	LLK	1.55417E+02	5.26700E+02	2.10812E-02	4.13483E+00	-7.72353E-08	-4.13483E+00	1.16004E-05	0.00000E+00
201	1 TO 201	BLK	6.24978E+02	5.26701E+02	2.10759E-02	2.41732E+01	-2.67108E+00	-2.15021E+01	1.49470E-05	0.00000E+00
202	201 TO 202		1.09731E+03	5.26717E+02	2.10826E-02	-5.43209E-04	-1.64696E-01	-7.38530E-05	5.43558E-04	0.00000E+00
203	202 TO 203		1.25286E+03	5.26717E+02	2.10826E-02	-3.16519E-04	-6.78979E-01	-3.89543E-04	4.49922E-03	0.00000E+00
204	203 TO 204		1.25284E+03	5.36349E+02	2.13174E-02	2.05592E-04	-1.28808E+00	-9.84276E-03	8.39508E-03	0.00000E+00
205	204 TO 205		1.13519E+03	5.49689E+02	2.18189E-02	9.54172E-04	-1.25559E+00	-9.07535E-03	1.31158E-02	0.00000E+00
206	205 TO 206		6.72364E+02	5.51507E+02	2.24361E-02	8.24086E-04	-6.96156E-01	-4.09047E-02	1.87361E-02	0.00000E+00
207	206 TO 8		5.84606E+02	5.49877E+02	2.25135E-02	-8.32138E-01	-3.72560E-01	-1.43823E-05	1.05359E-02	0.00000E+00
26	0 TO 14		0.00000E+00	1.19902E+03	4.14408E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
25	0 TO 14		0.00000E+00	1.19902E+03	4.14408E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
24	0 TO 12		2.55846E+03	4.03332E+02	1.89228E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
23	0 TO 14		0.00000E+00	1.19902E+03	4.14408E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

VOLUME NUMBER	FLOW REG.	LIQ. ENTH. (BTU/LB)	GAS ENTH. (BTU/LB)	LIQ. TEMP. (DEG. F)	GAS TEMP. (DEG. F)	IF AREA DEN (FT2/FT3)	IF HT COEFF (B/H-FT2-F)	IF MASS TRN (LB/SEC)	TOT MAS TRN (LB/SEC)	LIQ. HT RT (BTU/SEC)
8	4	5.60392E+02	1.18826E+03	5.58136E+02	5.58118E+02	3.27330E+01	3.95557E+05	8.14081E+01	8.14081E+01	-9.80578E+04
11	4	5.58745E+02	1.18872E+03	5.56861E+02	5.56857E+02	1.15405E+02	9.54727E+05	3.49357E+01	3.49357E+01	-5.98158E+04
12	2	5.27037E+02	1.18863E+03	5.32103E+02	5.57119E+02	5.13167E-01	7.44184E+02	-1.39512E+01	-1.39512E+01	1.80976E+04
13	2	5.26865E+02	1.18712E+03	5.32021E+02	5.61146E+02	1.18973E-02	4.17693E+03	-1.18958E-01	-1.18958E-01	1.41217E+02
18	2	5.27190E+02	1.18476E+03	5.32366E+02	5.67022E+02	4.51559E-03	3.07249E+03	-1.09978E-01	-1.09978E-01	7.53134E+03
103	2	5.49747E+02	1.18790E+03	5.49997E+02	5.59083E+02	7.99655E+02	4.17079E+02	-2.03732E+02	4.45597E+02	2.03476E+05
104	3	5.60206E+02	1.18799E+03	5.58008E+02	5.58844E+02	1.29177E+01	2.60743E+04	-2.45541E+01	1.85861E+03	-8.50096E+05
105	3	5.61031E+02	1.18814E+03	5.58627E+02	5.58442E+02	5.06866E+00	1.64149E+06	1.38431E+02	1.20424E+03	-6.72793E+05
106	4	5.60059E+02	1.18826E+03	5.57884E+02	5.58126E+02	1.42316E+01	3.62514E+04	-1.40364E+00	-1.40364E+00	1.66789E+03
204	2	5.49413E+02	1.18812E+03	5.49729E+02	5.58482E+02	1.50771E+01	5.38457E+02	-6.27784E+00	-6.27784E+00	2.90466E+04
205	2	5.50216E+02	1.18818E+03	5.50347E+02	5.58339E+02	7.27596E+01	4.54245E+02	-2.33655E+01	-2.33655E+01	4.22778E+04
206	2	5.48366E+02	1.18821E+03	5.48914E+02	5.58254E+02	8.58030E+01	3.56153E+02	-3.14650E+00	-3.14650E+00	3.73870E+03

JUNCTION NUMBER	FLOW REG.	SLIP VEL. (FT/SEC)	VOID FRACTION	LIQUID FLOW (LB/SEC)	GAS FLOW (LB/SEC)	SLIP CNVCTN (BTU/SEC)	GAS VEL. (FT/SEC)	LIQ. VEL. (FT/SEC)	VG/VL	SLIP ACCEL. (FT/SEC**2)
9	-2	-1.47236E+00	7.34864E-01	2.10512E+04	3.28217E+03	4.84034E+04	5.46981E+01	5.32258E+01	1.02766E+00	1.17572E+01
12	-2	-3.67257E+00	7.25202E-01	2.09916E+04	3.29322E+03	1.20550E+05	5.49839E+01	5.13113E+01	1.07157E+00	1.19412E+01
13	2	1.58512E+00	2.67632E-04	9.33946E+03	1.27856E-01	-2.73993E+00	4.89427E+01	5.05278E+01	9.68629E-01	-1.14972E+00
15	2	3.62992E+00	2.67632E-04	9.32961E+03	1.14475E-01	-1.14996E+01	2.39059E+01	2.75358E+01	8.68175E-01	6.88293E-02
104	3	-1.92779E+00	2.41615E-01	1.80551E+04	3.63635E+02	2.89417E+04	1.51909E+01	1.32631E+01	1.14535E+00	6.16098E-01
105	5	-1.30368E+01	5.85980E-01	1.76579E+04	2.15029E+03	4.39380E+05	3.71190E+01	2.40822E+01	1.54134E+00	-2.54978E+00

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     106       5  -1.83322E+01  6.77038E-01  1.77493E+04  3.29442E+03  6.86494E+05  4.93994E+01  3.10672E+01  1.59008E+00 -5.89712E+00
     107       5  -1.04919E+01  7.13636E-01  1.84617E+04  3.28682E+03  4.05829E+05  4.68911E+01  3.63992E+01  1.28825E+00 -8.82191E+00
     205       2  -1.13032E+00  7.81361E-03  1.13357E+03  1.62626E+00  7.25540E+02  1.61760E+00  4.87275E-01  3.31968E+00  2.57457E-01
     206       2  -1.50286E+00  3.56589E-02  6.64130E+02  8.23376E+00  4.38445E+03  1.79689E+00  2.94027E-01  6.11130E+00  3.82343E-02
     207       2  -1.72224E+00  4.15056E-02  5.74068E+02  1.05383E+01  5.85889E+03  1.97736E+00  2.55117E-01  7.75079E+00 -2.39873E-01

   BUBL          BUBBLE       BUBBLE       MIXTURE      MIXTURE      BUBBLE
   SET    VOL.   GRADIENT     VELOCITY     LEVEL        QUALITY      MASS
   NUMB.  NUMB.  PARAMETER    (FT/SEC)     (FT)                      (LB)
      1       9  5.00000E-02  4.44038E+02  4.73033E+00  1.09538E-03  2.78839E+01

   PUMP   VOL.   PUMP SPEED   NORM. PUMP   NORM. FRIC.  NORM. MOT.   POWER TO H2O
   NUMB.  NUMB.  (RPM)        TORQUE       TORQUE       TORQUE       (BTU/HR)
      1      18  1.66500E+03  9.94699E-01  1.00000E+00  0.00000E+00  2.66438E+07

  HEAT COND.    VOL. HT TRAN   SURF. FLUX   CRIT. FLUX   H.T. COEF.   SURF. TEMP.  MASS FLUX    STORD ENRGY  POWR TO H20  DRYOUT PNT
  NUMBER        NUM. MODE-COR  (BTU/HR-FT2) (BTU/HR-FT2) (BTU/H-F2-F) (DEG. F)     (LBM/HR-FT2) (BTU)        (BTU/HR)     ()
      1 RGHT     103  20-DB-T  1.61023E+05  7.82719E+05  8.69948E+03  5.68719E+02  1.06091E+06  1.09330E+07  2.60501E+09
      2 RGHT     104  20-DB-T  2.94556E+05  7.26779E+05  1.90292E+04  5.73567E+02  1.14935E+06  1.53419E+07  4.76528E+09
      3 RGHT     105  20-DB-T  1.63806E+05  6.95472E+05  1.54209E+04  5.69225E+02  1.22828E+06  1.10020E+07  2.65004E+09
      4 LEFT     103   1-DB-L -2.04833E+03  1.32339E+06  2.94458E+03  5.49514E+02  1.06091E+06               -8.19466E+06
        RGHT     203   1-DB-L  2.58320E+03  1.62245E+05  3.01470E+02  5.48093E+02  8.88126E+04  4.52870E+05  1.03344E+07
      5 LEFT     104   1-DB-L  1.69695E+03  1.06165E+06  4.50825E+03  5.58464E+02  1.14935E+06               6.78888E+06
        RGHT     204   1-DB-L  2.45434E+03  1.56936E+05  2.92021E+02  5.58139E+02  8.46397E+04  4.61458E+05  9.81890E+06
      6 LEFT     105   1-DB-L -1.06096E+03  1.06389E+06  4.71134E+03  5.58377E+02  1.22828E+06              -4.24451E+06
        RGHT     205   1-DB-L  1.57545E+03  1.38239E+05  2.32684E+02  5.57139E+02  6.40535E+04  4.60793E+05  6.30279E+06
      7 LEFT      11   1-DB-L -3.93087E+04  3.06704E+05  5.21100E+03  5.49316E+02  2.67561E+06              -6.58334E+07
        RGHT      12   1-DB-L  3.11719E+03  2.23432E+05  9.39617E+02  5.35421E+02  7.16860E+05  1.40770E+06  5.68109E+06
      8 LEFT       8   1-DB-L -1.26381E+04  9.00000E+04  1.14751E+03  5.47120E+02  9.35712E+05              -4.76584E+06
        RGHT      12   1-DB-L -5.91490E+02  2.09184E+05  1.52402E+03  5.31715E+02  7.16860E+05  6.45958E+06 -2.27911E+05

   CORE   COND.  DEPTH REAC.  DEPTH REAC.  HEAT GEN.    COND. HEAT-  DIR. MODER-  AVG. METAL   CENTERLINE   FUEL
   NUMB.  NUMB.  EXT. ZR-H2O  INT. ZR-H2O  ZR-H2O       ING RATE     ATOR HT RT   TEMPERATURE  TEMPERATURE  ENTHALPY
                 (FT)         (FT)         (BTU/HR)     (BTU/HR)     (BTU/HR)     (DEG. F)     (DEG. F)     (CAL/GM)
      1       1  0.00000E+00  0.00000E+00  0.00000E+00  1.43958E+09  4.12681E+07  1.47581E+03  1.92796E+03  5.43219E+01
      2       2  0.00000E+00  0.00000E+00  0.00000E+00  4.38063E+09  1.16440E+08  2.03209E+03  2.97950E+03  7.74899E+01
      3       3  0.00000E+00  0.00000E+00  0.00000E+00  3.04608E+09  8.30503E+07  1.48497E+03  1.93692E+03  5.46986E+01
      4       4  0.00000E+00  0.00000E+00  0.00000E+00  8.01436E+06  2.22071E+07  5.48839E+02
      5       5  0.00000E+00  0.00000E+00  0.00000E+00  2.38799E+07  6.78970E+07  5.58507E+02
      6       6  0.00000E+00  0.00000E+00  0.00000E+00  1.79070E+07  4.59528E+07  5.57759E+02
0         AVERAGE CORE            MINIMUM  HEIGHT              HOT  SPOT                    MINUMUM DNBR POSITION
            (RETRAN)                (HOT CHANNEL)               (HOT CHANNEL)                   (HOT CHANNEL)
   LHGR(KW/FT)      DNBR      LHGR(KW/FT)      DNBR      LHGR(KW/FT)      DNBR      POS. (FT)    LHGR(KW/FT)  MDNBR
   9.32904E+00  3.55993E+00  1.61179E+01  1.29178E+00  1.64613E+01  0.00000E+00  8.50000E+00  1.30675E+01  1.05759E+00
       TOTAL         INVERSE    CONTROL ROD    CONTROL ROD      DENSITY       DOPPLER       RESIDUAL       PROMPT     DECAY HEA&T
     REACTIVITY       PERIOD      POSITION     REACTIVITY     REACTIVITY     REACTIVITY     REACTIVITY       POWER         POWER
      (K-1)/K         (1/SEC)        (FT)         (K-1)/K        (K-1)/K        (K-1)/K        (K-1)K
  -1.697649E-03 -4.140850E+00  1.801001E+00 -3.037204E-03  2.828776E-03 -1.869598E-03  3.803781E-04  9.950665E-01  7.885891E-02
    REGION   NORM. POWER    REGIONWISE     CHANGE IN FEEDBACK VAR. (FROM TIME = 0.0)
    NUMBER   DISTRIBUTION   REACTIVITY  NORMALIZED RHO     FUEL TEMP.     MOD. TEMP.
                              (K-1)/K                      (DEG.F)**1/2   DEG. F)


         1    0.000000E+00  4.872889E-04  6.977788E-04    0.000000E+00  4.178558E-01
         2    1.769737E-02 -2.149482E-03  8.691884E-02    1.003733E+00  6.466816E+00
         3    1.448935E-01 -2.188809E-06  8.691884E-02    1.003733E+00  6.466816E+00
         4    2.345849E-01 -3.335379E-04  1.638547E-02    1.477554E+00  1.008542E+01
         5    2.592315E-01 -7.070849E-05  1.638547E-02    1.477554E+00  1.008542E+01
         6    2.246039E-01  5.429945E-04  4.335208E-02    1.121139E+00  1.090096E+01
         7    1.189888E-01 -5.006611E-05  4.335208E-02    1.121139E+00  1.090096E+01
         8    0.000000E+00 -1.219482E-04  1.255057E-01    0.000000E+00  1.087339E+01
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LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:58:43
 TTWOB WITH SPACE TIME KINETICS - RETRAN-3D SAMPLE PROBLEM                                                      CPU TIME =    2.683
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *


     SYSTEM        SYSTEM        TIME STP       SYSTEM        VOL    10       JUN    17       JUN    24       BUBL    9       REACTVTY
  ELAPSED TIME  ELAPSED TIME      ACTUAL      NORM. POWER    AVG. PRESS.       FLOW            FLOW         MIX. LEVEL    TOTAL REAC
     (SEC)         (SEC)                                       (PSIA)        (LB/SEC)        (LB/SEC)         (FEET)        (K-1)/K
  1.00000E+00   1.00000E+00   3.46500E+03   1.07393E+00   1.10397E+03   1.71522E+03   2.55846E+03   4.73033E+00  -1.69765E-03
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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   52
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:58:43
 TTWOB WITH SPACE TIME KINETICS - RETRAN-3D SAMPLE PROBLEM                                                      CPU TIME =    2.683
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *



     SYSTEM       REACTVTY      REACTVTY      REACTVTY      REACTVTY
  ELAPSED TIME  ROD WORTH     DOPPLER REAC  DENSITY REAC  RESIDUE REAC
     (SEC)        (K-1)/K       (K-1)/K       (K-1)/K       (K-1)/K
  1.00000E+00  -3.03720E-03  -1.86960E-03   2.82878E-03   3.80378E-04
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10.0 PWR ATWS SAMPLE PROBLEM

This sample problem is used for analysis of a loss of feedwater (LOFW) ATWS of a U-tube PWR. However, the results are not totally applicable to a specific plant. The geometric nodalization used for the LOFW ATWS transient is shown in Figure VII.10-1. The model utilizes 43 volumes, 52 junctions, and 15 heat conductors. The off-rated power initialization procedure option is used to adjust secondary pressures to match target initial power.

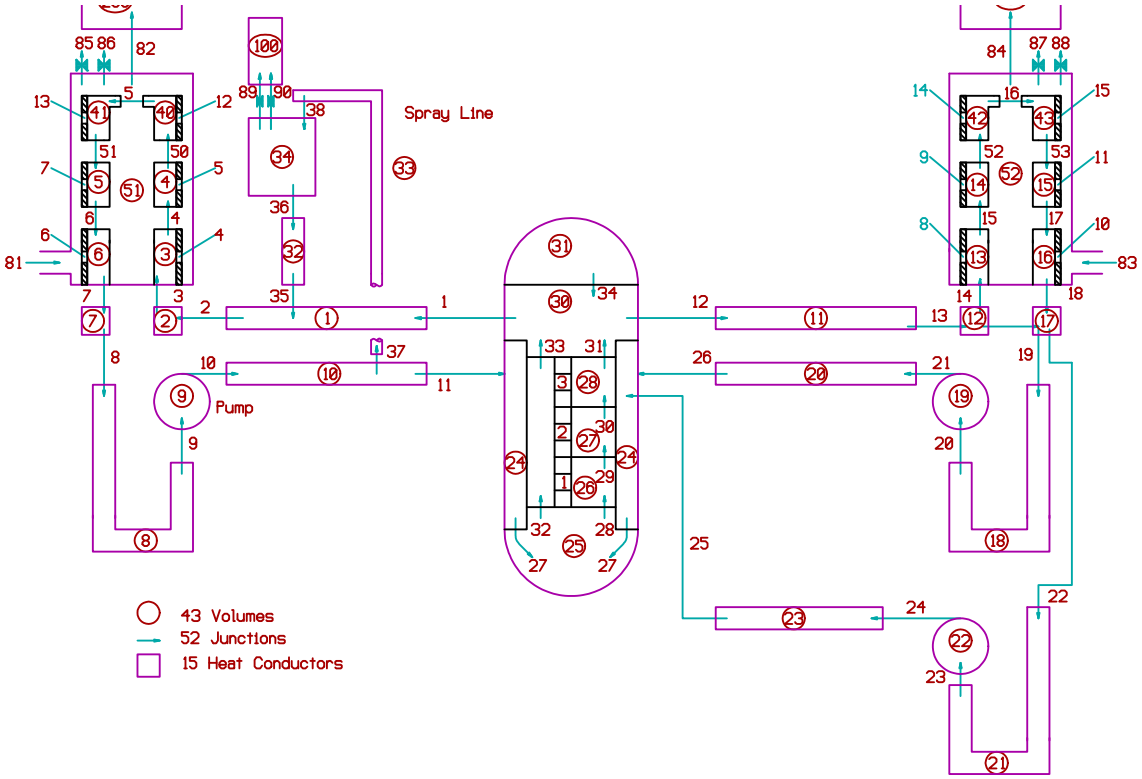


Figure VII.10-1. Schematic Diagram of the ATWS Sample Problem

The LOFW ATWS leads to a boil-off of the secondary side of steam generators. The heat removal from the primary side degrades as the top of the U tubes in the steam generators is uncovered. The degraded heat transfer increases the temperature of the primary water leading to a pressure rise and a rise of pressurizer water level. The increase in water moderator temperature decreases the coolant density and the core power slightly. As the transient continues, the high primary-side pressure opens the pressurizer relief and safety valves. The steam mass and energy removal slows the rise in the primary pressure and temperature. The energy removal through the valves and to the auxiliary feedwater is not sufficient to fully cope with the primary heat source. The steam generator

secondary side eventually boils dry. The primary heat then causes the pressure and temperature of the primary system to increase further. The rising temperature reduces the coolant density and consequently the power continues to drop. The pressurizer eventually goes solid and the primary pressure may reach values in excess of 27.6 MPa (4000 psia). The steam generator secondary side, meanwhile, has dropped in pressure below 3.4 MPa (500 psia); causing a low pressure trip closing the main steam isolation valves and stopping steam flow from the steam generators. The steam generator's secondary side starts to refill with auxiliary feedwater.

The reduced core power produced eventually is more than matched by the heat removal in the steam generator and the energy loss through the relief and safety valves. The primary-system pressure and temperature fall and the valves close. The system takes several minutes further to equilibrate during which the steam generator relief valve opens and closes and high pressure injection (HPI) comes on with borated water which eventually shuts the reactor down and long-term cooling is then initiated. The input and selected output for the ATWS Sample Problem are given below.

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LISTING OF INPUT DATA FOR CASE  1

    1    =ATWS  (LOSS OF FEEDWATER) - RETRAN-3D SAMPLE PROBLEM
    2    *
    3    ********************************************************************************
    4    *
    5    *  PROBLEM DIMENSIONS
    6    *
    7    *        1     2     3     4     5     6     7     8     9    10    11    12
    8    *      TAPE PRNPLT  POW   SS  NVOID GENTRN HTMAP SLIP  5EQ  NCOND  NSOL  PNMTH
    9    010001   0     0     1     0     0     0     0     0     0     0     2     0
   10    *
   11    *
   12    *10005    POWER
   13    010005    2710.
   14    *
   15    *
   16    *  MINOR EDIT VARIABLES
   17    020000 TIMX  0 NTTS  0
   18    020001 PRES 34 MIXL 34
   19    020002 WQ** 51 MIXL 51 PRES 51 LIQM 51
   20    020003 TEMP 25 TEMP 30
   21    020004 COUT  1 COUT -2 COUT -1
   22    020005 WP** 82 WP** 89 WP** 90
   23    020006 NELM 34 NELT 34 NEVT 34
   24    *
   25    *
   26    * FORMAT FOR TAPE60
   27    *
   28    025000 1
   29    025001 '(5(1X,1P,E15.7))'
   30    *
   31    *  TIME STEP DATA CARDS
   32    *3XXX0  RTG  MIN  RST  MAJ  DMP  NCHK  DELTMX  LAST
   33    030010  0.   0.2  0.   1.   1.   0     0.1       1.
   34    030020  0.   2.0  0.   24.  24.  0     0.5      25.
   35    030030  0.   2.5  0.   25.  25.  0     0.5      50.
   36    030040  0.   2.5  0.   50.  50.  0     0.05     65.
   37    030050  0.   2.5  0.   50.  50.  0     0.005   100.
   38    030060  0.   2.5  0.   50.  50.  0     0.01    500.
   39    *
   40    *  TIME STEP CONSTANTS
   41    *3XXX1  EPSP  COUR
   42    030011   0.   1.0
   43    030021   0.   1.0
   44    *
   45    *  TRIP CONTROL DATA
   46    *    IDTRP IDSIG IX1 IX2 SETPOINT DELAY  DESCRIPTION
   47    040010   1   1    0   0    150.    0.0   "END PROBLEM ON TIME             "
   48    040020   2   1    0   0   1000.    0.0   "TRIP RC PUMPS (NO TRIP)         "
   49    040030   3   4   34   0  10000.    1.4   "REACTOR TRIP FOR HIGH PRSZR PRES"
   50    040040   3   2    0   0   1.098  10.+6  "REACTOR TRIP ON HIGH NEUTRON PWR"
   51    040050   3  -9   19   0  7879.19 10.+6  "REACTOR TRIP ON LOW COOLANT FLOW"
   52    040060   4   1    0   0      0.    0.0   "GENERAL MISC TRIP AT TIME 0     "
   53    040070   5   1    0   0   1000.    0.0   "SUBST TRIP FOR PRESS SPRAY VV   "
   54    040080   6   4   51   0   1000.    0.0   "(LP1) OPEN MAIN STM SAFETY BNK 1"
   55    040090  -6  -4   51   0    961.    0.0   "(LP1)RESEAT MAIN STM SAFTY BNK 1"
   56    040100   7   4   51   0   1040.    0.0   "(LP1) OPEN MAIN STM SAFETY BNK 2"
   57    040110  -7  -4   51   0    999.    0.0   "(LP1)RESEAT MAIN STM SAFTY BNK 2"
   58    040120   8   4   52   0   1000.    0.0   "(LP2) OPEN MAIN STM SAFETY BNK 1"
   59    040130  -8  -4   52   0    961.    0.0   "(LP2)RESEAT MAIN STM SAFTY BNK 1"
   60    040140   9   4   52   0   1040.    0.0   "(LP2) OPEN MAIN STM SAFETY BNK 2"
   61    040150  -9  -4   52   0    999.    0.0   "(LP2)RESEAT MAIN STM SAFTY BNK 2"
   62    040160   3   1    0   0   1000.    1.4   "NO REACTOR TRIP                 "
   63    040170  10   4   34   0   2400.    0.0   "OPEN PRESSURIZER RELIEF VALVES  "
   64    040180 -10  -4   34   0   2300.    0.0   "CLOSE PRESSURIZER RELIEF VALVES "
   65    040190  11   4   34   0   2500.    0.0   "OPEN PRESSURIZER SAFETY VALVES  "
   66    040200 -11  -4   34   0   2400.    0.0   "CLOSE PRESSURIZER SAFETY VALVES "
   67    040270  14  -4   34   0   2200.    0.0   "TURN ON BACKUP HEATERS (LO PRES)"
   68    040290 -14   4   34   0   2225.    0.0   "TURN OFF BACKUP HTRS (HIGH PRES)"
   69    040300 -14  -6   34   0      7.69  0.0   "TURN OFF BACKUP HTRS (LOW LEVEL)"
   70    040310  15  -4   34   0   2225.    0.0   "TURN ON PROP. HEATERS           "
   71    040320 -15   4   34   0   2275.    0.0   "TURN OFF PROP. HEATERS          "
   72    040210  12  -4   51   0    500.    0.9   "VALVE ON SECONDARY              "
   73    040220  13  -4   52   0    500.    0.9   "VALVE ON SECONDARY              "
   74    *
   75    *
   76    *  VOLUME DATA
   77    *       1  2     3       4      5        6       7     8     9     10      11
   78    *5XXX1 IB IR PRESSURE ENTHALPY QUAL    VOLUME  HEIGHT  FL  FLOWA  DIAM    ELEV
   79    050011  0  0      0.      0.     0.     140.61    4.13  0.   9.62  3.50   -1.75
   80    050021  0  0      0.      0.     0.     254.00    6.423 0.  14.57  4.31   -0.483
   81    050031  0  0      0.      0.     0.     229.095  11.734 0.  19.52  .0545   5.94
   82    050041  0  0      0.      0.     0.     178.367   9.948 0.  19.52  .0545  17.674
   83    050401  0  0      0.      0.     0.     171.235   9.948 0.  19.52  .0545  27.622
   84    050411  0  0      0.      0.     0.     171.235   9.948 0.  19.52  .0545  27.622
   85    050051  0  0      0.      0.     0.     178.367   9.948 0.  19.52  .0545  17.674
   86    050061  0  0      0.      0.     0.     229.095  11.734 0.  19.52  .0545   5.94
   87    050071  0  0      0.      0.     0.     237.40    6.66  0.  14.67  4.32   -0.72
   88    050081  0  0      0.      0.     0.     224.00    8.30  0.   9.82  2.50   -7.25
   89    050091  0  0      0.      0.     0.     222.00    3.17  0.  1.+10  1.+10  -1.92
   90    050101  0  0      0.      0.     0.     164.40    2.50  0.   9.82  2.50   -1.25
   91    050111  0  0      0.      0.     0.     140.61    4.13  0.   9.62  3.50   -1.75
   92    050121  0  0      0.      0.     0.     254.00    6.423 0.  14.57  4.31   -0.483
   93    050131  0  0      0.      0.     0.     229.095  11.734 0.  19.52  .0545   5.94
   94    050141  0  0      0.      0.     0.     178.367   9.948 0.  19.52  .0545  17.674
   95    050421  0  0      0.      0.     0.     171.235   9.948 0.  19.52  .0545  27.622
   96    050431  0  0      0.      0.     0.     171.235   9.948 0.  19.52  .0545  27.622
   97    050151  0  0      0.      0.     0.     178.367   9.948 0.  19.52  .0545  17.674
   98    050161  0  0      0.      0.     0.     229.095  11.734 0.  19.52  .0545   5.94
   99    050171  0  0      0.      0.     0.     237.40    6.66  0.  14.67  4.32   -0.72
  100    050181  0  0      0.      0.     0.     112.00    8.30  0.   4.91  2.50   -7.25
```


PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

```
050191  0  0     0.      0.     0.     112.00    3.17  0.   1+10  1+10   -1.92
050201  0  0     0.      0.     0.      82.30    2.50  0.   4.91  2.50   -1.25
050211  0  0     0.      0.     0.     112.00    8.30  0.   4.91  2.50   -7.25
050221  0  0     0.      0.     0.     112.00    3.17  0.   1+10  1+10   -1.92
050231  0  0     0.      0.     0.      82.10    2.50  0.   4.91  2.50   -1.25
050241  0  0     0.      0.     0.     992.9    29.7   0.  30.76  1.1886 -23.2
050251  0  0     0.      0.     0.     869.4    10.0   0.   1+10  1+10   -27.2
050261  0  0     0.      0.     0.     233.3     4.36  0.  53.5   .04492 -17.4
050271  0  0     0.      0.     0.     233.3     4.36  0.  53.5   .04492 -13.04
050281  0  0     0.      0.     0.     233.3     4.36  0.  53.5   .04492 -8.68
050291  0  0     0.      0.     0.     167.0    13.08  0.  12.77  4.032  -17.4
050301  0  0     0.      0.     0.    1210.1    10.6   0.   1+10  1+10   -4.32
050311  0  0     0.      0.     0.     699.0     6.92  0.   1.      .0     6.28
050321  0  0     0.      0.     0.      32.00   11.55  0.    .559  .8438  1.75
050331  0  0     0.      0.     0.      10.76   49.59  0.    .0645 .2865  1.25
050341  1  0     0.      0.     0.    1500.     32.92  0.  49.81  7.964  12.94
*
050511  2  0     0.      0.     0.    8022.08  116.907 0.  17.155 1.+4  7.72654
050521  3  0     0.      0.     0.    8022.08  116.907 0.  17.155 1.+4  7.72654
051001  0  0     0.      0.     0.       1.+7  100.0   0. 100.0   0.0     0.0
052001  0  0     0.      0.     0.       1.+7  200.0   0. 100.0   0.0     0.0
053001  0  0     0.      0.     0.       1.+7  200.0   0. 100.0   0.0     0.0
*
*
*  BUBBLE DATA
*60XXY  ALPH   VBUB   MIXL   IWILSN
060011   1.0    0.0  17.03      1
060021   1.0    3.0  72.03
060031   1.0    3.0  72.03
*
*
*  JUNCTION DATA (CARD 1)
*        1    2  3  4     5           6        7       8        9    10
*8XXX1 FROM   TO PP VV  FLOWRATE     AREA      ELEV    INERT    KFOR  KREV
080011  30    1  0  0   16944.5     9.62      0.00    1.06    .193   -1.0
080121  30   11  0  0   16944.5     9.62      0.00    1.06    .193   -1.0
080021   1    2  0  0   16944.5     9.62      0.95    1.35   0.80     0.55
080131  11   12  0  0       0.0     9.62      0.95    1.35   0.80     0.55
080031   2    3  0  0       0.0    19.52      5.94    0.98   0.24     0.29
080141  12   13  0  0       0.0    19.52      5.94    0.98   0.24     0.29
080041   3    4  0  0       0.0    19.52     17.674    .76   0.0      0.0
080151  13   14  0  0       0.0    19.52     17.674    .76   0.0      0.0
080501   4   40  0  0       0.0    19.52     27.622    .76   0.0      0.0
080511  41    5  0  0       0.0    19.52     27.622    .76   0.0      0.0
080521  14   42  0  0       0.0    19.52     27.622    .76   0.0      0.0
080531  43   15  0  0       0.0    19.52     27.622    .76   0.0      0.0
080051  40   41  0  0       0.0    19.52     32.82     .76   0.20     0.2
080161  42   43  0  0       0.0    19.52     32.82     .76   0.20     0.2
080061   5    6  0  0       0.0    19.52     17.674    .76   0.0      0.0
080171  15   16  0  0       0.0    19.52     17.674    .76   0.0      0.0
080071   6    7  0  0       0.0    19.52      5.94     .93   0.29     0.24
080181  16   17  0  0       0.0    19.52      5.94     .93   0.29     0.24
080081   7    8  0  0       0.0     9.82      0.16    1.71   0.55     0.79
080191  17   18  0  0    8472.25    4.91      0.16    2.59   0.55     0.79
080221  17   21  0  0       0.0     4.91      0.16    2.59   0.55     0.79
080091   8    9 -1  0       0.0     9.82     -1.92    2.32   0.12     0.12
080201  18   19 -2  0       0.0     4.91     -1.92    4.64   0.12     0.12
080231  21   22 -3  0       0.0     4.91     -1.92    4.64   0.12     0.12
080101   9   10  1  0       0.0     9.82      0.0     2.00  -1.0     -1.0
080211  19   20  2  0       0.0     4.91      0.0     4.00  -1.0     -1.0
080241  22   23  3  0       0.0     4.91      0.0     4.00  -1.0     -1.0
080111  10   24  0  0   16944.5     9.82      0.0     1.08    .686   -1.0
080251  23   24  0  0       0.0     4.91      0.0     1.79    .61    -1.0
080261  20   24  0  0       0.0     4.91      0.0     1.79    .61    -1.0
080271  24   25  0  0   33889.0    29.      -23.2      .6628 2.07    -1.0
080281  25   26  0  0   32639.0    53.5     -17.4      .1498  .753   -1.0
080291  26   27  0  0       0.0    53.5     -13.04     .0815 1.81    -1.0
080301  27   28  0  0       0.0    53.5      -8.68     .0815 1.73    -1.0
080311  28   30  0  0   32639.0    53.5      -4.32     .6484 4.585   -1.0
080321  25   29  0  0    1250.0    12.77    -17.4      .5121  257.   -1.0
080331  29   30  0  0    1250.0    12.77     -4.32     .5121 -1.0    -1.0
080341  31   30  0  0       0.0     1.0       6.28    6.92    1.5     1.5
080351  32    1  0  0       0.0      .5592    1.75   46.9     1.07    0.68
080361  34   32  0  0       0.0      .5592   12.94   51.39    1.9     1.9
080371  10   33  0  0       0.0      .0751    1.25 984.9     3.09    3.09
080381  33   34  0  1       0.0      .0645   45.86 1295.3    3.239   3.239
080811   0   51  1  0       0.0     1.442     7.72654 0.0    0.0     0.0
080821  51 200  0  8       0.0     6.305   124.63   15.0   -1.0    -1.0
080831   0   52  2  0       0.0     1.442     7.72654 0.0    0.0     0.0
080841  52 300  0  9       0.0     6.305   124.63   15.0   -1.0    -1.0
080851   0   51  3  2       0.0     0.444   124.63    0.0    0.0     0.0
080861   0   51  3  3       0.0     0.444   124.63    0.0    0.0     0.0
080871   0   52  4  4       0.0     0.444   124.63    0.0    0.0     0.0
080881   0   52  4  5       0.0     0.444   124.63    0.0    0.0     0.0
080891 100   34  0  6       0.0     0.022    45.86   15.0    1.0     1.0
080901 100   34  0  7       0.0     0.039    45.86   15.0    1.0     1.0
*
*  JUNCTION DATA (CARD 2)
*       11   12  13  14    15      16   17  18  19   20   21   22
*8XXX2  JV   JC  JL  MV    DJ      CC   IF  TP  IHQ  ISP ANG1 ANG2
080012   1    1   0   0   0.0     1.0  11   0   0    0
080122   1    1   0   0   0.0     1.0  11   0   0    0
080022   1    1   0   0   0.0     1.0  11   0   0    0
080132   1    1   0   0   3.50    1.0   0   0   0    0
080032   0    1   0   0   4.985   1.0   0   0   0    0
080142   0    1   0   0   4.985   1.0   0   0   0    0
080042   0    1   0   0   4.985   1.0   0   0   0    0
080152   0    1   0   0   4.985   1.0   0   0   0    0
080502   0    1   0   0   4.985   1.0   0   0   1    0
080512   0    1   0   0   4.985   1.0   0   0   1    0
080522   0    1   0   0   4.985   1.0   0   0   1    0
080532   0    1   0   0   4.985   1.0   0   0   1    0
```

```
080052   1   1   0   0   4.985    1.0   0   0   0    0
080162   1   1   0   0   4.985    1.0   0   0   0    0
080062   0   1   0   0   4.985    1.0   0   0   0    0
080172   0   1   0   0   4.985    1.0   0   0   0    0
080072   1   1   0   0   4.985    1.0   0   0   0    0
080182   1   1   0   0   4.985    1.0   0   0   0    0
080082   1   1   0   0   3.536    1.0   0   0   0    0
080192   1   1   0   0   0.0      1.0  11   0   0    0
080222   1   1   0   0   2.50     1.0   0   0   0    0
080092   0   1   0   0   3.536    1.0   0   0   0    0
080202   0   1   0   0   2.50     1.0   0   0   0    0
080232   0   1   0   0   2.50     1.0   0   0   0    0
080102   1   1   0   0   3.536    1.0   0   0   0    0
080212   1   1   0   0   2.50     1.0   0   0   0    0
080242   1   1   0   0   2.50     1.0   0   0   0    0
080272   0   1   0   0   6.0765   1.0   0   0   0    0
080282   0   1   0   0   8.253    1.0   0   0   1    0
080292   0   1   0   0   8.253    1.0   0   0   1    0
080302   0   1   0   0   8.253    1.0   0   0   1    0
080312   0   1   0   0   8.253    1.0   0   0   1    0
080322   0   1   0   0   4.032    1.0   0   0   0    0
080332   0   1   0   0   4.032    1.0   0   0   0    0
080342   0   1   0   0   1.1284   1.0   0   0   0    0
080362   2   1   0   0   0.8438   1.0   0   0   0    0
080372   0   1   0   3   0.3092   1.0   0   0   0    0
080382   2   1   0   0   0.0631   1.0   0   0   0    1
080812   0   1   0   0   1.355    0.0   0   0   0    0
080822   0   2   0   0   2.833    1.0   0   0   0    0
080832   0   1   0   0   1.355    0.0   0   0   0    0
080842   0   2   0   0   2.833    1.0   0   0   0    0
080112   1   1   0   0   0.0      1.0  11   0   0    0
080252   1   1   0   0   2.50     1.0   0   0   0    0
080262   1   1   0   0   2.50     1.0   0   0   0    0
080352   0   1   0   3    .8438   1.0   0   0   0    0
080852   0   1   0   0   0.75     1.0   0   0   0    0  0. 180.
080862   0   1   0   0   0.75     1.0   0   0   0    0  0. 180.
080872   0   1   0   0   0.75     1.0   0   0   0    0  0. 180.
080882   0   1   0   0   0.75     1.0   0   0   0    0  0. 180.
080892   0   2   0   0    .167     .74  0   0   0    0
080902   0   2   0   0    .223     .785 0   0   0    0
*
*
*  PUMP DESCRIPTION DATA CARDS
*       1  2  3 4 5      6     7      8      9      10       11      12   13    14
*90XXY PC TP RV P M  SPEED  SPR   FLOW   HEAD  TORQUE  INERTIA DENSY MT FRICTION
090011 1  2  0  0 0   883. .845  186250. 273.2 64807.4 200000. 46.9  0.  5452.
090021 1  2  0  0 0   883. .845   93125. 273.2 32403.7 100000. 46.9  0.  2726.
090031 1  2  0  0 0   883. .845   93125. 273.2 32403.7 100000. 46.9  0.  2726.
*
*
*  PUMP CURVE SET DATA
100000   1    0
*
*
*  VALVE DATA
110010  1000 -6  0  0.  0.  0.  0.   * PRESSURIZER SPRAY VALVE
110020   -6   0  0  0.  0.  0.  0.   * MAIN STM SAFETY BANK 1 (4 VALVES)-LOOP 1
110030   -7   0  0  0.  0.  0.  0.   * MAIN STM SAFETY BANK 2 (4 VALVES)-LOOP 1
110040   -8   0  0  0.  0.  0.  0.   * MAIN STM SAFETY BANK 1 (4 VALVES)-LOOP 2
110050   -9   0  0  0.  0.  0.  0.   * MAIN STM SAFETY BANK 2 (4 VALVES)-LOOP 2
110060  -10   0  0  0.  0.  0.  0.   * PRESSURIZER RELIEF VALVES
110070  -11   0  0  0.  0.  0.  0.   * PRESSURIZER SAFETY VALVES
110080   12   5  0  0.  0.  0.  0.
110090   13   6  0  0.  0.  0.  0.
*
120101     4     0.0    0.0    2300.      0.0   2350.     1.0     8000.   1.0
120201     3     0.0    0.0       7.69  300.0     30.0  300.0
120301     3   -30.0    0.0       1.2   300.0     30.0  300.0
120401     4     0.0  300.0    2225.    300.0   2275.     0.0     8000.   0.0
120501     3     0.0    1.0       6.0     0.0      1.+6   0.0
120601     3     0.0    1.0       6.0     0.0      1.+6   0.0
*
*  SG FDWTR FILL 13XXY1 CARDS
130101    -5     4    0     0     0.0     1074.125443   393.98    815.
130201    -5     4    0     0     0.0     1074.125443   393.98    815.
130301    -2     6    1     0  1000.0    -1862.8       1199.10   1000.
130401    -2     8    1     0  1000.0    -1862.8       1199.10   1000.
130102    0.1   0.0     393.98  815.        52.99  0.0   80.0     815.
130202    0.1   0.0     393.98  815.        52.99  0.0   80.0     815.
130302 1100.  -2049.   1199.1  1100.
130402 1100.  -2049.   1199.1  1100.
130103   53.0    64.45   80.0   815.  1000.0    64.45    80.0     815.
130203   53.0    64.45   80.0   815.  1000.0    64.45    80.0     815.
*
*
*  KINETICS CONSTANTS DATA
*       BOVL
140000  253.57
*
*
*  REACTIVITY COEFFICIENTS
*140XX0 DENWGHT FLTMWGT FULTEMCOEF    WATTEMCOEF
140010   0.333   1.0     -.000533     0.0012206
140020   0.334   1.0     -.000533     0.0012206
140030   0.333   1.0     -.000533     0.0012206
*
*
*  SCRAM REACTIVITY
141001 -10  3  0  0.0  0.0  0.25 -0.192  0.42 -0.4486  0.5  -0.64  2.4  -5.77
141002  2.5 -5.992 2.59 -6.152  2.67  -6.248  2.8 -6.40845  100.  -6.40845
*
*  DENSITY REACTIVITY TABLE
```

```
142001  -11   30.0  -11.828    32.0    -9.149   34.0   -6.837
142002        36.0   -4.841    38.0    -3.294   40.0   -2.096
142003        42.0   -1.115    44.0    -0.333   46.0    0.167
142004        48.0    0.566    50.0     0.982
*
*  DOPPLER TABLE DATA
143001 0
*
*  DIRECT MODERATOR HEATING DATA
*44000         QPMOD    QDMOD
144000         0.025     0.0
144001         0.025     0.0
144002         0.025     0.0
*
*  1973 ANS DECAY HEAT
146000 1
*
*
*  HEAT CONDUCTOR DATA
*        1    2    3    4      5   6        7          8          9
*15XXX1 VSL  VSR  GOM  ELEV   MCL MCR      ASUL       ASUR       AVOL
150011   0    26   1   0.0     2   2        0.0     16345.2     149.83
150021   0    27   1   0.0     2   2        0.0     18158.6     166.46
150031   0    28   1   0.0     2   2        0.0     13912.0     127.43
150041   3    51   2   4.974   2   2    13290.98    15241.953    57.065
150051   4    51   2  14.922   2   2    13290.98    15241.953    57.065
150121  40    51   2  24.870   2   2    13290.98    15241.953    57.065
150131  41    51   2  24.870   2   2    13290.98    15241.953    57.065
150061   6    51   2   4.974   2   2    13290.98    15241.953    57.065
150071   5    51   2  14.922   2   2    13290.98    15241.953    57.065
150081  13    52   2   4.974   2   2    13290.98    15241.953    57.065
150091  14    52   2  14.922   2   2    13290.98    15241.953    57.065
150141  42    52   2  24.870   2   2    13290.98    15241.953    57.065
150151  43    52   2  24.870   2   2    13290.98    15241.953    57.065
150101  16    52   2   4.974   2   2    13290.98    15241.953    57.065
150111  15    52   2  14.922   2   2    13290.98    15241.953    57.065
*
*           10        11       12          13          14       15       16
*15XXX2     DML       DMR      DHEL        DHER        CHNL     CHNR     HXQF
150012      0.0      .04492    0.0       0.04864       0.0      3.84     0
150022      0.0      .04492    0.0       0.04864       0.0      4.36     0
150032      0.0      .04492    0.0       0.04864       0.0      4.36     0
150042      0.0545   .081423   0.0545    0.08238       9.948    9.948    1
150052      0.0545   .081423   0.0545    0.08238       9.948    9.948    1
150122      0.0545   .081423   0.0545    0.08238       9.948    9.948    1
150132      0.0545   .081423   0.0545    0.08238       9.948    9.948    1
150062      0.0545   .081423   0.0545    0.08238       9.948    9.948    1
150072      0.0545   .081423   0.0545    0.08238       9.948    9.948    1
150082      0.0545   .081423   0.0545    0.08238       9.948    9.948    2
150092      0.0545   .081423   0.0545    0.08238       9.948    9.948    2
150142      0.0545   .081423   0.0545    0.08238       9.948    9.948    2
150152      0.0545   .081423   0.0545    0.08238       9.948    9.948    2
150102      0.0545   .081423   0.0545    0.08238       9.948    9.948    2
150112      0.0545   .081423   0.0545    0.08238       9.948    9.948    2
*
*
*  CORE SECTION DATA
*16XXX0  ISLB        CLTI       QFRAC
160010     1      2.1667E-3    .21141
160020     2      2.1667E-3    .51169
160030     3      2.1667E-3    .27690
*
*  CONDUCTOR GEOMETRY DATA
*17XXYY  IG   REG   MAT   SS   RADIUS   WIDTH   PF
170101    2    3     1     4     0.    .01579  1.0   * FUEL PELLET
170102    1    4     1               3.25-4   0.0   * GAP
170103    0    2     3                .00222  0.0   * CLAD
170201    2    1     3     3  .02725   .004    0.0   -11.0  * SG TUBES
*
*  THERMAL CONDUCTIVITY TABLES
180100 -20
180101                          500.   3.341    650.   2.971
180102        800.   2.677     950.   2.439   1100.   2.242
180103       1250.   2.078    1400.   1.940   1550.   1.823
180104       1700.   1.724    1850.   1.639   2000.   1.568
180105       2150.   1.507    2300.   1.457   2450.   1.415
180106       2600.   1.382    3100.   1.323   3600.   1.333
180107       4100.   1.406    4600.   1.538   5100.   1.730
*
180200  18
180201         32.   7.812     212.   7.992    392.   8.208
180202        572.   8.784     752.   9.540    932.  10.404
180203       1112.  11.268    1292.  12.492   1472.  13.176
180204       1652.  13.968    1832.  14.796   2012.  16.128
180205       2192.  17.784    2372.  19.656   2552.  21.780
180206       2732.  24.048    3092.  28.908   3360.  33.120
*
*         INCONEL 600
180300  -3  212.  10.   752.  11.   1832.  18.
180400    1     700.     0.08125
*
*
*  VOLUMETRIC HEAT CAPACITY TABLES
190100  16
190101         32.   34.45    122.   38.35    212.   40.95
190102        392.   43.55    752.   46.80   2012.   51.35
190103       2732.   52.65   3092.   56.55   3452.   63.05
190104       3812.   72.80   4352.   89.70   4532.   94.25
190105       4712.   98.15   4892.  100.10   5144.  101.40
190106       8000.  101.40
*      ZIRCALOY
190200   5
```

```
190201          0.  28.392  1480.3  34.476  1675.0  85.176
190202      1787.5  34.476  3500.0  34.476
*       INCONEL
190300  -9
190301        392.  60.935    482.  62.143    662.  64.507
190302        752.  65.557   1022.  67.764   1202.  73.489
190303       1382.  75.853   1562.  78.217   1652.  79.425
190400    1     700.     0.00593
*
*
*  THERMAL EXPANSION DATA
200100 -13
200101       440.6 3.40E-6   890.6 4.27E-6  1340.6 4.77E-6
200102      1790.6 5.19E-6  2240.6 5.71E-6  2960.6 6.02E-6
200103      3140.6 6.40E-6  3590.6 6.91E-6  4040.6 7.28E-6
200104      4490.6 7.68E-6  4940.6 8.10E-6  5390.6 1.48E-5
200105      5840.6 1.51E-5
*         ZIRCALOY
200200  19
200201        80.6     0.0   260.6 2.69E-6   440.6 2.72E-6
200202       620.6 3.22E-6   800.6 3.37E-6   980.6 3.47E-6
200203      1160.6 3.62E-6  1340.6 3.66E-6  1520.6 3.81E-6
200204      1700.6 3.94E-6  1880.6 4.04E-6  2060.6 4.17E-6
200205      2240.6 4.24E-6  2420.6 4.26E-6  2600.6 4.46E-6
200206      2780.6 4.50E-6  2960.6 4.59E-6  3140.6 4.59E-6
200207      3320.6 4.70E-6
*         INCONEL
200300   5
200301        200.  7.1E-6    600.  7.7E-6   1000.  8.1E-6
200302       1400.  8.7E-6   1600.  9.0E-6
* GAP
200400  -2
200401         0.0     0.0   2000.     0.0
*
*  PRESSURIZER HEATER
210101   0      15   34  5   300.  28.            * PROPORTIONAL HEATERS
210201   0      14   34  5  1200.  28.            * BACKUP HEATERS
*
*  STACK CARDS
*            ISHD     ....NCON....
220011       -1        4   5  12
220021       -1        6   7  13
220031       -1        8   9  14
220041       -1       10  11  15
*
*
*  STEADY STATE POWER REMOVAL DATA
230011  1   81   82   0.5
230021  2   83   84   0.5
*
*
*  STEADY STATE INITIALIZATION CONVERGENCE CRITERIA
*      LCOUNT ACEPSI HEPSI EPSIM VEPSI EPSIMG
230000   35   1.E-5  1.E-5 1.E-5
*
*
*  VOLUME INITIAL CONDITIONS
*
*       LVOL   PRES    TEMP    ENTH     X     XNC
231025   25       0.     0.    539.7    0.     0.
231034   34    2250.     0.      0.     0.     0.
231051   51     841.     0.      0.    0.03    0.
231052   52     841.     0.      0.    0.03    0.
231100  100      20.     0.    800.0    0.     0.
231200  200      20.     0.    800.0    0.     0.
231300  300      20.     0.    800.0    0.     0.
*
*
*  JUNCTION INITIAL CONDITIONS
*
*        JUN  JESTW    WP    SPLTV1    SPLTV2
232001     1    0   16944.5
232002     2    0   16944.5
232011    11    0   16944.5
232012    12    0   16944.5
232019    19    0    8472.25
232027    27    0   33889.0
232028    28    0   32639.0
232031    31    0   32639.0
232032    32    0    1250.0
232033    33    1    1250.0
*
*
* OFF-RATED POWER INITIALIZATION PROCEDURE INPUT
*
*23600Y  FULPOW  IEBAL  PPOWER  IPZR  ITVJUN  IGTPRS   IGTPZL  ITOLIM
236001    2710.     1
*
*2360XY   ISGVOL  IRRJUN  IFWJUN  ISTJUN  IGTSGP  IGTSGR  IGTFWS
236011      51
236021      52
*
*
*  NON-EQUILIBRIUM VOLUME DATA
*61XXXY  NEQVOL  SEPFG   VRAIN  IHTC  VLHTC
*610340     34      0      0.0    0     0.0
*61XXXY  NEQVOL  SEPFG   NNODEP  IHTC  CFCV/CONST CTRB  VRAIN
611340     34      0     0       1     0.0        0.0    0.0
*
*
* CONTROL INPUT DEFINITION
702001   1  PNRM,  0        1.02       1.02
```

```
   509    702002   2  WP**, 28        1.0        0.0
   510    702003   3  CONS,  0    37503.5    37503.5
   511    702004   4  TEMP, 25        1.0        0.0
   512    702005   5  TEMP, 30        1.0        0.0
   513    702006   6  PHIR,  1        1.0        0.0
   514    702007   7  PHIR,  2        1.0        0.0
   515    702008   8  PHIR,  3        1.0        0.0
   516    702009   9  CONS,  0   177156.62  177156.62
   517    702010  10  PRES, 34        1.0        0.0
   518    702011  11  CONS,  0        1.0        1.0
   519    *
   520    * CONTROL BLOCK DESCRIPTION
   521    703001  -1  DIV,  2   3   1.0     0.0   0.0   1.0
   522    703002  -2  SUM,  4   5   0.5     1.0   1.0   0.0
   523    703003  -3  SUM,  6   7   1.0     1.0   1.0   0.0
   524    703004  -4  SUM, -3   8   0.3333  1.0   1.0   0.0
   525    703005  -5  DIV, -4   9   1.02    0.0   0.0   1.02
   526    703006  -6  FNG,  10  1   1.0     0.0   0.0   0.0
   527    703011 -11  SUM,  11  11  1.04    1.0   0.0   1.04
   528    *
   529    ********************************************************************************
   530    * MAKE FJUNR = 0.0 FOR JUNCTIONS WITH POSITIVE FLOW
   531    * FJUNR = -1.0 IS ALLOWED ONLY WHEN FLOW IS NEGATIVE
   532    *
   533    *8XXX1 FROM  TO PP VV  FLOWRATE     AREA      ELEV   INERT    KFOR  KREV
   534    080011  30    1  0  0   16944.5     9.62      0.00   1.06    .193   0.0
+                                                                  *** THIS CARD IS A REPLACEMENT CARD. ***
   535    080121  30   11  0  0   16944.5     9.62      0.00   1.06    .193   0.0
+                                                                  *** THIS CARD IS A REPLACEMENT CARD. ***
   536    080101   9   10  1  0       0.0     9.82      0.0    2.00  -1.0     0.0
+                                                                  *** THIS CARD IS A REPLACEMENT CARD. ***
   537    080211  19   20  2  0       0.0     4.91      0.0    4.00  -1.0     0.0
+                                                                  *** THIS CARD IS A REPLACEMENT CARD. ***
   538    080241  22   23  3  0       0.0     4.91      0.0    4.00  -1.0     0.0
+                                                                  *** THIS CARD IS A REPLACEMENT CARD. ***
   539    080111  10   24  0  0   16944.5     9.82      0.0    1.08    .686   0.0
+                                                                  *** THIS CARD IS A REPLACEMENT CARD. ***
   540    080251  23   24  0  0       0.0     4.91      0.0    1.79    .61    0.0
+                                                                  *** THIS CARD IS A REPLACEMENT CARD. ***
   541    080261  20   24  0  0       0.0     4.91      0.0    1.79    .61    0.0
+                                                                  *** THIS CARD IS A REPLACEMENT CARD. ***
   542    080271  24  25   0  0   33889.0    29.      -23.2     .6628 2.07    0.0
+                                                                  *** THIS CARD IS A REPLACEMENT CARD. ***
   543    080281  25  26   0  0   32639.0    53.5     -17.4     .1498  .753   0.0
+                                                                  *** THIS CARD IS A REPLACEMENT CARD. ***
   544    080291  26  27   0  0       0.0    53.5     -13.04    .0815 1.81    0.0
+                                                                  *** THIS CARD IS A REPLACEMENT CARD. ***
   545    080301  27  28   0  0       0.0    53.5      -8.68    .0815 1.73    0.0
+                                                                  *** THIS CARD IS A REPLACEMENT CARD. ***
   546    080311  28  30   0  0   32639.0    53.5      -4.32    .6484 4.585   0.0
+                                                                  *** THIS CARD IS A REPLACEMENT CARD. ***
   547    080321  25  29   0  0    1250.0    12.77     -17.4     .5121  257.   0.0
+                                                                  *** THIS CARD IS A REPLACEMENT CARD. ***
   548    080331  29  30   0  0    1250.0    12.77      -4.32    .5121 -1.0    0.0
+                                                                  *** THIS CARD IS A REPLACEMENT CARD. ***
   549    *
   550    . END TERMINATOR
```

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page    1
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:40
 ATWS  (LOSS OF FEEDWATER) - RETRAN-3D SAMPLE PROBLEM                                                           CPU TIME =    0.016
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

RETRAN PROBLEM CONTROL AND DESCRIPTION DATA.

    WORD  DESCRIPTION
    ====  ===================================================================
      1   RESTART FILE OPTION (SAVE=-1 / NO SAVE=0) .................... =    0
      2   PRINTER PLOT OPTION (YES=1 / NO=0) ........................... =    0
      3   POWER OPTION (TAPE OPTNS<0 / NO/TBL=0 / PT KIN=1 / 1D=2 / 3D=3) =    1
      4   USE STEADY-STATE SOLUTION (YES=0 / NO=1) ..................... =    0
      5   USE NEUTRON VOID MODEL (YES=1 / NO=0) ........................ =    0
      6   USE GENERALIZED TRANSPORT MODEL (NO=0 / VAP=1 / LIQ=-1) ....... =    0
      7   HEAT TRANSFER MAP OPTION (FORCED=0 / NAT CONV=1) ............. =    0
      8   SLIP OPTION (DYN=1 / Z-L=2 / C-L=3 / Z-L TAUGL=4 / C-L TAUGL=5) =    0
      9   FIVE-EQUATION OPTION (NO= 0 / YES=1) ......................... =    0
     10   NONCONDENSABLE GAS FLOW OPTION (NO=0 / YES=1) ................ =    0
     11   TH MATRIX DIRECT SOLVER OPTION (4-EQ=2 / 6-EQ=3) ............. =    2
     12   TH MATRIX ITERATIVE SOLVER OPTION (NO<=1 / YES=2) ............ =    0

    (DIMENSIONS AND OPTIONS AUTOMATICALLY DETERMINED BY CONTENT OF INPUT DATA)

          NUMBER OF MINOR EDIT SETS (0200XX DATA )...................... =   19
          NUMBER OF TIME-STEP CONTROL SETS (03XXX0 DATA )............... =    6
          NUMBER OF TRIP CONTROL SETS (04XXX0 DATA ).................... =   27
          NUMBER OF CONTROL VOLUME DESCRIPTIONS (05XXXY DATA ).......... =   43
          NUMBER OF BUBBLE RISE DESCRIPTIONS (060XXY DATA) ............. =    3
          NUMBER OF TIME DEPENDENT VOLUMES FORM CARDS (07XXYY DATA) ..... =    0
          NUMBER OF JUNCTION DESCRIPTIONS (08XXXY DATA) ................ =   52
          NUMBER OF CENTRIFUGAL PUMP DESCRIPTIONS (090XXY DATA )......... =    3
          NUMBER OF VALVE DESCRIPTIONS (11XXXY DATA) ................... =    9
          NUMBER OF GENERAL DATA TABLE DESCRIPTIONS (12XXYY DATA) ....... =    6
          NUMBER OF FILL DESCRIPTIONS (13XXYY DATA )..................... =    4
          NUMBER OF HEAT CONDUCTOR DESCRIPTIONS (15XXXY DATA) ........... =   15
          NUMBER OF HEAT CONDUCTOR GEOMETRY DESCRIPTIONS (17XXYY DATA) .. =    2
          NUMBER OF HEAT CONDUCTOR MATERIAL DESCRIPTIONS (18XXYY DATA) .. =    4
          NUMBER OF CORE SECTION DESCRIPTIONS (16XXXY DATA) ............ =    3
          NUMBER OF NON-CONDUCTNG HEAT EXCHNGR DESCRIPTIONS (21XXYY DATA) =    2
          NUMBER OF TIME DEP BCS FROM TAPE (IREAD<0 ON 05XXXY DATA) ..... =    0
          NUMBER OF SPECIFIED HEAT TRAN COEF DESCRIPTIONS (015XXX DATA) . =    0
          TWO-REGION NONEQ VOL DESCRIPTIONS (610XXX OR 611XXX DATA) ..... =    1
          TEMP. TRANSPORT DELAY OPTION (MESH>0 ON 05XXXY DATA) .......... =    0
          AUXILIARY DNB MODEL (8001XX DATA INCLUDED) .................... =    0
          CONTROL SYSTEM MODEL (702XXX OR 702XXXX DATA) ................ =    1
          ACCUMULATOR MODEL DESCRIPTIONS (620XXX OR 621XXX DATA)......... =    0
          DYNAMIC GAP CONDUCTANCE MODEL DESCRIPTIONS (225XX0 DATA) ...... =    0
          NUMBER OF HT CONDUCTOR STACK DESCRIPTIONS (2200XY DATA) ....... =    4
          NUMBER OF TURBINE SHAFT DESCRIPTIONS (500XXY DATA) ........... =    0
          NUMBER OF PROFILE FIT DESCRIPTIONS (061XX1 DATA) ............. =    0
          NUMBER OF STEAM-WATER SEPARATOR DESCRIPTIONS (60XXX0 DATA) .... =    0


                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * *                                                 * * *
                   * * *          STEADY-STATE OPTION    =   0           * * *
                   * * *                                                 * * *
                   * * *          SLIP OPTION            =   0           * * *
                   * * *                                                 * * *
                   * * *          NUMERICS OPTION        =   2           * * *
                   * * *                                                 * * *
                   * * *          HEAT TRANSFER OPTION   =   0           * * *
                   * * *                                                 * * *
                   * * *          NEW EQUATIONS OPTION   =   0           * * *
                   * * *                                                 * * *
                   * * *         USING THE 4-EQ SOLVER - SOLVE3          * * *
                   * * *                                                 * * *
                   * * *     USING STANDARD STEADY-STATE SOLUTION        * * *
                   * * *                                                 * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *


INITIAL THERMAL POWER (MEGAWATTS) =  2.71000E+03


AIR IS THE DEFAULT NONCONDENSABLE GAS.
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PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE -- NRC APPROVED VERSION 29/08/14 Page 45
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis 11:57:40
ATWS (LOSS OF FEEDWATER) - RETRAN-3D SAMPLE PROBLEM CPU TIME = 0.047
* *

NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	ENERGY BALANCE (BTU)	TOTAL MASS BALANCE (LBM)	NCG MASS BALANCE (LBM)	AVERAGE TIME STEP (SEC)	CURRENT TIME STEP (SEC)	ELAPSED TIME (SEC)	TIME STEP NUM STANDRD/ACTUL
1.00000E+00	2.71000E+03	9.28305E+09	2.22486E+09	3.14410E+06	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0 0

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	VOID FRAC.	POWR TO H2O (BTU/SEC)
1	2.25796E+03	6.04394E+03	6.15513E+02	4.29837E+01	6.01037E+02	0.00000E+00	0.00000E+00	0.00000E+00
2	2.25526E+03	1.09172E+04	6.15513E+02	4.29813E+01	6.01030E+02	0.00000E+00	0.00000E+00	0.00000E+00
3	2.25108E+03	1.01621E+04	5.93706E+02	4.43578E+01	5.85522E+02	0.00000E+00	0.00000E+00	-3.69510E+05
4	2.24352E+03	8.01294E+03	5.84234E+02	4.49239E+01	5.78547E+02	0.00000E+00	0.00000E+00	-3.20983E+05
5	2.23271E+03	8.40647E+03	5.44796E+02	4.71302E+01	5.48183E+02	0.00000E+00	0.00000E+00	-1.18078E+05
6	2.23218E+03	1.08618E+04	5.39423E+02	4.74117E+01	5.43886E+02	0.00000E+00	0.00000E+00	-9.10518E+04
7	2.23105E+03	1.12554E+04	5.39423E+02	4.74110E+01	5.43884E+02	0.00000E+00	0.00000E+00	0.00000E+00
8	2.22523E+03	1.06193E+04	5.39423E+02	4.74076E+01	5.43874E+02	0.00000E+00	0.00000E+00	0.00000E+00
9	2.26177E+03	1.05260E+04	5.39700E+02	4.74145E+01	5.44161E+02	0.00000E+00	0.00000E+00	4.69660E+03
10	2.28360E+03	7.79704E+03	5.39700E+02	4.74272E+01	5.44199E+02	0.00000E+00	0.00000E+00	0.00000E+00
11	2.25796E+03	6.04394E+03	6.15513E+02	4.29837E+01	6.01037E+02	0.00000E+00	0.00000E+00	0.00000E+00
12	2.25526E+03	1.09172E+04	6.15513E+02	4.29813E+01	6.01030E+02	0.00000E+00	0.00000E+00	0.00000E+00
13	2.25108E+03	1.01621E+04	5.93706E+02	4.43578E+01	5.85522E+02	0.00000E+00	0.00000E+00	-3.69510E+05
14	2.24352E+03	8.01294E+03	5.84234E+02	4.49239E+01	5.78547E+02	0.00000E+00	0.00000E+00	-3.20983E+05
15	2.23271E+03	8.40647E+03	5.44796E+02	4.71302E+01	5.48183E+02	0.00000E+00	0.00000E+00	-1.18078E+05
16	2.23218E+03	1.08618E+04	5.39423E+02	4.74117E+01	5.43886E+02	0.00000E+00	0.00000E+00	-9.10518E+04
17	2.23257E+03	1.12556E+04	5.39423E+02	4.74119E+01	5.43887E+02	0.00000E+00	0.00000E+00	0.00000E+00
18	2.22526E+03	5.30965E+03	5.39423E+02	4.74076E+01	5.43874E+02	0.00000E+00	0.00000E+00	0.00000E+00
19	2.26180E+03	5.31043E+03	5.39700E+02	4.74145E+01	5.44161E+02	0.00000E+00	0.00000E+00	2.34830E+03
20	2.28303E+03	3.90323E+03	5.39700E+02	4.74269E+01	5.44198E+02	0.00000E+00	0.00000E+00	0.00000E+00
21	2.22526E+03	5.30965E+03	5.39423E+02	4.74076E+01	5.43874E+02	0.00000E+00	0.00000E+00	0.00000E+00
22	2.26180E+03	5.31043E+03	5.39700E+02	4.74145E+01	5.44161E+02	0.00000E+00	0.00000E+00	2.34830E+03
23	2.28303E+03	3.89375E+03	5.39700E+02	4.74269E+01	5.44198E+02	0.00000E+00	0.00000E+00	0.00000E+00
24	2.28722E+03	4.70926E+04	5.39700E+02	4.74294E+01	5.44206E+02	0.00000E+00	0.00000E+00	0.00000E+00
25	2.28611E+03	4.12345E+04	5.39700E+02	4.74287E+01	5.44204E+02	0.00000E+00	0.00000E+00	0.00000E+00
26	2.28175E+03	1.09625E+04	5.48021E+02	4.69888E+01	5.50835E+02	0.00000E+00	0.00000E+00	5.43161E+05
27	2.27758E+03	1.05929E+04	5.76481E+02	4.54046E+01	5.72831E+02	0.00000E+00	0.00000E+00	1.31465E+06
28	2.27339E+03	1.01517E+04	6.07518E+02	4.35134E+01	5.95483E+02	0.00000E+00	0.00000E+00	7.11420E+05
29	2.27675E+03	7.91968E+03	5.39700E+02	4.74232E+01	5.44187E+02	0.00000E+00	0.00000E+00	0.00000E+00
30	2.26715E+03	5.20248E+04	6.15513E+02	4.29922E+01	6.01062E+02	0.00000E+00	0.00000E+00	0.00000E+00
31	2.26453E+03	3.00498E+04	6.15513E+02	4.29898E+01	6.01055E+02	0.00000E+00	0.00000E+00	0.00000E+00
32	2.25580E+03	1.37542E+03	6.15513E+02	4.29818E+01	6.01032E+02	0.00000E+00	0.00000E+00	0.00000E+00
33	2.27502E+03	5.10263E+02	5.39700E+02	4.74222E+01	5.44184E+02	0.00000E+00	0.00000E+00	0.00000E+00
34 LIQ REG	2.25000E+03	2.84320E+04	7.01238E+02	3.66404E+01	6.54077E+02	0.00000E+00	4.82685E-01	0.00000E+00
VAP REG		4.53199E+03	1.11784E+03	6.25941E+00	6.54077E+02	1.00000E+00		0.00000E+00
40	2.23682E+03	7.90667E+03	5.62450E+02	4.61744E+01	5.62037E+02	0.00000E+00	0.00000E+00	-2.08640E+05
41	2.23300E+03	7.95684E+03	5.57107E+02	4.64674E+01	5.57883E+02	0.00000E+00	0.00000E+00	-1.81050E+05
42	2.23682E+03	7.90667E+03	5.62450E+02	4.61744E+01	5.62037E+02	0.00000E+00	0.00000E+00	-2.08640E+05
43	2.23300E+03	7.95684E+03	5.57107E+02	4.64674E+01	5.57883E+02	0.00000E+00	0.00000E+00	-1.81050E+05
51	8.62569E+02	1.49908E+05	5.63987E+02	1.86869E+01	5.26506E+02	6.42004E-02	6.32696E-01	1.28931E+06
52	8.62569E+02	1.49908E+05	5.63987E+02	1.86869E+01	5.26506E+02	6.42004E-02	6.32696E-01	1.28931E+06
100	2.00000E+01	7.92795E+05	8.00000E+02	7.92795E-02	2.27954E+02	6.28874E-01	9.99504E-01	0.00000E+00
200	2.00000E+01	7.92795E+05	8.00000E+02	7.92795E-02	2.27954E+02	6.28874E-01	9.99504E-01	0.00000E+00
300	2.00000E+01	7.92795E+05	8.00000E+02	7.92795E-02	2.27954E+02	6.28874E-01	9.99504E-01	0.00000E+00

JUNCTION NUMBER	CONNECTS VOLUMES	CHOK/ PATH	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E D I F F E R E N T I A L S VEL. PSI	ELEV. PSI	FRIC. PSI	ACCL. PSI	PUMP PSI
1	30 TO 1		1.69445E+04	6.15513E+02	2.32601E-02	-7.78943E+00	1.98559E-01	-1.60008E+00	-2.20601E-13	0.00000E+00
2	1 TO 2		1.69445E+04	6.15513E+02	2.32646E-02	4.39195E+00	-7.20395E-01	-6.37062E+00	2.39364E-13	0.00000E+00
3	2 TO 3		1.69445E+04	6.15513E+02	2.32660E-02	1.56247E+00	-2.76584E+00	-2.97499E+00	4.37116E-08	0.00000E+00
4	3 TO 4		1.69445E+04	5.93706E+02	2.25440E-02	1.03940E-01	-3.35902E+00	-4.30548E+00	3.62698E-08	0.00000E+00
5	40 TO 41		1.69445E+04	5.62450E+02	2.16570E-02	4.88849E-02	4.55714E-04	-3.86635E+00	-4.52401E-08	0.00000E+00
6	5 TO 6		1.69445E+04	5.44796E+02	2.12178E-02	2.39743E-02	3.55965E+00	-4.12084E+00	-5.68142E-09	0.00000E+00
7	6 TO 7		1.69445E+04	5.39423E+02	2.10919E-02	-1.31139E+00	3.02808E+00	-2.84029E+00	8.19754E-09	0.00000E+00
8	7 TO 8		1.69445E+04	5.39423E+02	2.10921E-02	-3.74101E+00	1.87990E+00	-3.95975E+00	5.34397E-11	0.00000E+00
9	8 TO 9		1.69445E+04	5.39423E+02	2.10937E-02	6.77732E+00	-9.10368E-01	-1.01005E+00	-1.42969E-10	3.16852E+01
10	9 TO 10		1.69445E+04	5.39700E+02	2.10906E-02	-6.77500E+00	-1.10305E-01	-2.97591E+00	3.00132E-11	3.16852E+01
11	10 TO 24		1.69445E+04	5.39700E+02	2.10849E-02	5.74120E+00	2.75024E+00	-4.86910E+00	-5.56049E-11	0.00000E+00
12	30 TO 11		1.69445E+04	6.15513E+02	2.32601E-02	-7.78943E+00	1.98559E-01	-1.60008E+00	-2.20601E-13	0.00000E+00
13	11 TO 12		1.69445E+04	6.15513E+02	2.32646E-02	4.39195E+00	-7.20395E-01	-6.37062E+00	2.39364E-13	0.00000E+00
14	12 TO 13		1.69445E+04	6.15513E+02	2.32660E-02	1.56247E+00	-2.76584E+00	-2.97499E+00	4.37119E-08	0.00000E+00
15	13 TO 14		1.69445E+04	5.93706E+02	2.25440E-02	1.03940E-01	-3.35902E+00	-4.30548E+00	3.62698E-08	0.00000E+00
16	42 TO 43		1.69445E+04	5.62450E+02	2.16570E-02	4.88849E-02	4.55714E-04	-3.86635E+00	-4.52407E-08	0.00000E+00
17	15 TO 16		1.69445E+04	5.44796E+02	2.12178E-02	2.39743E-02	3.55965E+00	-4.12084E+00	-5.68125E-09	0.00000E+00
18	16 TO 17		1.69445E+04	5.39423E+02	2.10919E-02	2.07058E-01	3.02810E+00	-2.84029E+00	8.18477E-09	0.00000E+00
19	17 TO 18		8.47225E+03	5.39423E+02	2.10918E-02	-5.25940E+00	1.87992E+00	-3.93387E+00	6.62326E-11	0.00000E+00
20	18 TO 19		8.47225E+03	5.39423E+02	2.10937E-02	6.77719E+00	-9.10368E-01	-1.01005E+00	-1.42543E-10	3.16852E+01
21	19 TO 20		8.47225E+03	5.39700E+02	2.10906E-02	-6.77504E+00	-1.10305E-01	-3.57221E+00	2.99894E-11	3.16852E+01
22	17 TO 21		8.47225E+03	5.39423E+02	2.10918E-02	-5.25940E+00	1.87992E+00	-3.93387E+00	6.62326E-11	0.00000E+00
23	21 TO 22		8.47225E+03	5.39423E+02	2.10937E-02	6.77719E+00	-9.10368E-01	-1.01005E+00	-1.42543E-10	3.16852E+01
24	22 TO 23		8.47225E+03	5.39700E+02	2.10906E-02	-6.77504E+00	-1.10305E-01	-3.57256E+00	2.95667E-11	3.16852E+01
25	23 TO 24		8.47225E+03	5.39700E+02	2.10851E-02	5.74121E+00	2.75024E+00	-4.29829E+00	-5.56075E-11	0.00000E+00
26	20 TO 24		8.47225E+03	5.39700E+02	2.10851E-02	5.74121E+00	2.75024E+00	-4.29865E+00	-5.60330E-11	0.00000E+00
27	24 TO 25		3.38890E+04	5.39700E+02	2.10840E-02	1.03574E+00	4.56179E+00	-6.71168E+00	4.88498E-14	0.00000E+00
28	25 TO 26		3.26390E+04	5.39700E+02	2.10843E-02	-8.63054E-01	-2.29232E+00	-1.20418E+00	-5.63993E-14	0.00000E+00
29	26 TO 27		3.26390E+04	5.56341E+02	2.14867E-02	-6.18620E-02	-1.39873E+00	-2.71002E+00	2.18936E-13	0.00000E+00
30	27 TO 28		3.26390E+04	5.96620E+02	2.26244E-02	-7.52588E-02	-1.34612E+00	-2.76313E+00	-3.47944E-13	0.00000E+00
31	28 TO 30		3.26390E+04	6.18417E+02	2.33603E-02	9.08753E-01	-2.24110E+00	-4.91196E+00	2.63789E-13	0.00000E+00
32	25 TO 29		1.25000E+03	5.39700E+02	2.10843E-02	-2.18047E-02	-3.73476E+00	-5.60347E+00	-5.77316E-14	0.00000E+00
33	29 TO 30		1.25000E+03	5.39700E+02	2.10867E-02	2.18022E-02	-3.73616E+00	-5.88458E+00	1.35891E-13	0.00000E+00
34	31 TO 30		0.00000E+00	6.15513E+02	2.32614E-02	0.00000E+00	2.61530E+00	0.00000E+00	4.35207E-14	0.00000E+00
35	32 TO 1		0.00000E+00	6.15513E+02	2.32657E-02	0.00000E+00	2.15209E+00	0.00000E+00	-4.52971E-14	0.00000E+00
36	34 TO 32		0.00000E+00	6.15513E+02	2.32657E-02	0.00000E+00	5.80450E+00	0.00000E+00	-4.97380E-14	0.00000E+00
37	10 TO 33		0.00000E+00	5.39700E+02	2.10849E-02	0.00000E+00	-8.57721E+00	0.00000E+00	1.77636E-15	0.00000E+00
38	33 TO 34		0.00000E+00	5.39700E+02	2.10872E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
50	4 TO 40		1.69445E+04	5.74763E+02	2.19878E-02	7.21265E-02	-3.14669E+00	-3.62673E+00	-2.42200E-08	0.00000E+00
51	41 TO 5		1.69445E+04	5.51765E+02	2.13867E-02	3.57158E-02	3.23302E+00	-3.55518E+00	-3.62071E-08	0.00000E+00
52	14 TO 42		1.69445E+04	5.74763E+02	2.19878E-02	7.21265E-02	-3.14669E+00	-3.62673E+00	-2.42200E-08	0.00000E+00
53	43 TO 15		1.69445E+04	5.51765E+02	2.13867E-02	3.57158E-02	3.23302E+00	-3.55518E+00	-3.62067E-08	0.00000E+00
82	51 TO 200		1.54889E+03	1.19758E+03	5.27375E-01	1.65584E-02	-1.91294E+00	-8.40672E+02	4.57412E-14	0.00000E+00

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84	52 TO 300	1.54889E+03	1.19758E+03	5.27375E-01	1.65584E-02	-1.91294E+00	-8.40672E+02	4.50751E-14	0.00000E+00
89	100 TO 34	0.00000E+00	1.11784E+03	1.59759E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
90	100 TO 34	0.00000E+00	1.11784E+03	1.59759E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
88	0 TO 52	0.00000E+00	1.19758E+03	5.27375E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
87	0 TO 52	0.00000E+00	1.19758E+03	5.27375E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
86	0 TO 51	0.00000E+00	1.19758E+03	5.27375E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
85	0 TO 51	0.00000E+00	1.19758E+03	5.27375E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
83	0 TO 52	1.54889E+03	3.65170E+02	1.88216E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
81	0 TO 51	1.54889E+03	3.65170E+02	1.88216E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

BUBL SET NUMB.	VOL. NUMB.	BUBBLE GRADIENT PARAMETER	BUBBLE VELOCITY (FT/SEC)	MIXTURE LEVEL (FT)	MIXTURE QUALITY	BUBBLE MASS (LB)
1	34	1.00000E+00	0.00000E+00	1.70300E+01	0.00000E+00	0.00000E+00
2	51	1.00000E+00	1.47380E+01	7.20300E+01	2.62721E-02	3.78499E+03
3	52	1.00000E+00	1.47380E+01	7.20300E+01	2.62721E-02	3.78499E+03

PUMP NUMB.	VOL. NUMB.	PUMP SPEED (RPM)	NORM. PUMP TORQUE	NORM. FRIC. TORQUE	NORM. MOT. TORQUE	POWER TO H2O (BTU/HR)
1	9	7.46135E+02	7.21593E-01	1.00000E+00	1.00000E+00	1.69078E+07
2	19	7.46135E+02	7.21593E-01	1.00000E+00	1.00000E+00	8.45388E+06
3	22	7.46135E+02	7.21593E-01	1.00000E+00	1.00000E+00	8.45388E+06

HEAT COND. NUMBER	VOL. NUM.	HT TRAN MODE-COR	SURF. FLUX (BTU/HR-FT2)	CRIT. FLUX (BTU/HR-FT2)	H.T. COEF. (BTU/H-F2-F)	SURF. TEMP. (DEG. F)	MASS FLUX (LBM/HR-FT2)	STORD ENRGY (BTU)	POWR TO H20 (BTU/HR)	DRYOUT PNT ()
1 RGHT	26	1-DB-L	1.16860E+05	8.91854E+05	5.24259E+03	5.73126E+02	2.19627E+06	7.56156E+06	1.90992E+09	
2 RGHT	27	1-DB-L	2.54587E+05	8.92857E+05	5.34197E+03	6.20489E+02	2.19627E+06	1.36636E+07	4.62270E+09	
3 RGHT	28	1-DB-L	1.79966E+05	8.93865E+05	5.45573E+03	6.28470E+02	2.19627E+06	8.60951E+06	2.50157E+09	
4 LEFT	3	1-DB-L	-1.00086E+05	9.29169E+05	6.89425E+03	5.71005E+02	3.12501E+06		-1.33023E+09	
RGHT	51	2-THOM	8.72752E+04	3.41533E+05	8.13620E+03	5.37232E+02	3.25036E+05	1.99210E+06	1.33023E+09	
5 LEFT	4	1-DB-L	-8.69422E+04	9.30015E+05	6.85062E+03	5.65856E+02	3.12501E+06		-1.15554E+09	
RGHT	51	2-THOM	7.58136E+04	3.41533E+05	7.58315E+03	5.36503E+02	3.25036E+05	1.98067E+06	1.15554E+09	
12 LEFT	40	1-DB-L	-5.65126E+04	9.30768E+05	6.75288E+03	5.53669E+02	3.12501E+06		-7.51103E+08	
RGHT	51	2-THOM	4.92790E+04	3.41533E+05	6.11374E+03	5.34566E+02	3.25036E+05	1.95323E+06	7.51103E+08	
6 LEFT	6	1-DB-L	-2.46625E+04	9.31289E+05	6.65180E+03	5.40179E+02	3.12501E+06		-3.27787E+08	
RGHT	51	2-THOM	2.15057E+04	3.41533E+05	4.03881E+03	5.31830E+02	3.25036E+05	1.92174E+06	3.27787E+08	
7 LEFT	5	1-DB-L	-3.19829E+04	9.31229E+05	6.67530E+03	5.43392E+02	3.12501E+06		-4.25081E+08	
RGHT	51	2-THOM	2.78891E+04	3.41533E+05	4.59932E+03	5.32569E+02	3.25036E+05	1.92941E+06	4.25081E+08	
13 LEFT	41	1-DB-L	-4.90396E+04	9.31197E+05	6.72937E+03	5.50596E+02	3.12501E+06		-6.51779E+08	
RGHT	51	2-THOM	4.27625E+04	3.41533E+05	5.69518E+03	5.34014E+02	3.25036E+05	1.94619E+06	6.51779E+08	
8 LEFT	13	1-DB-L	-1.00086E+05	9.29169E+05	6.89425E+03	5.71005E+02	3.12501E+06		-1.33023E+09	
RGHT	52	2-THOM	8.72752E+04	3.41533E+05	8.13620E+03	5.37232E+02	3.25036E+05	1.99210E+06	1.33023E+09	
9 LEFT	14	1-DB-L	-8.69422E+04	9.30015E+05	6.85062E+03	5.65856E+02	3.12501E+06		-1.15554E+09	
RGHT	52	2-THOM	7.58136E+04	3.41533E+05	7.58315E+03	5.36503E+02	3.25036E+05	1.98067E+06	1.15554E+09	
14 LEFT	42	1-DB-L	-5.65126E+04	9.30768E+05	6.75288E+03	5.53669E+02	3.12501E+06		-7.51103E+08	
RGHT	52	2-THOM	4.92790E+04	3.41533E+05	6.11374E+03	5.34566E+02	3.25036E+05	1.95323E+06	7.51103E+08	
10 LEFT	16	1-DB-L	-2.46625E+04	9.31289E+05	6.65180E+03	5.40179E+02	3.12501E+06		-3.27787E+08	
RGHT	52	2-THOM	2.15057E+04	3.41533E+05	4.03881E+03	5.31830E+02	3.25036E+05	1.92174E+06	3.27787E+08	
11 LEFT	15	1-DB-L	-3.19829E+04	9.31229E+05	6.67530E+03	5.43392E+02	3.12501E+06		-4.25081E+08	
RGHT	52	2-THOM	2.78891E+04	3.41533E+05	4.59932E+03	5.32569E+02	3.25036E+05	1.92941E+06	4.25081E+08	
15 LEFT	43	1-DB-L	-4.90396E+04	9.31197E+05	6.72937E+03	5.50596E+02	3.12501E+06		-6.51779E+08	
RGHT	52	2-THOM	4.27625E+04	3.41533E+05	5.69518E+03	5.34014E+02	3.25036E+05	1.94619E+06	6.51779E+08	

CORE NUMB.	COND. NUMB.	DEPTH REAC. EXT. ZR-H2O (FT)	DEPTH REAC. INT. ZR-H2O (FT)	HEAT GEN. ZR-H2O (BTU/HR)	COND. HEAT-ING RATE (BTU/HR)	DIR. MODER-ATOR HT RT (BTU/HR)	AVG. METAL TEMPERATURE (DEG. F)	CENTERLINE TEMPERATURE (DEG. F)	FUEL ENTHALPY (CAL/GM)
1	1	0.00000E+00	0.00000E+00	0.00000E+00	1.90992E+09	4.54631E+07	1.28084E+03	1.56021E+03	0.00000E+00
2	2	0.00000E+00	0.00000E+00	0.00000E+00	4.62270E+09	1.10037E+08	2.03357E+03	2.83641E+03	0.00000E+00
3	3	0.00000E+00	0.00000E+00	0.00000E+00	2.50157E+09	5.95465E+07	1.68684E+03	2.19927E+03	0.00000E+00

REACTOR PERIOD (SEC)	FISSION POWER	DECAY HEAT POWER	TOTAL REACTIVITY ($)	CONTROL REACTIVITY ($)	COOL. TEMP. REACTIVITY ($)	VOID REACTIVITY ($)	FUEL TEMP. REACTIVITY ($)	DOPPLER REACTIVITY ($)
0.00000E+00	9.30010E-01	6.99900E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

HEAT EXCGR. NUMBER	VOLUME NUMBER	POWR TO H2O (BTU/HR)
1	34	0.00000E+00
2	34	0.00000E+00

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE -- NRC APPROVED VERSION 29/08/14 Page 59
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis 11:57:51
ATWS (LOSS OF FEEDWATER) - RETRAN-3D SAMPLE PROBLEM CPU TIME = 9.126
* *

NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	ENERGY BALANCE (BTU)	TOTAL MASS BALANCE (LBM)	NCG MASS BALANCE (LBM)	AVERAGE TIME STEP (SEC)	CURRENT TIME STEP (SEC)	ELAPSED TIME (SEC)	TIME STEP NUM STANDRD/ACTUL
									12408
7.18185E-02	1.94628E+02	6.91097E+08	2.48662E+09	3.16214E+06	0.00000E+00	1.00000E-02	1.00000E-02	1.50000E+02	12450

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	VOID FRAC.	POWR TO H2O (BTU/SEC)
1	2.36227E+03	5.20616E+03	6.98655E+02	3.70255E+01	6.53018E+02	0.00000E+00	0.00000E+00	0.00000E+00
2	2.36029E+03	9.40475E+03	6.98605E+02	3.70266E+01	6.52985E+02	0.00000E+00	0.00000E+00	0.00000E+00
3	2.35685E+03	8.50476E+03	6.97342E+02	3.71233E+01	6.52286E+02	0.00000E+00	0.00000E+00	-1.63722E+04
4	2.35077E+03	6.62903E+03	6.96710E+02	3.71651E+01	6.51921E+02	0.00000E+00	0.00000E+00	-1.63722E+04
5	2.34214E+03	6.68950E+03	6.92323E+02	3.75041E+01	6.49472E+02	0.00000E+00	0.00000E+00	-1.61926E+04
6	2.34171E+03	8.61523E+03	6.91043E+02	3.76055E+01	6.48757E+02	0.00000E+00	0.00000E+00	-1.61926E+04
7	2.34077E+03	8.92891E+03	6.90954E+02	3.76112E+01	6.48704E+02	0.00000E+00	0.00000E+00	0.00000E+00
8	2.33603E+03	8.42483E+03	6.90872E+02	3.76108E+01	6.48644E+02	0.00000E+00	0.00000E+00	0.00000E+00
9	2.36494E+03	8.35557E+03	6.91066E+02	3.76377E+01	6.48841E+02	0.00000E+00	0.00000E+00	3.72624E+03
10	2.38195E+03	6.19249E+03	6.91007E+02	3.76672E+01	6.48860E+02	0.00000E+00	0.00000E+00	0.00000E+00
11	2.36221E+03	5.20615E+03	6.98655E+02	3.70254E+01	6.53018E+02	0.00000E+00	0.00000E+00	0.00000E+00
12	2.36012E+03	9.40469E+03	6.98604E+02	3.70263E+01	6.52984E+02	0.00000E+00	0.00000E+00	0.00000E+00
13	2.35668E+03	8.50478E+03	6.97338E+02	3.71234E+01	6.52283E+02	0.00000E+00	0.00000E+00	-1.63770E+04
14	2.35062E+03	6.62906E+03	6.96704E+02	3.71653E+01	6.51918E+02	0.00000E+00	0.00000E+00	-1.63770E+04
15	2.34202E+03	6.68975E+03	6.92303E+02	3.75055E+01	6.49461E+02	0.00000E+00	0.00000E+00	-1.62002E+04
16	2.34160E+03	8.61566E+03	6.91018E+02	3.76074E+01	6.48743E+02	0.00000E+00	0.00000E+00	-1.62002E+04
17	2.34190E+03	8.92986E+03	6.90924E+02	3.76153E+01	6.48691E+02	0.00000E+00	0.00000E+00	0.00000E+00
18	2.33598E+03	4.21272E+03	6.90837E+02	3.76135E+01	6.48624E+02	0.00000E+00	0.00000E+00	0.00000E+00
19	2.36491E+03	4.21578E+03	6.91025E+02	3.76409E+01	6.48818E+02	0.00000E+00	0.00000E+00	1.86356E+03
20	2.38149E+03	3.10025E+03	6.90961E+02	3.76702E+01	6.48833E+02	0.00000E+00	0.00000E+00	0.00000E+00
21	2.33598E+03	4.21272E+03	6.90837E+02	3.76135E+01	6.48624E+02	0.00000E+00	0.00000E+00	0.00000E+00
22	2.36491E+03	4.21578E+03	6.91025E+02	3.76409E+01	6.48818E+02	0.00000E+00	0.00000E+00	1.86356E+03
23	2.38149E+03	3.09272E+03	6.90961E+02	3.76701E+01	6.48833E+02	0.00000E+00	0.00000E+00	0.00000E+00
24	2.38484E+03	3.74228E+04	6.90767E+02	3.76904E+01	6.48734E+02	0.00000E+00	0.00000E+00	0.00000E+00
25	2.38389E+03	3.27829E+04	6.90533E+02	3.77075E+01	6.48600E+02	0.00000E+00	0.00000E+00	0.00000E+00
26	2.38041E+03	8.77968E+03	6.91415E+02	3.76326E+01	6.49083E+02	0.00000E+00	0.00000E+00	4.79888E+04
27	2.37711E+03	8.72074E+03	6.94526E+02	3.73799E+01	6.50800E+02	0.00000E+00	0.00000E+00	1.17600E+05
28	2.37386E+03	8.65507E+03	6.97971E+02	3.70985E+01	6.52681E+02	0.00000E+00	0.00000E+00	6.39207E+04
29	2.37660E+03	6.33266E+03	6.87706E+02	3.79201E+01	6.46987E+02	0.00000E+00	0.00000E+00	0.00000E+00
30	2.36897E+03	4.48148E+04	6.98678E+02	3.70339E+01	6.53051E+02	0.00000E+00	0.00000E+00	0.00000E+00
31	2.36658E+03	3.00647E+04	6.16621E+02	4.30110E+01	6.02102E+02	0.00000E+00	0.00000E+00	0.00000E+00
32	2.36032E+03	1.18663E+03	6.97916E+02	3.70823E+01	6.52610E+02	0.00000E+00	0.00000E+00	0.00000E+00
33	2.36600E+03	4.07031E+02	6.88680E+02	3.78281E+01	6.47505E+02	0.00000E+00	0.00000E+00	0.00000E+00
34 LIQ REG	2.35420E+03	5.80748E+04	6.77060E+02	3.87165E+01	6.40788E+02	0.00000E+00	0.00000E+00	0.00000E+00
VAP REG		0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00		0.00000E+00
40	2.34539E+03	6.38840E+03	6.94835E+02	3.73078E+01	6.50874E+02	0.00000E+00	0.00000E+00	-1.63018E+04
41	2.34236E+03	6.39632E+03	6.94202E+02	3.73541E+01	6.50516E+02	0.00000E+00	0.00000E+00	-1.62765E+04
42	2.34524E+03	6.38851E+03	6.94824E+02	3.73085E+01	6.50868E+02	0.00000E+00	0.00000E+00	-1.63067E+04
43	2.34222E+03	6.39647E+03	6.94189E+02	3.73549E+01	6.50508E+02	0.00000E+00	0.00000E+00	-1.62821E+04
51	5.95088E+02	1.01216E+04	1.21078E+03	1.26171E+00	4.92488E+02	1.00000E+00	1.00000E+00	9.76887E+04
52	5.95456E+02	1.01289E+04	1.21074E+03	1.26262E+00	4.92516E+02	1.00000E+00	1.00000E+00	9.76962E+04
100	2.11375E+01	8.41907E+05	7.96784E+02	8.41907E-02	2.30924E+02	6.23662E-01	9.99466E-01	0.00000E+00
200	2.69121E+01	9.41601E+05	8.76543E+02	9.41601E-02	2.44242E+02	6.99285E-01	9.99519E-01	0.00000E+00
300	2.69117E+01	9.41593E+05	8.76538E+02	9.41593E-02	2.44241E+02	6.99280E-01	9.99519E-01	0.00000E+00

JUNCTION NUMBER	CONNECTS VOLUMES	CHOK/ PATH	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E VEL. PSI	ELEV. PSI	D I F F E R E N T I A L S FRIC. PSI	ACCL. PSI	PUMP PSI
1	30 TO 1		1.36833E+04	6.98678E+02	2.70021E-02	-5.66767E+00	1.71044E-01	-1.21161E+00	-6.48165E-03	0.00000E+00
2	1 TO 2		1.35514E+04	6.98655E+02	2.70083E-02	3.37275E+00	-6.20579E-01	-4.73095E+00	-3.83991E-03	0.00000E+00
3	2 TO 3		1.35558E+04	6.98605E+02	2.70075E-02	1.11860E+00	-2.33830E+00	-2.22292E+00	-2.92175E-03	0.00000E+00
4	3 TO 4		1.35599E+04	6.97342E+02	2.69371E-02	5.56189E-03	-2.79627E+00	-3.29269E+00	-2.40591E-03	0.00000E+00
5	40 TO 41		1.35667E+04	6.94835E+02	2.68039E-02	5.64801E-03	7.20082E-05	-3.03845E+00	-2.60027E-03	0.00000E+00
6	5 TO 6		1.35740E+04	6.92322E+02	2.66636E-02	5.69568E-03	2.82763E+00	-3.27197E+00	-2.78679E-03	0.00000E+00
7	6 TO 7		1.35789E+04	6.91043E+02	2.65917E-02	-1.06879E+00	2.40194E+00	-2.26806E+00	-3.50470E-03	0.00000E+00
8	7 TO 8		1.35840E+04	6.90953E+02	2.65876E-02	-3.03573E+00	1.49139E+00	-3.20570E+00	-6.49096E-03	0.00000E+00
9	8 TO 9		1.35888E+04	6.90871E+02	2.65879E-02	5.49063E+00	-7.22480E-01	-8.16850E-01	-9.21756E-03	2.49486E+01
10	9 TO 10		1.35934E+04	6.91065E+02	2.65690E-02	-5.45150E+00	-8.75604E-02	-2.41134E+00	-7.28928E-03	2.49486E+01
11	10 TO 24		1.35456E+04	6.91006E+02	2.65482E-02	4.61653E+00	2.18553E+00	-3.91576E+00	-4.10710E-03	0.00000E+00
12	30 TO 11		1.35154E+04	6.98678E+02	2.70021E-02	-5.75510E+00	1.71044E-01	-1.18215E+00	-6.75119E-04	0.00000E+00
13	11 TO 12		1.35177E+04	6.98655E+02	2.70083E-02	3.24141E+00	-6.20576E-01	-4.70741E+00	-8.82605E-04	0.00000E+00
14	12 TO 13		1.35220E+04	6.98604E+02	2.70077E-02	1.11305E+00	-2.33830E+00	-2.21265E+00	-7.17585E-04	0.00000E+00
15	13 TO 14		1.35262E+04	6.97338E+02	2.69371E-02	5.56683E-03	-2.79628E+00	-3.27767E+00	-6.56262E-04	0.00000E+00
16	42 TO 43		1.35329E+04	6.94823E+02	2.68034E-02	5.64781E-03	7.22695E-05	-3.02441E+00	-7.97602E-04	0.00000E+00
17	15 TO 16		1.35401E+04	6.92302E+02	2.66626E-02	5.68724E-03	2.82776E+00	-3.25694E+00	-9.41583E-04	0.00000E+00
18	16 TO 17		1.35451E+04	6.91017E+02	2.65904E-02	1.60607E-01	2.40211E+00	-2.25745E+00	-1.21990E-03	0.00000E+00
19	17 TO 18		6.77514E+03	6.90923E+02	2.65848E-02	-4.24438E+00	1.49152E+00	-3.16891E+00	-1.74307E-03	0.00000E+00
20	18 TO 19		6.77758E+03	6.90836E+02	2.65860E-02	5.46272E+00	-7.22538E-01	-8.12793E-01	-3.67584E-03	2.50019E+01
21	19 TO 20		6.78001E+03	6.91024E+02	2.65667E-02	-5.46546E+00	-8.75679E-02	-2.88033E+00	-2.34773E-03	2.50019E+01
22	17 TO 21		6.77515E+03	6.90923E+02	2.65848E-02	-4.24438E+00	1.49152E+00	-3.16891E+00	-1.74316E-03	0.00000E+00
23	21 TO 22		6.77758E+03	6.90836E+02	2.65860E-02	5.46272E+00	-7.22538E-01	-8.12793E-01	-3.67599E-03	2.50019E+01
24	22 TO 23		6.78001E+03	6.91024E+02	2.65667E-02	-5.46546E+00	-8.75679E-02	-2.88061E+00	-2.34786E-03	2.50019E+01
25	23 TO 24		6.78179E+03	6.90961E+02	2.65461E-02	4.63016E+00	2.18553E+00	-3.46586E+00	-1.12469E-03	0.00000E+00
26	20 TO 24		6.78179E+03	6.90960E+02	2.65461E-02	4.63016E+00	2.18553E+00	-3.46614E+00	-1.12461E-03	0.00000E+00
27	24 TO 25		2.71321E+04	6.90766E+02	2.65318E-02	8.34111E-01	3.62499E+00	-5.41089E+00	-3.63326E-03	0.00000E+00
28	25 TO 26		2.61787E+04	6.90533E+02	2.65197E-02	-6.88237E-01	-1.82665E+00	-9.66505E-01	-9.34210E-04	0.00000E+00
29	26 TO 27		2.61845E+04	6.92307E+02	2.66227E-02	-9.88784E-03	-1.13561E+00	-2.14982E+00	-5.21391E-04	0.00000E+00
30	27 TO 28		2.61890E+04	6.96762E+02	2.68811E-02	-1.08659E-02	-1.12752E+00	-2.11394E+00	-5.21987E-04	0.00000E+00
31	28 TO 30		2.61921E+04	6.99193E+02	2.70271E-02	6.95161E-01	-1.92469E+00	-3.66315E+00	-4.16041E-03	0.00000E+00
32	25 TO 29		9.75930E+02	6.90532E+02	2.65197E-02	-1.68766E-02	-2.97915E+00	-4.29605E+00	1.52655E-04	0.00000E+00
33	29 TO 30		9.83399E+02	6.87702E+02	2.63709E-02	1.67149E-02	-3.08529E+00	-4.55469E+00	8.39903E-05	0.00000E+00
34	31 TO 30		4.40772E+00	6.16622E+02	2.32499E-02	-7.09406E-11	2.39652E+00	-3.54788E-04	2.51008E-04	0.00000E+00
35	32 TO 1		-1.34171E+02	6.98655E+02	2.70083E-02	0.00000E+00	1.85614E+00	1.67364E-01	1.43736E-01	0.00000E+00
36	34 TO 32		-1.35003E+02	6.97916E+02	2.69669E-02	6.36263E-05	5.82000E+00	3.76297E-01	1.57403E-01	0.00000E+00
37	10 TO 33		5.12782E+01	6.91006E+02	2.65482E-02	0.00000E+00	-6.84058E+00	-8.96466E+00	7.24297E-02	0.00000E+00
38	33 TO 34		5.17155E+01	6.88678E+02	2.64351E-02	-1.23708E-05	-7.79821E-01	-1.08364E+01	9.99332E-02	0.00000E+00
50	4 TO 40		1.35633E+04	6.96089E+02	2.68707E-02	5.54571E-03	-2.57243E+00	-2.82083E+00	-2.48851E-03	0.00000E+00
51	41 TO 5		1.35702E+04	6.93579E+02	2.67350E-02	5.82302E-03	2.58574E+00	-2.81200E+00	-2.69234E-03	0.00000E+00
52	14 TO 42		1.35295E+04	6.96081E+02	2.68704E-02	5.54810E-03	-2.57246E+00	-2.80794E+00	-7.11905E-04	0.00000E+00
53	43 TO 15		1.35364E+04	6.93564E+02	2.67343E-02	5.81926E-03	2.58582E+00	-2.79909E+00	-8.69102E-04	0.00000E+00
82	51 TO 200		0.00000E+00	1.21078E+03	7.92645E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

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84	52 TO	300	0.00000E+00	1.21074E+03	7.92076E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
89	100 TO	34 XHN	-2.29775E+02	6.77061E+02	2.58286E-02	2.75568E-05	-4.42555E+00	-1.39406E-06	2.95363E-02	0.00000E+00
90	100 TO	34	0.00000E+00	6.77061E+02	2.58286E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
88	0 TO	52	0.00000E+00	1.21074E+03	7.92076E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
87	0 TO	52	0.00000E+00	1.21074E+03	7.92076E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
86	0 TO	51	0.00000E+00	1.21078E+03	7.92645E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
85	0 TO	51	0.00000E+00	1.21078E+03	7.92645E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
83	0 TO	52	9.29369E+01	5.11900E+01	1.60403E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
81	0 TO	51	9.29369E+01	5.11900E+01	1.60403E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

BUBL SET NUMB.	VOL. NUMB.	BUBBLE GRADIENT PARAMETER	BUBBLE VELOCITY (FT/SEC)	MIXTURE LEVEL (FT)	MIXTURE QUALITY	BUBBLE MASS (LB)
1	34	1.00000E+00	0.00000E+00	3.29200E+01	0.00000E+00	0.00000E+00
2	51	1.00000E+00	1.47380E+01	0.00000E+00	1.00000E+00	0.00000E+00
3	52	1.00000E+00	1.47380E+01	0.00000E+00	1.00000E+00	0.00000E+00

PUMP NUMB.	VOL. NUMB.	PUMP SPEED (RPM)	NORM. PUMP TORQUE	NORM. FRIC. TORQUE	NORM. MOT. TORQUE	POWER TO H2O (BTU/HR)
1	9	7.46135E+02	5.72505E-01	1.00000E+00	0.00000E+00	1.34145E+07
2	19	7.46135E+02	5.72640E-01	1.00000E+00	0.00000E+00	6.70881E+06
3	22	7.46135E+02	5.72640E-01	1.00000E+00	0.00000E+00	6.70881E+06

HEAT COND. NUMBER	VOL. NUM.	HT TRAN MODE-COR	SURF. FLUX (BTU/HR-FT2)	CRIT. FLUX (BTU/HR-FT2)	H.T. COEF. (BTU/H-F2-F)	SURF. TEMP. (DEG. F)	MASS FLUX (LBM/HR-FT2)	STORD ENRGY (BTU)	POWR TO H20 (BTU/HR)	DRYOUT PNT ()
1 RGHT	26	1-DB-L	1.04928E+04	8.13998E+05	4.91835E+03	6.51216E+02	1.76177E+06	4.39727E+06	1.71491E+08	
2 RGHT	27	1-DB-L	2.31420E+04	8.15025E+05	4.93705E+03	6.55488E+02	1.76212E+06	5.42306E+06	4.20203E+08	
3 RGHT	28	1-DB-L	1.64275E+04	8.16027E+05	4.95824E+03	6.55994E+02	1.76237E+06	3.95288E+06	2.28345E+08	
4 LEFT	3	1-DB-L	-4.44155E+03	8.61329E+05	6.30526E+03	6.51582E+02	2.50045E+06		-5.89401E+07	
RGHT	51	8-DB-V	3.88436E+03	1.00280E+05	2.46432E+01	6.50106E+02	9.75147E+03	2.39024E+06	5.90691E+07	
5 LEFT	4	1-DB-L	-4.43463E+03	8.62518E+05	6.30161E+03	6.51218E+02	2.50115E+06		-5.89401E+07	
RGHT	51	8-DB-V	3.87546E+03	1.00280E+05	2.46432E+01	6.49744E+02	9.75147E+03	2.38873E+06	5.90691E+07	
12 LEFT	40	1-DB-L	-4.41553E+03	8.63572E+05	6.28847E+03	6.50172E+02	2.50177E+06		-5.86863E+07	
RGHT	51	8-DB-V	3.84989E+03	1.00280E+05	2.46432E+01	6.48707E+02	9.75147E+03	2.38440E+06	5.86794E+07	
6 LEFT	6	1-DB-L	-4.36782E+03	8.64455E+05	6.26468E+03	6.48060E+02	2.50388E+06		-5.82932E+07	
RGHT	51	8-DB-V	3.79826E+03	1.00280E+05	2.46432E+01	6.46612E+02	9.75147E+03	2.37565E+06	5.81579E+07	
7 LEFT	5	1-DB-L	-4.38596E+03	8.64298E+05	6.27238E+03	6.48773E+02	2.50308E+06		-5.82932E+07	
RGHT	51	8-DB-V	3.81568E+03	1.00280E+05	2.46432E+01	6.47318E+02	9.75147E+03	2.37860E+06	5.81579E+07	
13 LEFT	41	1-DB-L	-4.40869E+03	8.64194E+05	6.28492E+03	6.49814E+02	2.50241E+06		-5.85954E+07	
RGHT	51	8-DB-V	3.84113E+03	1.00280E+05	2.46432E+01	6.48351E+02	9.75147E+03	2.38291E+06	5.85458E+07	
8 LEFT	13	1-DB-L	-4.44282E+03	8.60750E+05	6.29261E+03	6.51577E+02	2.49420E+06		-5.89571E+07	
RGHT	52	8-DB-V	3.88479E+03	1.00282E+05	2.46509E+01	6.50101E+02	9.75147E+03	2.39022E+06	5.90752E+07	
9 LEFT	14	1-DB-L	-4.43591E+03	8.61941E+05	6.28895E+03	6.51212E+02	2.49489E+06		-5.89571E+07	
RGHT	52	8-DB-V	3.87586E+03	1.00282E+05	2.46509E+01	6.49739E+02	9.75147E+03	2.38871E+06	5.90752E+07	
14 LEFT	42	1-DB-L	-4.41688E+03	8.62997E+05	6.27579E+03	6.50164E+02	2.49551E+06		-5.87042E+07	
RGHT	52	8-DB-V	3.85020E+03	1.00282E+05	2.46509E+01	6.48698E+02	9.75147E+03	2.38436E+06	5.86842E+07	
10 LEFT	16	1-DB-L	-4.37090E+03	8.63877E+05	6.25196E+03	6.48043E+02	2.49762E+06		-5.83206E+07	
RGHT	52	8-DB-V	3.79835E+03	1.00282E+05	2.46509E+01	6.46594E+02	9.75147E+03	2.37558E+06	5.81607E+07	
11 LEFT	15	1-DB-L	-4.38802E+03	8.63721E+05	6.25967E+03	6.48760E+02	2.49682E+06		-5.83206E+07	
RGHT	52	8-DB-V	3.81586E+03	1.00282E+05	2.46509E+01	6.47305E+02	9.75147E+03	2.37855E+06	5.81607E+07	
15 LEFT	43	1-DB-L	-4.41021E+03	8.63618E+05	6.27223E+03	6.49805E+02	2.49615E+06		-5.86156E+07	
RGHT	52	8-DB-V	3.84141E+03	1.00282E+05	2.46509E+01	6.48342E+02	9.75147E+03	2.38287E+06	5.85502E+07	

CORE NUMB.	COND. NUMB.	DEPTH REAC. EXT. ZR-H2O (FT)	DEPTH REAC. INT. ZR-H2O (FT)	HEAT GEN. ZR-H2O (BTU/HR)	COND. HEAT-ING RATE (BTU/HR)	DIR. MODER-ATOR HT RT (BTU/HR)	AVG. METAL TEMPERATURE (DEG. F)	CENTERLINE TEMPERATURE (DEG. F)	FUEL ENTHALPY (CAL/GM)
1	1	0.00000E+00	0.00000E+00	0.00000E+00	1.39163E+08	1.26888E+06	7.17403E+02	7.35618E+02	0.00000E+00
2	2	0.00000E+00	0.00000E+00	0.00000E+00	3.36741E+08	3.15698E+06	8.01314E+02	8.44311E+02	0.00000E+00
3	3	0.00000E+00	0.00000E+00	0.00000E+00	1.82166E+08	1.76922E+06	7.59500E+02	7.89009E+02	0.00000E+00

REACTOR PERIOD (SEC)	FISSION POWER	DECAY HEAT POWER	TOTAL REACTIVITY ($)	CONTROL REACTIVITY ($)	COOL. TEMP. REACTIVITY ($)	VOID REACTIVITY ($)	FUEL TEMP. REACTIVITY ($)	DOPPLER REACTIVITY ($)
-3.18545E+01	3.24099E-02	3.94085E-02	-1.99778E+00	0.00000E+00	2.84905E-01	-3.73402E+00	1.45133E+00	0.00000E+00

HEAT EXCGR. NUMBER	VOLUME NUMBER	POWR TO H2O (BTU/HR)
1	34	0.00000E+00
2	34	0.00000E+00

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LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:51
 ATWS  (LOSS OF FEEDWATER) - RETRAN-3D SAMPLE PROBLEM                                                           CPU TIME =     9.126
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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SYSTEM ELAPSED TIME (SEC)	SYSTEM ELAPSED TIME (SEC)	TIME STP ACTUAL	VOL 34 AVG. PRESS. (PSIA)	BUBL 34 MIX. LEVEL (FEET)	VOL 51 POWR TO H2O (BTU/HR)	BUBL 51 MIX. LEVEL (FEET)	VOL 51 AVG. PRESS. (PSIA)	VOL 51 LIQUID MASS (LB)
1.07500E+02	1.07500E+02	8.19900E+03	3.41808E+03	3.29200E+01	3.20006E+08	0.00000E+00	3.75286E+02	0.00000E+00
1.10000E+02	1.10000E+02	8.44900E+03	3.48622E+03	3.29200E+01	3.40251E+08	0.00000E+00	3.84998E+02	0.00000E+00
1.12500E+02	1.12500E+02	8.69900E+03	3.50704E+03	3.29200E+01	3.51393E+08	0.00000E+00	3.96901E+02	0.00000E+00
1.15000E+02	1.15000E+02	8.94900E+03	3.49627E+03	3.29200E+01	3.56716E+08	0.00000E+00	4.09932E+02	0.00000E+00
1.17500E+02	1.17500E+02	9.19900E+03	3.46039E+03	3.29200E+01	3.59033E+08	0.00000E+00	4.23477E+02	0.00000E+00
1.20000E+02	1.20000E+02	9.44900E+03	3.40317E+03	3.29200E+01	3.59972E+08	0.00000E+00	4.37238E+02	0.00000E+00
1.22500E+02	1.22500E+02	9.69900E+03	3.32951E+03	3.29200E+01	3.60122E+08	0.00000E+00	4.51072E+02	0.00000E+00
1.25000E+02	1.25000E+02	9.94900E+03	3.24467E+03	3.29200E+01	3.59590E+08	0.00000E+00	4.64875E+02	0.00000E+00
1.27500E+02	1.27500E+02	1.01990E+04	3.16377E+03	3.29200E+01	3.55979E+08	0.00000E+00	4.78419E+02	0.00000E+00
1.30000E+02	1.30000E+02	1.04490E+04	3.06930E+03	3.29200E+01	3.56101E+08	0.00000E+00	4.91667E+02	0.00000E+00
1.32500E+02	1.32500E+02	1.06990E+04	2.96481E+03	3.29200E+01	3.56070E+08	0.00000E+00	5.04937E+02	0.00000E+00
1.35000E+02	1.35000E+02	1.09490E+04	2.84757E+03	3.29200E+01	3.55313E+08	0.00000E+00	5.18142E+02	0.00000E+00
1.37500E+02	1.37500E+02	1.11990E+04	2.72690E+03	3.29200E+01	3.54472E+08	0.00000E+00	5.31230E+02	0.00000E+00
1.40000E+02	1.40000E+02	1.14490E+04	2.60695E+03	3.29200E+01	3.53622E+08	0.00000E+00	5.44198E+02	0.00000E+00
1.42500E+02	1.42500E+02	1.16990E+04	2.48900E+03	3.29200E+01	3.52756E+08	0.00000E+00	5.57045E+02	0.00000E+00
1.45000E+02	1.45000E+02	1.19500E+04	2.39813E+03	3.29200E+01	3.51936E+08	0.00000E+00	5.69768E+02	0.00000E+00
1.47500E+02	1.47500E+02	1.22000E+04	2.38145E+03	3.29200E+01	3.51892E+08	0.00000E+00	5.82437E+02	0.00000E+00
1.50000E+02	1.50000E+02	1.24500E+04	2.35420E+03	3.29200E+01	3.51679E+08	0.00000E+00	5.95088E+02	0.00000E+00

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LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:51
 ATWS  (LOSS OF FEEDWATER) - RETRAN-3D SAMPLE PROBLEM                                                          CPU TIME =    9.126
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *
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SYSTEM ELAPSED TIME (SEC)	VOL 25 AVG. TEMP. (DEG F)	VOL 30 AVG. TEMP. (DEG F)	CBLK 1 OUTPUT	CBLK -2 OUTPUT	CBLK -1 OUTPUT	JUN 82 FLOW (LB/SEC)	JUN 89 FLOW (LB/SEC)	JUN 90 FLOW (LB/SEC)
1.07500E+02	6.25095E+02	6.45169E+02	3.18782E-01	6.35132E+02	7.84929E-01	0.00000E+00	-3.67878E+02	-6.91806E+02
1.10000E+02	6.30033E+02	6.48618E+02	2.87185E-01	6.39326E+02	7.79496E-01	0.00000E+00	-3.76514E+02	-7.08045E+02
1.12500E+02	6.34068E+02	6.50876E+02	2.59682E-01	6.42472E+02	7.73545E-01	0.00000E+00	-3.79029E+02	-7.12775E+02
1.15000E+02	6.37748E+02	6.52569E+02	2.32869E-01	6.45159E+02	7.66628E-01	0.00000E+00	-3.77447E+02	-7.09799E+02
1.17500E+02	6.40971E+02	6.54011E+02	2.06946E-01	6.47491E+02	7.59709E-01	0.00000E+00	-3.72610E+02	-7.00703E+02
1.20000E+02	6.43417E+02	6.55105E+02	1.84768E-01	6.49261E+02	7.53545E-01	0.00000E+00	-3.64992E+02	-6.86378E+02
1.22500E+02	6.45129E+02	6.55700E+02	1.66189E-01	6.50415E+02	7.47944E-01	0.00000E+00	-3.54511E+02	-6.66669E+02
1.25000E+02	6.46366E+02	6.55849E+02	1.50170E-01	6.51107E+02	7.42460E-01	0.00000E+00	-3.42464E+02	-6.44013E+02
1.27500E+02	6.47415E+02	6.53966E+02	1.36716E-01	6.50691E+02	7.37215E-01	0.00000E+00	-3.29959E+02	-6.20496E+02
1.30000E+02	6.46522E+02	6.54452E+02	1.28786E-01	6.50487E+02	7.31522E-01	0.00000E+00	-3.14409E+02	-5.91255E+02
1.32500E+02	6.47308E+02	6.54398E+02	1.17681E-01	6.50853E+02	7.26728E-01	0.00000E+00	-3.11735E+02	-5.86226E+02
1.35000E+02	6.47747E+02	6.54305E+02	1.07995E-01	6.51026E+02	7.22417E-01	0.00000E+00	-3.13976E+02	-5.90440E+02
1.37500E+02	6.48023E+02	6.54068E+02	9.94371E-02	6.51046E+02	7.17636E-01	0.00000E+00	-2.98292E+02	-5.60946E+02
1.40000E+02	6.48128E+02	6.53768E+02	9.19899E-02	6.50948E+02	7.13242E-01	0.00000E+00	-2.82158E+02	-5.30607E+02
1.42500E+02	6.48091E+02	6.53381E+02	8.56146E-02	6.50736E+02	7.09129E-01	0.00000E+00	-2.65918E+02	-5.00066E+02
1.45000E+02	6.48093E+02	6.53057E+02	8.02671E-02	6.50575E+02	6.99310E-01	0.00000E+00	-2.45940E+02	0.00000E+00
1.47500E+02	6.48425E+02	6.53105E+02	7.65284E-02	6.50765E+02	6.99972E-01	0.00000E+00	-2.39497E+02	0.00000E+00
1.50000E+02	6.48600E+02	6.53051E+02	7.32548E-02	6.50826E+02	6.98033E-01	0.00000E+00	-2.29775E+02	0.00000E+00

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 LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis             11:57:51
  ATWS  (LOSS OF FEEDWATER) - RETRAN-3D SAMPLE PROBLEM                                                            CPU TIME =    9.126
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SYSTEM ELAPSED TIME (SEC)	NEQV 34 LIQ REG MASS (LB)	NEQV 34 LIQ REG TEMP (DEG F)	NEQV 34 VAP REG TEMP (DEG F)
1.07500E+02	6.02797E+04	6.45410E+02	0.00000E+00
1.10000E+02	6.03856E+04	6.45867E+02	0.00000E+00
1.12500E+02	6.04085E+04	6.46062E+02	0.00000E+00
1.15000E+02	6.03758E+04	6.46088E+02	0.00000E+00
1.17500E+02	6.02991E+04	6.45975E+02	0.00000E+00
1.20000E+02	6.01843E+04	6.45738E+02	0.00000E+00
1.22500E+02	6.00391E+04	6.45399E+02	0.00000E+00
1.25000E+02	5.98720E+04	6.44983E+02	0.00000E+00
1.27500E+02	5.97041E+04	6.42793E+02	0.00000E+00
1.30000E+02	5.95143E+04	6.42611E+02	0.00000E+00
1.32500E+02	5.93072E+04	6.42377E+02	0.00000E+00
1.35000E+02	5.90774E+04	6.42079E+02	0.00000E+00
1.37500E+02	5.88390E+04	6.41760E+02	0.00000E+00
1.40000E+02	5.86009E+04	6.41428E+02	0.00000E+00
1.42500E+02	5.83656E+04	6.41088E+02	0.00000E+00
1.45000E+02	5.81788E+04	6.40842E+02	0.00000E+00
1.47500E+02	5.81339E+04	6.40849E+02	0.00000E+00
1.50000E+02	5.80748E+04	6.40788E+02	0.00000E+00

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11.0 THREE-COMPONENT FLOW TEST PROBLEM

The three-component model is a vertical pipe consisting of 3 volumes plus 1 time dependent volume. Three fills are used (air, water, and vapor) to provide the inlet conditions. Figure VII.11-1 shows the noding diagram representing the RETRAN model for the three component flow test.

The analysis is performed to show the use of the five-equation solution method and the propagation of the air through the volumes. The steady-state initialization feature is used to define the initial flow conditions and system pressure defined by the time-dependent volume. The inlet boundary flows are

- Liquid Water - 6.4 lb/sec at 290 Btu/lbm,
- Water Vapor - 0.00064 lb/sec at 1200 Btu/lbm, and
- Air - 0.0064 lb/sec at 200 Btu/lbm.

and the time-dependent volume pressure is 78 psi. The Chexal-Lellouche drift flux model is used to define the slip velocity in the internal pipe junctions.

A 10-second null transient is run with 1.0-second time steps, which is an order of magnitude (13 times) larger than the mixture Courant limit of 0.077 seconds. Between 10 and 15 seconds, the air flow is ramped linearly from 0.0064 lb/sec after which it remains constant. The flows and pressures are at a new steady-state condition in the 20.0-second major edit.

The input listing for the straight pipe with air and the output from the RETRAN program module at time 0.0 seconds and 20.0 seconds along with the minor edits are given.

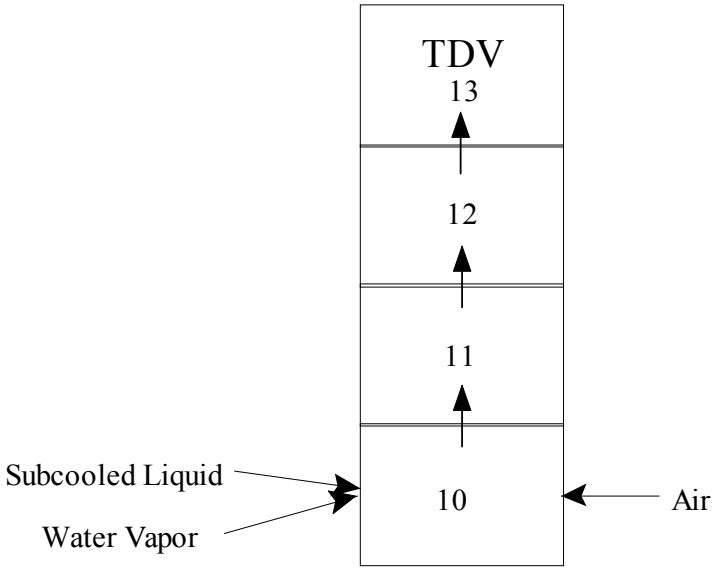


Figure VII.11-1. Noding Diagram for Three-Component Flow Test

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```
LISTING OF INPUT DATA FOR CASE  1

    1    = STRAIGHT PIPE WITH AIR - SS WITH AIR FLOW RAMP - RETRAN-3D SAMPLE PROBLEM
    2    *------------------------------------------------------------------------*
    3    *                     ------------------------------
    4    *                     :            HEM             :
    5    *                     : STEADY STATE INITILIZATION :
    6    *                     : STANDARD SOLUTION TECHNIQUE:
    7    *                     ------------------------------
    8    *      TAPE PRNPLT  POW    SS  NVOID GENTRN HTMAP SLIP  5EQ  NCOND  NSOL  PNMTH
    9    010001   0     0     0     0     0     0     1     3     1     1     3     0
   10    *
   11    020000 TIMX  0  NTTS  0
   12    020001 AVEX 10  AVEX 11  AVEX 12  XNC* 10  XNC* 11 XNC* 12 PRES 10 WP** 13
   13    *
   14    *
   15    * FORMAT FOR TAPE60
   16    *
   17    025000 1
   18    025001 '(5(1X,1P,E15.7))'
   19    *
   20    *   TIME STEP CONTROL - new
   21    *       TRTG  TMIN   TRST TMAJ   TDMP   NCHK   DLTM      TLAST
   22    030010  0.5   0.1    1.0  5.0     5.0    0      1.0      10.0
   23    030020  0.5   0.1    1.0  5.0     5.0    0      0.1      20.0
   24    030030  0.1   0.1    1.0  5.0     5.0    0      0.1     200.0
   25    *
   26    030011  0.   50.
   27    *
   28    *
   29    *   TRIP CONTROL
   30    *      IDTRP   IDSIG   IX1   IX2   SETPT   DELAY
   31    040010   1       1      0     0    20.0     0.0  " PROBLEM END TIME"
   32    040020   2       1      0     0     0.0     0.0  " FILL & POWR TRIP"
   33    *
   34    *        VOLUME DATA
   35    *      IBUB IREAD   P       HW    X     V       ZVOL      FLOWL
   36    050101  0     0     0.0    0.0  0.0   0.0668  1.0       1.0    *
   37    050111  0     0     0.0    0.0  0.0   0.0668  1.0       1.0    *
   38    050121  0     0     0.0    0.0  0.0   0.0668  1.0       1.0    *
   39    050131  0     1     0.0    0.0  0.0   0.0668  1.0       1.0    *
   40    *
   41    *       FLOWA    D1AMV    ELEV   EOVRD MESH HTGL/IMAP
   42    050102  0.0668   0.2917   0.0     0.0
   43    050112  0.0668   0.2917   1.0     0.0
   44    050122  0.0668   0.2917   2.0     0.0
   45    050132  0.0668   0.2917   3.0     0.0    0   1  * no 5-eqns in TDV
   46    *
   47    * TDV DATA CARD
   48    070100  2
   49    070101  0.0  78.0  134.  1.0   1.0  0.
   50    070102 10.0  78.0  134.  1.0   1.0  0.
   51    *
   52    *      IW1 IW2 IP IV    WP       AJUN     ZJUN   INERTA FJF   FJR
   53    080011  0   10  1  0   0.0       .0668     0.5     5.1    0.    0.    *
   54    081011  0   10  2  0   0.0       .0668     0.5     5.1    0.    0.    *
   55    081021  0   10  3  0   0.0       .0668     0.5     5.1    0.    0.    *
   56    080111 10   11  0  0   0.0       .0668     1.0     5.1    0.    0.    *
   57    080121 11   12  0  0   0.0       .0668     2.0     5.1    0.    0.    *
   58    080131 12   13  0  0   0.0       .0668     3.0     5.1    0.    0.    *
   59    *     JVERT JCHOK JCALI MVMIX  DIAMJ CON IFRJ JTPMJ ANGLE IHQCOR
   60    080012  0     -1    0     0    0.0  1.0  -99   0    0.    0
   61    081012  0     -1    0     0    0.0  1.0  -99   0    0.    0
   62    081022  0     -1    0     0    0.0  1.0  -99   0    0.    0
   63    080112  0     -1    0     0    0.0  1.0    0   0    0.    0
   64    080122  0     -1    0     0    0.0  1.0    0   0    0.    0
   65    080132  0     -1    0     0    0.0  1.0    0   0    0.    0
   66    *
   67    **  FILL TABLE FOR JUNCTION # 1  (AIR)
   68    **     NFILL  ITFILL    JX      JY
   69    *
   70    130100   4       2       0      -11     * 3
   71    *       TIME     FLOW     ENTH     PRESS
   72    130101    0.0  .0064       200.00   58.9
   73    130102    10.  .0064       200.00   58.9
   74    130103    15.  .1000       200.00   58.9
   75    130104 1000.0  .1000       200.00   58.9
   76    *
   77    **  FILL TABLE FOR JUNCTION # 101 (water)
   78    **     NFILL  ITFILL    JX      JY
   79    130200      1    2       0      -01
   80    130201    0.0   6.4      290.       58.9
   81    *
   82    **  FILL TABLE FOR JUNCTION # 102 (vapor)
   83    **     NFILL  ITFILL    JX      JY
   84    130300   1       2       0     -01
   85    130301    0.0   .00064  1200.       58.9
   86    *
   87    *           acel  h    M   Vsl  Mv
   88    230000  50  0.0  0.0  0.0  0.0  1.E-6
   89    *
   90    702001   1  WGJ* 102 1.0  0.0
   91    702002   2  XPNC 102 1.0  0.0
   92    702003   3  WGJ* 11 1.0  0.0
   93    702004   4  XPNC 11 1.0  0.0
   94    702005   5  MDOT 10 1.0  0.0
   95    702006   6  CONS  0 1.0  1.0
   96    *
   97    703001  -1  SUM  6  2  1.0  1.0 -1.0  0.0
   98    703002  -2  MUL  1 -1  1.0  0.0  0.0  0.0
   99    703003  -3  SUM  6  4  1.0  1.0 -1.0  0.0
  100    703004  -4  MUL  3 -3 -1.0  1.0 -1.0  0.0
```


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```
101    703005  -5  SUM -2 -4  1.0  1.0  1.0  0.0
102    703006  -6  SUM -5  5  1.0  1.0  1.0  0.0
103    *
104    702010  10  TEML  10  1.0  0.0
105    702011  11  SATT  10  1.0  0.0
106    702012  12  VAPH  10  1.0  0.0
107    702013  13  STHF  10  1.0  0.0
108    *
109    703010 -10  SUM  10  11  1.0  1.0  -1.0  0.0
110    703011 -11  SUM  12  13  1.0  1.0  -1.0  0.0
111    703012 -12  DIV -10 -11  1.0  0.0   0.0  0.0
112    *
113    702020  20  PRES 10  1.0  0.0
114    702021  21  PNC* 10  1.0  0.0
115    702022  22  PRES 11  1.0  0.0
116    702023  23  PNC* 11  1.0  0.0
117    702024  24  PRES 12  1.0  0.0
118    702025  25  PNC* 12  1.0  0.0
119    *
120    703020 -20  SUM  20  21  1.0  1.0  -1.0  0.0
121    703021 -21  SUM  22  23  1.0  1.0  -1.0  0.0
122    703022 -22  SUM  24  25  1.0  1.0  -1.0  0.0
123    . END
```


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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page    1
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis           11:57:53
  STRAIGHT PIPE WITH AIR - SS WITH AIR FLOW RAMP - RETRAN-3D SAMPLE PROBLEM                                    CPU TIME =    0.000
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

RETRAN PROBLEM CONTROL AND DESCRIPTION DATA.

    WORD  DESCRIPTION
    ====  ========================================================================
      1   RESTART FILE OPTION (SAVE=-1 / NO SAVE=0) ..................... =    0
      2   PRINTER PLOT OPTION (YES=1 / NO=0) ............................ =    0
      3   POWER OPTION (TAPE OPTNS<0 / NO/TBL=0 / PT KIN=1 / 1D=2 / 3D=3) =    0
      4   USE STEADY-STATE SOLUTION (YES=0 / NO=1) ...................... =    0
      5   USE NEUTRON VOID MODEL (YES=1 / NO=0) ......................... =    0
      6   USE GENERALIZED TRANSPORT MODEL (NO=0 / VAP=1 / LIQ=-1) ....... =    0
      7   HEAT TRANSFER MAP OPTION (FORCED=0 / NAT CONV=1) .............. =    1
      8   SLIP OPTION (DYN=1 / Z-L=2 / C-L=3 / Z-L TAUGL=4 / C-L TAUGL=5) =    3
      9   FIVE-EQUATION OPTION (NO= 0 / YES=1) .......................... =    1
     10   NONCONDENSABLE GAS FLOW OPTION (NO=0 / YES=1) ................. =    1
     11   TH MATRIX DIRECT SOLVER OPTION (4-EQ=2 / 6-EQ=3) .............. =    3
     12   TH MATRIX ITERATIVE SOLVER OPTION (NO<=1 / YES=2) ............. =    0

    (DIMENSIONS AND OPTIONS AUTOMATICALLY DETERMINED BY CONTENT OF INPUT DATA)

          NUMBER OF MINOR EDIT SETS (0200XX DATA )....................... =   10
          NUMBER OF TIME-STEP CONTROL SETS (03XXX0 DATA )................ =    3
          NUMBER OF TRIP CONTROL SETS (04XXX0 DATA )..................... =    2
          NUMBER OF CONTROL VOLUME DESCRIPTIONS (05XXXY DATA )........... =    4
          NUMBER OF BUBBLE RISE DESCRIPTIONS (060XXY DATA) .............. =    0
          NUMBER OF TIME DEPENDENT VOLUMES FORM CARDS (07XXYY DATA) ..... =    1
          NUMBER OF JUNCTION DESCRIPTIONS (08XXXY DATA) ................. =    6
          NUMBER OF CENTRIFUGAL PUMP DESCRIPTIONS (090XXY DATA )......... =    0
          NUMBER OF VALVE DESCRIPTIONS (11XXXY DATA) .................... =    0
          NUMBER OF GENERAL DATA TABLE DESCRIPTIONS (12XXYY DATA) ....... =    0
          NUMBER OF FILL DESCRIPTIONS (13XXYY DATA )..................... =    3
          NUMBER OF HEAT CONDUCTOR DESCRIPTIONS (15XXXY DATA) ........... =    0
          NUMBER OF HEAT CONDUCTOR GEOMETRY DESCRIPTIONS (17XXYY DATA) .. =    0
          NUMBER OF HEAT CONDUCTOR MATERIAL DESCRIPTIONS (18XXYY DATA) .. =    0
          NUMBER OF CORE SECTION DESCRIPTIONS (16XXXY DATA) ............. =    0
          NUMBER OF NON-CONDUCTNG HEAT EXCHNGR DESCRIPTIONS (21XXYY DATA) =    0
          NUMBER OF TIME DEP BCS FROM TAPE (IREAD<0 ON 05XXXY DATA) ..... =    0
          NUMBER OF SPECIFIED HEAT TRAN COEF DESCRIPTIONS (015XXX DATA) . =    0
          TWO-REGION NONEQ VOL DESCRIPTIONS (610XXX OR 611XXX DATA) ..... =    0
          TEMP. TRANSPORT DELAY OPTION (MESH>0 ON 05XXXY DATA) .......... =    0
          AUXILIARY DNB MODEL (8001XX DATA INCLUDED) .................... =    0
          CONTROL SYSTEM MODEL (702XXX OR 702XXXX DATA) ................. =    1
          ACCUMULATOR MODEL DESCRIPTIONS (620XXX OR 621XXX DATA)......... =    0
          DYNAMIC GAP CONDUCTANCE MODEL DESCRIPTIONS (225XX0 DATA) ...... =    0
          NUMBER OF HT CONDUCTOR STACK DESCRIPTIONS (2200XY DATA) ....... =    0
          NUMBER OF TURBINE SHAFT DESCRIPTIONS (500XXY DATA) ............ =    0
          NUMBER OF PROFILE FIT DESCRIPTIONS (061XX1 DATA) .............. =    0
          NUMBER OF STEAM-WATER SEPARATOR DESCRIPTIONS (60XXX0 DATA) .... =    0


                    * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                    * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                    * * *                                                           * * *
                    * * *           STEADY-STATE OPTION    =   0                    * * *
                    * * *                                                           * * *
                    * * *           SLIP OPTION            =   3                    * * *
                    * * *                                                           * * *
                    * * *           NUMERICS OPTION        =   3                    * * *
                    * * *                                                           * * *
                    * * *           HEAT TRANSFER OPTION   =   1                    * * *
                    * * *                                                           * * *
                    * * *           NEW EQUATIONS OPTION   =   1                    * * *
                    * * *                                                           * * *
                    * * *          USING THE 6-EQ SOLVER - SOLVE4                   * * *
                    * * *                                                           * * *
                    * * *       USING STANDARD STEADY-STATE SOLUTION                * * *
                    * * *                                                           * * *
                    * * *     USING THE NONCONDENSABLE GAS FLOW OPTION              * * *
                    * * *                                                           * * *
                    * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                    * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *


INITIAL THERMAL POWER (MEGAWATTS) =  0.00000E+00


AIR IS THE DEFAULT NONCONDENSABLE GAS.
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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   17
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis           11:57:53
  STRAIGHT PIPE WITH AIR - SS WITH AIR FLOW RAMP - RETRAN-3D SAMPLE PROBLEM                                   CPU TIME =    0.031
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

  NORMALIZED    CORE          THERMAL       ENERGY       TOTAL MASS   NCG MASS     AVERAGE      CURRENT      ELAPSED    TIME STEP NUM
  CORE          POWER         POWER         BALANCE      BALANCE      BALANCE      TIME STEP    TIME STEP    TIME       STANDRD/ACTUL
  POWER         (MW)          (BTU/HR)      (BTU)        (LBM)        (LBM)        (SEC)        (SEC)        (SEC)                0
  0.00000E+00   0.00000E+00   0.00000E+00   1.06085E+03  6.44249E+00  1.03455E-03  0.00000E+00  0.00000E+00  0.00000E+00          0

VOLUME          AVG. PRES.    TOT. MASS     AVG. ENTH.   AVG. DEN.    AVG. TEMP.   AVG. QUAL.   VOID FRAC.   POWR TO H2O  NCG QUALITY
NUMBER          (PSIA)        (LB)          (BTU/LB)     (LB/FT3)     (DEG. F)                               (BTU/SEC)
    10          7.82748E+01   7.46351E-01   2.75008E+02  1.11729E+01  2.94140E+02  1.31530E-02  8.07665E-01  0.00000E+00  3.32089E-02
    11          7.83450E+01   7.80886E-01   2.76278E+02  1.16899E+01  2.96026E+02  1.24494E-02  7.98399E-01  0.00000E+00  3.56515E-02
    12          7.82610E+01   8.06422E-01   2.77144E+02  1.20722E+01  2.97328E+02  1.19484E-02  7.91541E-01  0.00000E+00  3.75658E-02
    13          7.80000E+01   4.10883E+00   1.02275E+02  6.15095E+01  1.34000E+02  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00

JUNCTION   CONNECTS     CHOK/ JUN. FLOW     JUN. ENTH.   JUN. SPVL.   P R E S S U R E    D I F F E R E N T I A L S
NUMBER     VOLUMES      PATH  (LB/SEC)      (BTU/LB)     (FT3/LB)     VEL. PSI     ELEV. PSI    FRIC. PSI    ACCL. PSI    PUMP PSI
    11     10 TO     11       6.40704E+00   2.75008E+02  8.95021E-02  1.58443E-01 -7.93849E-02 -8.87360E-03 -2.19214E-08  0.00000E+00
    12     11 TO     12       6.40704E+00   2.76278E+02  8.55438E-02  7.08696E-03 -8.25073E-02 -8.57131E-03  6.56982E-08  0.00000E+00
    13     12 TO     13       6.40704E+00   2.77144E+02  8.28350E-02  2.87025E-03 -2.55492E-01 -8.36218E-03  1.27769E-08  0.00000E+00
   102      0 TO     10       6.40000E-04   1.20000E+03  7.77762E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
   101      0 TO     10       6.40000E+00   2.90000E+02  2.47360E-01  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
     1      0 TO     10       6.40000E-03   2.00000E+02  5.24736E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00

VOLUME    FLOW  LIQ. ENTH.    GAS ENTH.     LIQ. TEMP.   GAS TEMP.    IF AREA DEN  IF HT COEFF  IF MASS TRN  TOT MAS TRN  LIQ. HT RT
NUMBER    REG.  (BTU/LB)      (BTU/LB)      (DEG. F)     (DEG. F)     (FT2/FT3)    (B/H-FT2-F)  (LB/SEC)     (LB/SEC)     (BTU/SEC)
    10      4   2.63357E+02   1.14915E+03   2.94042E+02  3.09315E+02  8.59952E+00  6.41905E+03 -1.70236E-02 -1.70236E-02  2.01269E+01
    11      5   2.65306E+02   1.14670E+03   2.95945E+02  3.09261E+02  1.32088E+01  3.70977E+03 -1.32038E-02 -1.32038E-02  1.56106E+01
    12      5   2.66652E+02   1.14475E+03   2.97260E+02  3.09097E+02  1.30448E+01  2.92314E+03 -9.14807E-03 -9.14807E-03  1.08152E+01

JUNCTION  FLOW  SLIP VEL.     VOID          LIQUID FLOW  GAS FLOW     SLIP CNVCTN  GAS VEL.     LIQ. VEL.    VG/VL        SLIP ACCEL.
NUMBER    REG.  (FT/SEC)      FRACTION      (LB/SEC)     (LB/SEC)     (BTU/SEC)    (FT/SEC)     (FT/SEC)                  (FT/SEC**2)
    11      0  -1.11945E+01   8.07665E-01   6.21432E+00  1.92719E-01  9.60629E+01  1.96318E+01  8.43724E+00  2.32680E+00 -4.43777E-06
    12      0  -1.03903E+01   7.98399E-01   6.22752E+00  1.79516E-01  8.79212E+01  1.84658E+01  8.07548E+00  2.28665E+00 -1.22517E-06
    13      0  -9.85401E+00   7.91541E-01   6.23667E+00  1.70368E-01  8.23772E+01  1.76813E+01  7.82728E+00  2.25893E+00 -4.65366E-07
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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   22
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:53
  STRAIGHT PIPE WITH AIR - SS WITH AIR FLOW RAMP - RETRAN-3D SAMPLE PROBLEM                                     CPU TIME =    0.047
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *
```

SYSTEM ELAPSED TIME (SEC)	SYSTEM ELAPSED TIME (SEC)	TIME STP ACTUAL	VOL 10 AVG. QUALITY	VOL 11 AVG. QUALITY	VOL 12 AVG. QUALITY	VOL 10 NCG QUAITY	VOL 11 NCG QUAITY	VOL 12 NCG QUAITY
0.00000E+00	0.00000E+00	0.00000E+00	1.31530E-02	1.24494E-02	1.19484E-02	3.32089E-02	3.56515E-02	3.75658E-02
1.00000E+00	1.00000E+00	1.00000E+00	1.31530E-02	1.24494E-02	1.19484E-02	3.32089E-02	3.56515E-02	3.75658E-02
2.00000E+00	2.00000E+00	2.00000E+00	1.31529E-02	1.24494E-02	1.19484E-02	3.32089E-02	3.56515E-02	3.75658E-02
3.00000E+00	3.00000E+00	3.00000E+00	1.31529E-02	1.24494E-02	1.19484E-02	3.32089E-02	3.56515E-02	3.75658E-02
4.00000E+00	4.00000E+00	4.00000E+00	1.31529E-02	1.24494E-02	1.19484E-02	3.32089E-02	3.56515E-02	3.75658E-02
5.00000E+00	5.00000E+00	5.00000E+00	1.31529E-02	1.24494E-02	1.19484E-02	3.32089E-02	3.56515E-02	3.75658E-02
6.00000E+00	6.00000E+00	6.00000E+00	1.31529E-02	1.24494E-02	1.19484E-02	3.32089E-02	3.56515E-02	3.75658E-02
7.00000E+00	7.00000E+00	7.00000E+00	1.31529E-02	1.24494E-02	1.19484E-02	3.32089E-02	3.56515E-02	3.75658E-02
8.00000E+00	8.00000E+00	8.00000E+00	1.31529E-02	1.24494E-02	1.19484E-02	3.32089E-02	3.56515E-02	3.75658E-02
9.00000E+00	9.00000E+00	9.00000E+00	1.31529E-02	1.24494E-02	1.19484E-02	3.32089E-02	3.56515E-02	3.75658E-02
1.00000E+01	1.00000E+01	1.00000E+01	1.31529E-02	1.24494E-02	1.19484E-02	3.32089E-02	3.56515E-02	3.75658E-02
1.01000E+01	1.01000E+01	1.10000E+01	1.32499E-02	1.25043E-02	1.19736E-02	3.94828E-02	4.00117E-02	4.05025E-02
1.02000E+01	1.02000E+01	1.20000E+01	1.33312E-02	1.25789E-02	1.20295E-02	4.78363E-02	4.73769E-02	4.65292E-02
1.03000E+01	1.03000E+01	1.30000E+01	1.34067E-02	1.26479E-02	1.20879E-02	5.68417E-02	5.62558E-02	5.47134E-02
1.04000E+01	1.04000E+01	1.40000E+01	1.34853E-02	1.27179E-02	1.21534E-02	6.60031E-02	6.57576E-02	6.40699E-02
1.05000E+01	1.05000E+01	1.50000E+01	1.35695E-02	1.27914E-02	1.22237E-02	7.51394E-02	7.54528E-02	7.39659E-02
1.06000E+01	1.06000E+01	1.60000E+01	1.36601E-02	1.28709E-02	1.23000E-02	8.41727E-02	8.51369E-02	8.40353E-02
1.07000E+01	1.07000E+01	1.70000E+01	1.37573E-02	1.29576E-02	1.23829E-02	9.30606E-02	9.47123E-02	9.40855E-02
1.08000E+01	1.08000E+01	1.80000E+01	1.38621E-02	1.30520E-02	1.24727E-02	1.01769E-01	1.04127E-01	1.04016E-01
1.09000E+01	1.09000E+01	1.90000E+01	1.39763E-02	1.31543E-02	1.25696E-02	1.10264E-01	1.13346E-01	1.13772E-01
1.10000E+01	1.10000E+01	2.00000E+01	1.40956E-02	1.32631E-02	1.26729E-02	1.18564E-01	1.22358E-01	1.23324E-01
1.11000E+01	1.11000E+01	2.10000E+01	1.42166E-02	1.33776E-02	1.27829E-02	1.26687E-01	1.31158E-01	1.32651E-01
1.12000E+01	1.12000E+01	2.20000E+01	1.43381E-02	1.34971E-02	1.28993E-02	1.34631E-01	1.39742E-01	1.41743E-01
1.13000E+01	1.13000E+01	2.30000E+01	1.44596E-02	1.36205E-02	1.30214E-02	1.42401E-01	1.48110E-01	1.50594E-01
1.14000E+01	1.14000E+01	2.40000E+01	1.45809E-02	1.37468E-02	1.31485E-02	1.50004E-01	1.56263E-01	1.59200E-01
1.15000E+01	1.15000E+01	2.50000E+01	1.47017E-02	1.38752E-02	1.32798E-02	1.57446E-01	1.64206E-01	1.67560E-01
1.16000E+01	1.16000E+01	2.60000E+01	1.48222E-02	1.40052E-02	1.34146E-02	1.64733E-01	1.71944E-01	1.75676E-01
1.17000E+01	1.17000E+01	2.70000E+01	1.49424E-02	1.41362E-02	1.35522E-02	1.71870E-01	1.79484E-01	1.83551E-01
1.18000E+01	1.18000E+01	2.80000E+01	1.50624E-02	1.42679E-02	1.36922E-02	1.78864E-01	1.86832E-01	1.91192E-01
1.19000E+01	1.19000E+01	2.90000E+01	1.51824E-02	1.44003E-02	1.38340E-02	1.85716E-01	1.93994E-01	1.98604E-01
1.20000E+01	1.20000E+01	3.00000E+01	1.53024E-02	1.45331E-02	1.39773E-02	1.92431E-01	2.00978E-01	2.05795E-01
1.21000E+01	1.21000E+01	3.10000E+01	1.54227E-02	1.46665E-02	1.41219E-02	1.99012E-01	2.07788E-01	2.12772E-01
1.22000E+01	1.22000E+01	3.20000E+01	1.55434E-02	1.48003E-02	1.42677E-02	2.05461E-01	2.14428E-01	2.19541E-01
1.23000E+01	1.23000E+01	3.30000E+01	1.56644E-02	1.49348E-02	1.44144E-02	2.11781E-01	2.20905E-01	2.26110E-01
1.24000E+01	1.24000E+01	3.40000E+01	1.57860E-02	1.50698E-02	1.45620E-02	2.17974E-01	2.27220E-01	2.32484E-01
1.25000E+01	1.25000E+01	3.50000E+01	1.59081E-02	1.52057E-02	1.47107E-02	2.24040E-01	2.33377E-01	2.38669E-01
1.26000E+01	1.26000E+01	3.60000E+01	1.60308E-02	1.53423E-02	1.48603E-02	2.29982E-01	2.39379E-01	2.44670E-01
1.27000E+01	1.27000E+01	3.70000E+01	1.61542E-02	1.54799E-02	1.50109E-02	2.35802E-01	2.45229E-01	2.50492E-01
1.28000E+01	1.28000E+01	3.80000E+01	1.62935E-02	1.56338E-02	1.50773E-02	2.41306E-01	2.50703E-01	2.57972E-01
1.29000E+01	1.29000E+01	3.90000E+01	1.64034E-02	1.57613E-02	1.51324E-02	2.47060E-01	2.56444E-01	2.64900E-01
1.30000E+01	1.30000E+01	4.00000E+01	1.65288E-02	1.59004E-02	1.52120E-02	2.52536E-01	2.61868E-01	2.71345E-01
1.31000E+01	1.31000E+01	4.10000E+01	1.66545E-02	1.60412E-02	1.53071E-02	2.57898E-01	2.67150E-01	2.77598E-01
1.32000E+01	1.32000E+01	4.20000E+01	1.67808E-02	1.61827E-02	1.54162E-02	2.63148E-01	2.72297E-01	2.83630E-01
1.33000E+01	1.33000E+01	4.30000E+01	1.69078E-02	1.63252E-02	1.55385E-02	2.68285E-01	2.77306E-01	2.89399E-01
1.34000E+01	1.34000E+01	4.40000E+01	1.70357E-02	1.64690E-02	1.56731E-02	2.73308E-01	2.82178E-01	2.94876E-01
1.35000E+01	1.35000E+01	4.50000E+01	1.71809E-02	1.65371E-02	1.58170E-02	2.77989E-01	2.88708E-01	3.00016E-01
1.36000E+01	1.36000E+01	4.60000E+01	1.72985E-02	1.65936E-02	1.59787E-02	2.82939E-01	2.94586E-01	3.05194E-01
1.37000E+01	1.37000E+01	4.70000E+01	1.74236E-02	1.66673E-02	1.61389E-02	2.87709E-01	3.00169E-01	3.09858E-01
1.38000E+01	1.38000E+01	4.80000E+01	1.75549E-02	1.67611E-02	1.63101E-02	2.92300E-01	3.05505E-01	3.14046E-01
1.39000E+01	1.39000E+01	4.90000E+01	1.76876E-02	1.68696E-02	1.64881E-02	2.96776E-01	3.10634E-01	3.17939E-01

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   23
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis             11:57:53
  STRAIGHT PIPE WITH AIR - SS WITH AIR FLOW RAMP - RETRAN-3D SAMPLE PROBLEM                                     CPU TIME =     0.047
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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SYSTEM ELAPSED TIME (SEC)	VOL 10 AVG. PRESS. (PSIA)	JUN 13 FLOW (LB/SEC)
0.00000E+00	7.82748E+01	6.40704E+00
1.00000E+00	7.82748E+01	6.40704E+00
2.00000E+00	7.82748E+01	6.40704E+00
3.00000E+00	7.82748E+01	6.40704E+00
4.00000E+00	7.82748E+01	6.40704E+00
5.00000E+00	7.82748E+01	6.40704E+00
6.00000E+00	7.82748E+01	6.40704E+00
7.00000E+00	7.82748E+01	6.40704E+00
8.00000E+00	7.82748E+01	6.40704E+00
9.00000E+00	7.82748E+01	6.40704E+00
1.00000E+01	7.82748E+01	6.40704E+00
1.01000E+01	7.90582E+01	6.36180E+00
1.02000E+01	7.94482E+01	6.39973E+00
1.03000E+01	7.96635E+01	6.41196E+00
1.04000E+01	7.97652E+01	6.43189E+00
1.05000E+01	7.98082E+01	6.44771E+00
1.06000E+01	7.98209E+01	6.46252E+00
1.07000E+01	7.98179E+01	6.47632E+00
1.08000E+01	7.98058E+01	6.48988E+00
1.09000E+01	7.97873E+01	6.50386E+00
1.10000E+01	7.97672E+01	6.51429E+00
1.11000E+01	7.97456E+01	6.52269E+00
1.12000E+01	7.97223E+01	6.53003E+00
1.13000E+01	7.96983E+01	6.53601E+00
1.14000E+01	7.96737E+01	6.54094E+00
1.15000E+01	7.96490E+01	6.54497E+00
1.16000E+01	7.96243E+01	6.54828E+00
1.17000E+01	7.95998E+01	6.55103E+00
1.18000E+01	7.95757E+01	6.55337E+00
1.19000E+01	7.95520E+01	6.55544E+00
1.20000E+01	7.95288E+01	6.55733E+00
1.21000E+01	7.95059E+01	6.55911E+00
1.22000E+01	7.94835E+01	6.56086E+00
1.23000E+01	7.94614E+01	6.56262E+00
1.24000E+01	7.94395E+01	6.56440E+00
1.25000E+01	7.94179E+01	6.56624E+00
1.26000E+01	7.93965E+01	6.56812E+00
1.27000E+01	7.93752E+01	6.57006E+00
1.28000E+01	7.94915E+01	6.52093E+00
1.29000E+01	7.93875E+01	6.53713E+00
1.30000E+01	7.93731E+01	6.54459E+00
1.31000E+01	7.93534E+01	6.55294E+00
1.32000E+01	7.93306E+01	6.56101E+00
1.33000E+01	7.93046E+01	6.56875E+00
1.34000E+01	7.92766E+01	6.57601E+00
1.35000E+01	7.93819E+01	6.54165E+00
1.36000E+01	7.93007E+01	6.55613E+00
1.37000E+01	7.92429E+01	6.56878E+00
1.38000E+01	7.92122E+01	6.57877E+00
1.39000E+01	7.91823E+01	6.58763E+00

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   24
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis           11:57:53
  STRAIGHT PIPE WITH AIR - SS WITH AIR FLOW RAMP - RETRAN-3D SAMPLE PROBLEM                                   CPU TIME =    0.047
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	ENERGY BALANCE (BTU)	TOTAL MASS BALANCE (LBM)	NCG MASS BALANCE (LBM)	AVERAGE TIME STEP (SEC)	CURRENT TIME STEP (SEC)	ELAPSED TIME (SEC)	TIME STEP NUM STANDRD/ACTUL
0.00000E+00	0.00000E+00	0.00000E+00	9.33190E+02	5.98938E+00	1.22569E-02	1.00000E-01	1.00000E-01	1.50000E+01	60

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	VOID FRAC.	POWR TO H2O (BTU/SEC)	NCG QUALITY
10	7.89078E+01	6.23137E-01	2.74336E+02	9.32839E+00	2.94255E+02	1.88733E-02	8.40327E-01	0.00000E+00	3.45629E-01
11	7.86981E+01	6.29195E-01	2.75019E+02	9.41908E+00	2.95146E+02	1.86525E-02	8.38654E-01	0.00000E+00	3.50656E-01
12	7.84220E+01	6.28217E-01	2.75145E+02	9.40444E+00	2.95261E+02	1.86085E-02	8.38886E-01	0.00000E+00	3.48737E-01
13	7.80000E+01	4.10883E+00	1.02275E+02	6.15095E+01	1.34000E+02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

JUNCTION NUMBER	CONNECTS VOLUMES	CHOK/ PATH	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E VEL. PSI	ELEV. PSI	D I F F E R E N T I A L S FRIC. PSI	ACCL. PSI	PUMP PSI
11	10 TO	11	6.52891E+00	2.74369E+02	1.06715E-01	1.33552E-01	-6.54866E-02	-1.15207E-02	2.77500E-01	0.00000E+00
12	11 TO	12	6.57590E+00	2.75153E+02	1.05381E-01	-1.28759E-03	-6.58614E-02	-1.15745E-02	2.05557E-01	0.00000E+00
13	12 TO	13	6.62548E+00	2.75313E+02	1.05500E-01	-1.74438E-03	-2.46487E-01	-1.17417E-02	1.65733E-01	0.00000E+00
102	0 TO	10	6.40000E-04	1.20000E+03	7.77762E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
101	0 TO	10	6.40000E+00	2.90000E+02	2.47360E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
1	0 TO	10	1.00000E-01	2.00000E+02	5.24736E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

VOLUME NUMBER	FLOW REG.	LIQ. ENTH. (BTU/LB)	GAS ENTH. (BTU/LB)	LIQ. TEMP. (DEG. F)	GAS TEMP. (DEG. F)	IF AREA DEN (FT2/FT3)	IF HT COEFF (B/H-FT2-F)	IF MASS TRN (LB/SEC)	TOT MAS TRN (LB/SEC)	LIQ. HT RT (BTU/SEC)
10	5	2.63597E+02	8.32602E+02	2.94275E+02	2.91602E+02	1.47576E+01	2.62983E+06	1.89696E+00	1.89696E+00	-2.23337E+03
11	5	2.64519E+02	8.27440E+02	2.95177E+02	2.91060E+02	1.46925E+01	2.63741E+06	3.24027E+00	3.24027E+00	-3.81429E+03
12	5	2.64637E+02	8.29330E+02	2.95292E+02	2.90974E+02	1.47678E+01	2.62673E+06	3.46476E+00	3.46476E+00	-4.07843E+03

JUNCTION NUMBER	FLOW REG.	SLIP VEL. (FT/SEC)	VOID FRACTION	LIQUID FLOW (LB/SEC)	GAS FLOW (LB/SEC)	SLIP CNVCTN (BTU/SEC)	GAS VEL. (FT/SEC)	LIQ. VEL. (FT/SEC)	VG/VL	SLIP ACCEL. (FT/SEC**2)
11	0	-1.43097E+01	8.39578E-01	6.24181E+00	2.87102E-01	9.39032E+01	2.44717E+01	1.01620E+01	2.40816E+00	-1.39270E+00
12	0	-1.38593E+01	8.37400E-01	6.29521E+00	2.80681E-01	8.90456E+01	2.39772E+01	1.01179E+01	2.36978E+00	-2.95052E+00
13	0	-1.38906E+01	8.37561E-01	6.34448E+00	2.80996E-01	8.89351E+01	2.40987E+01	1.02081E+01	2.36075E+00	-3.52883E+00

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   26
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:53
  STRAIGHT PIPE WITH AIR - SS WITH AIR FLOW RAMP - RETRAN-3D SAMPLE PROBLEM                                     CPU TIME =    0.047
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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SYSTEM ELAPSED TIME (SEC)	SYSTEM ELAPSED TIME (SEC)	TIME STP ACTUAL	VOL 10 AVG. QUALITY	VOL 11 AVG. QUALITY	VOL 12 AVG. QUALITY	VOL 10 NCG QUAITY	VOL 11 NCG QUAITY	VOL 12 NCG QUAITY
1.40000E+01	1.40000E+01	5.00000E+01	1.78210E-02	1.69910E-02	1.66712E-02	3.01143E-01	3.15525E-01	3.21577E-01
1.41000E+01	1.41000E+01	5.10000E+01	1.79554E-02	1.71243E-02	1.68585E-02	3.05403E-01	3.20152E-01	3.24981E-01
1.42000E+01	1.42000E+01	5.20000E+01	1.80908E-02	1.72683E-02	1.70491E-02	3.09554E-01	3.24503E-01	3.28174E-01
1.43000E+01	1.43000E+01	5.30000E+01	1.82272E-02	1.74217E-02	1.72422E-02	3.13598E-01	3.28577E-01	3.31178E-01
1.44000E+01	1.44000E+01	5.40000E+01	1.82966E-02	1.75809E-02	1.74359E-02	3.19243E-01	3.32360E-01	3.33993E-01
1.45000E+01	1.45000E+01	5.50000E+01	1.83531E-02	1.77598E-02	1.76358E-02	3.24114E-01	3.36170E-01	3.36866E-01
1.46000E+01	1.46000E+01	5.60000E+01	1.84233E-02	1.79256E-02	1.78315E-02	3.28867E-01	3.39608E-01	3.39608E-01
1.47000E+01	1.47000E+01	5.70000E+01	1.85145E-02	1.81015E-02	1.80256E-02	3.33388E-01	3.42667E-01	3.42054E-01
1.48000E+01	1.48000E+01	5.80000E+01	1.86222E-02	1.82832E-02	1.82211E-02	3.37684E-01	3.45488E-01	3.44346E-01
1.49000E+01	1.49000E+01	5.90000E+01	1.87423E-02	1.84671E-02	1.84155E-02	3.41771E-01	3.48144E-01	3.46569E-01
1.50000E+01	1.50000E+01	6.00000E+01	1.88733E-02	1.86525E-02	1.86085E-02	3.45629E-01	3.50656E-01	3.48737E-01
1.51000E+01	1.51000E+01	6.10000E+01	1.88365E-02	1.87477E-02	1.87609E-02	3.46194E-01	3.50866E-01	3.49280E-01
1.52000E+01	1.52000E+01	6.20000E+01	1.89105E-02	1.88424E-02	1.88827E-02	3.44678E-01	3.48504E-01	3.47302E-01
1.53000E+01	1.53000E+01	6.30000E+01	1.90278E-02	1.89776E-02	1.90068E-02	3.42356E-01	3.45407E-01	3.44320E-01
1.54000E+01	1.54000E+01	6.40000E+01	1.91325E-02	1.90980E-02	1.91198E-02	3.40123E-01	3.42573E-01	3.41601E-01
1.55000E+01	1.55000E+01	6.50000E+01	1.92170E-02	1.91955E-02	1.92123E-02	3.38135E-01	3.40102E-01	3.39265E-01
1.56000E+01	1.56000E+01	6.60000E+01	1.92857E-02	1.92743E-02	1.92874E-02	3.36365E-01	3.37940E-01	3.37235E-01
1.57000E+01	1.57000E+01	6.70000E+01	1.93402E-02	1.93365E-02	1.93471E-02	3.34824E-01	3.36081E-01	3.35494E-01
1.58000E+01	1.58000E+01	6.80000E+01	1.93819E-02	1.93840E-02	1.93931E-02	3.33513E-01	3.34514E-01	3.34028E-01
1.59000E+01	1.59000E+01	6.90000E+01	1.94123E-02	1.94188E-02	1.94272E-02	3.32427E-01	3.33219E-01	3.32816E-01
1.60000E+01	1.60000E+01	7.00000E+01	1.94332E-02	1.94427E-02	1.94511E-02	3.31548E-01	3.32173E-01	3.31833E-01
1.61000E+01	1.61000E+01	7.10000E+01	1.94462E-02	1.94576E-02	1.94664E-02	3.30858E-01	3.31349E-01	3.31054E-01
1.62000E+01	1.62000E+01	7.20000E+01	1.94528E-02	1.94653E-02	1.94747E-02	3.30336E-01	3.30719E-01	3.30454E-01
1.63000E+01	1.63000E+01	7.30000E+01	1.94542E-02	1.94672E-02	1.94774E-02	3.29964E-01	3.30255E-01	3.30007E-01
1.64000E+01	1.64000E+01	7.40000E+01	1.94518E-02	1.94648E-02	1.94757E-02	3.29708E-01	3.29937E-01	3.29696E-01
1.65000E+01	1.65000E+01	7.50000E+01	1.94465E-02	1.94596E-02	1.94700E-02	3.29565E-01	3.29722E-01	3.29510E-01
1.66000E+01	1.66000E+01	7.60000E+01	1.94389E-02	1.94521E-02	1.94618E-02	3.29505E-01	3.29612E-01	3.29403E-01
1.67000E+01	1.67000E+01	7.70000E+01	1.94306E-02	1.94433E-02	1.94527E-02	3.29502E-01	3.29573E-01	3.29364E-01
1.68000E+01	1.68000E+01	7.80000E+01	1.94220E-02	1.94338E-02	1.94428E-02	3.29545E-01	3.29591E-01	3.29380E-01
1.69000E+01	1.69000E+01	7.90000E+01	1.94137E-02	1.94241E-02	1.94328E-02	3.29617E-01	3.29649E-01	3.29436E-01
1.70000E+01	1.70000E+01	8.00000E+01	1.94062E-02	1.94147E-02	1.94230E-02	3.29706E-01	3.29736E-01	3.29519E-01
1.71000E+01	1.71000E+01	8.10000E+01	1.93995E-02	1.94059E-02	1.94137E-02	3.29803E-01	3.29840E-01	3.29621E-01
1.72000E+01	1.72000E+01	8.20000E+01	1.93939E-02	1.93979E-02	1.94050E-02	3.29901E-01	3.29953E-01	3.29734E-01
1.73000E+01	1.73000E+01	8.30000E+01	1.93893E-02	1.93908E-02	1.93972E-02	3.29994E-01	3.30069E-01	3.29850E-01
1.74000E+01	1.74000E+01	8.40000E+01	1.93856E-02	1.93846E-02	1.93902E-02	3.30079E-01	3.30181E-01	3.29965E-01
1.75000E+01	1.75000E+01	8.50000E+01	1.93829E-02	1.93795E-02	1.93842E-02	3.30153E-01	3.30286E-01	3.30076E-01
1.76000E+01	1.76000E+01	8.60000E+01	1.93810E-02	1.93753E-02	1.93791E-02	3.30215E-01	3.30382E-01	3.30180E-01
1.77000E+01	1.77000E+01	8.70000E+01	1.93798E-02	1.93720E-02	1.93748E-02	3.30266E-01	3.30467E-01	3.30274E-01
1.78000E+01	1.78000E+01	8.80000E+01	1.93792E-02	1.93695E-02	1.93714E-02	3.30306E-01	3.30539E-01	3.30359E-01
1.79000E+01	1.79000E+01	8.90000E+01	1.93790E-02	1.93677E-02	1.93686E-02	3.30335E-01	3.30600E-01	3.30432E-01
1.80000E+01	1.80000E+01	9.00000E+01	1.93791E-02	1.93666E-02	1.93666E-02	3.30355E-01	3.30649E-01	3.30495E-01
1.81000E+01	1.81000E+01	9.10000E+01	1.93795E-02	1.93660E-02	1.93652E-02	3.30368E-01	3.30687E-01	3.30547E-01
1.82000E+01	1.82000E+01	9.20000E+01	1.93800E-02	1.93658E-02	1.93642E-02	3.30374E-01	3.30716E-01	3.30589E-01
1.83000E+01	1.83000E+01	9.30000E+01	1.93806E-02	1.93659E-02	1.93637E-02	3.30375E-01	3.30736E-01	3.30622E-01
1.84000E+01	1.84000E+01	9.40000E+01	1.93813E-02	1.93662E-02	1.93635E-02	3.30373E-01	3.30748E-01	3.30647E-01
1.85000E+01	1.85000E+01	9.50000E+01	1.93818E-02	1.93667E-02	1.93637E-02	3.30368E-01	3.30756E-01	3.30661E-01
1.86000E+01	1.86000E+01	9.60000E+01	1.93825E-02	1.93674E-02	1.93642E-02	3.30360E-01	3.30756E-01	3.30672E-01
1.87000E+01	1.87000E+01	9.70000E+01	1.93830E-02	1.93681E-02	1.93646E-02	3.30352E-01	3.30754E-01	3.30679E-01
1.88000E+01	1.88000E+01	9.80000E+01	1.93835E-02	1.93688E-02	1.93651E-02	3.30344E-01	3.30749E-01	3.30683E-01
1.89000E+01	1.89000E+01	9.90000E+01	1.93839E-02	1.93695E-02	1.93655E-02	3.30336E-01	3.30742E-01	3.30684E-01

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   27
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:53
  STRAIGHT PIPE WITH AIR - SS WITH AIR FLOW RAMP - RETRAN-3D SAMPLE PROBLEM                                     CPU TIME =    0.047
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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SYSTEM ELAPSED TIME (SEC)	VOL 10 AVG. PRESS. (PSIA)	JUN 13 FLOW (LB/SEC)
1.40000E+01	7.91504E+01	6.59560E+00
1.41000E+01	7.91176E+01	6.60263E+00
1.42000E+01	7.90852E+01	6.60869E+00
1.43000E+01	7.90536E+01	6.61380E+00
1.44000E+01	7.91314E+01	6.58707E+00
1.45000E+01	7.90829E+01	6.59546E+00
1.46000E+01	7.90156E+01	6.60469E+00
1.47000E+01	7.89776E+01	6.61180E+00
1.48000E+01	7.89543E+01	6.61719E+00
1.49000E+01	7.89309E+01	6.62171E+00
1.50000E+01	7.89078E+01	6.62548E+00
1.51000E+01	7.80600E+01	6.64328E+00
1.52000E+01	7.77860E+01	6.64073E+00
1.53000E+01	7.78122E+01	6.62239E+00
1.54000E+01	7.78699E+01	6.60232E+00
1.55000E+01	7.79130E+01	6.58436E+00
1.56000E+01	7.79568E+01	6.56815E+00
1.57000E+01	7.80011E+01	6.55364E+00
1.58000E+01	7.80440E+01	6.54092E+00
1.59000E+01	7.80842E+01	6.52999E+00
1.60000E+01	7.81210E+01	6.52077E+00
1.61000E+01	7.81539E+01	6.51316E+00
1.62000E+01	7.81828E+01	6.50702E+00
1.63000E+01	7.82081E+01	6.50209E+00
1.64000E+01	7.82298E+01	6.49831E+00
1.65000E+01	7.82481E+01	6.49538E+00
1.66000E+01	7.82613E+01	6.49363E+00
1.67000E+01	7.82727E+01	6.49257E+00
1.68000E+01	7.82809E+01	6.49214E+00
1.69000E+01	7.82868E+01	6.49216E+00
1.70000E+01	7.82908E+01	6.49252E+00
1.71000E+01	7.82933E+01	6.49312E+00
1.72000E+01	7.82944E+01	6.49388E+00
1.73000E+01	7.82945E+01	6.49472E+00
1.74000E+01	7.82939E+01	6.49559E+00
1.75000E+01	7.82927E+01	6.49644E+00
1.76000E+01	7.82911E+01	6.49726E+00
1.77000E+01	7.82894E+01	6.49800E+00
1.78000E+01	7.82876E+01	6.49867E+00
1.79000E+01	7.82858E+01	6.49925E+00
1.80000E+01	7.82841E+01	6.49975E+00
1.81000E+01	7.82825E+01	6.50015E+00
1.82000E+01	7.82810E+01	6.50048E+00
1.83000E+01	7.82798E+01	6.50073E+00
1.84000E+01	7.82787E+01	6.50091E+00
1.85000E+01	7.82774E+01	6.50113E+00
1.86000E+01	7.82773E+01	6.50114E+00
1.87000E+01	7.82766E+01	6.50116E+00
1.88000E+01	7.82763E+01	6.50114E+00
1.89000E+01	7.82760E+01	6.50112E+00

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   28
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis           11:57:53
  STRAIGHT PIPE WITH AIR - SS WITH AIR FLOW RAMP - RETRAN-3D SAMPLE PROBLEM                                   CPU TIME =    0.047
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	ENERGY BALANCE (BTU)	TOTAL MASS BALANCE (LBM)	NCG MASS BALANCE (LBM)	AVERAGE TIME STEP (SEC)	CURRENT TIME STEP (SEC)	ELAPSED TIME (SEC)	TIME STEP NUM STANDRD/ACTUL
0.00000E+00	0.00000E+00	0.00000E+00	9.09212E+02	5.91562E+00	1.15712E-02	1.00000E-01	1.00000E-01	2.00000E+01	110

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	VOID FRAC.	POWR TO H2O (BTU/SEC)	NCG QUALITY
10	7.82763E+01	6.01894E-01	2.72754E+02	9.01039E+00	2.92112E+02	1.93848E-02	8.46043E-01	0.00000E+00	3.30297E-01
11	7.83306E+01	6.02630E-01	2.72790E+02	9.02141E+00	2.92162E+02	1.93726E-02	8.45848E-01	0.00000E+00	3.30676E-01
12	7.82565E+01	6.02259E-01	2.72784E+02	9.01585E+00	2.92157E+02	1.93692E-02	8.45943E-01	0.00000E+00	3.30634E-01
13	7.80000E+01	4.10883E+00	1.02275E+02	6.15095E+01	1.34000E+02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

JUNCTION NUMBER	CONNECTS VOLUMES	CHOK/ PATH	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E VEL. PSI	ELEV. PSI	D I F F E R E N T I A L S FRIC. PSI	ACCL. PSI	PUMP PSI
11	10 TO 11		6.50062E+00	2.72754E+02	1.10983E-01	1.28627E-01	-6.26104E-02	-1.17625E-02	-4.67732E-05	0.00000E+00
12	11 TO 12		6.50063E+00	2.72791E+02	1.10847E-01	7.84307E-05	-6.26297E-02	-1.17534E-02	-1.98847E-04	0.00000E+00
13	12 TO 13		6.50069E+00	2.72785E+02	1.10915E-01	-7.67195E-05	-2.44880E-01	-1.17574E-02	-2.53307E-04	0.00000E+00
102	0 TO 10		6.40000E-04	1.20000E+03	7.77762E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
101	0 TO 10		6.40000E+00	2.90000E+02	2.47360E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
1	0 TO 10		1.00000E-01	2.00000E+02	5.24736E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

VOLUME NUMBER	FLOW REG.	LIQ. ENTH. (BTU/LB)	GAS ENTH. (BTU/LB)	LIQ. TEMP. (DEG. F)	GAS TEMP. (DEG. F)	IF AREA DEN (FT2/FT3)	IF HT COEFF (B/H-FT2-F)	IF MASS TRN (LB/SEC)	TOT MAS TRN (LB/SEC)	LIQ. HT RT (BTU/SEC)
10	5	2.61382E+02	8.48052E+02	2.92111E+02	2.92187E+02	1.50847E+01	2.57972E+04	-5.95974E-04	-5.95974E-04	7.01717E-01
11	5	2.61433E+02	8.47680E+02	2.92161E+02	2.92205E+02	1.50746E+01	2.56014E+04	-3.37478E-04	-3.37478E-04	3.97357E-01
12	5	2.61429E+02	8.47706E+02	2.92157E+02	2.92147E+02	1.50781E+01	9.09897E+05	3.23932E-03	3.23932E-03	-3.81403E+00

JUNCTION NUMBER	FLOW REG.	SLIP VEL. (FT/SEC)	VOID FRACTION	LIQUID FLOW (LB/SEC)	GAS FLOW (LB/SEC)	SLIP CNVCTN (BTU/SEC)	GAS VEL. (FT/SEC)	LIQ. VEL. (FT/SEC)	VG/VL	SLIP ACCEL. (FT/SEC**2)
11	0	-1.54478E+01	8.46043E-01	6.19786E+00	3.02758E-01	1.03690E+02	2.59486E+01	1.05009E+01	2.47110E+00	-8.74725E-04
12	0	-1.54150E+01	8.45848E-01	6.19822E+00	3.02411E-01	1.03457E+02	2.59034E+01	1.04885E+01	2.46971E+00	-4.34188E-03
13	0	-1.54323E+01	8.45942E-01	6.19824E+00	3.02447E-01	1.03496E+02	2.59271E+01	1.04948E+01	2.47046E+00	-5.89694E-03

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   29
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:53
  STRAIGHT PIPE WITH AIR - SS WITH AIR FLOW RAMP - RETRAN-3D SAMPLE PROBLEM                                     CPU TIME =    0.047
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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SYSTEM ELAPSED TIME (SEC)	SYSTEM ELAPSED TIME (SEC)	TIME STP ACTUAL	VOL 10 AVG. QUALITY	VOL 11 AVG. QUALITY	VOL 12 AVG. QUALITY	VOL 10 NCG QUAITY	VOL 11 NCG QUAITY	VOL 12 NCG QUAITY
1.90000E+01	1.90000E+01	1.00000E+02	1.93842E-02	1.93701E-02	1.93660E-02	3.30328E-01	3.30735E-01	3.30682E-01
1.91000E+01	1.91000E+01	1.01000E+02	1.93845E-02	1.93706E-02	1.93664E-02	3.30322E-01	3.30726E-01	3.30679E-01
1.92000E+01	1.92000E+01	1.02000E+02	1.93847E-02	1.93711E-02	1.93669E-02	3.30316E-01	3.30718E-01	3.30675E-01
1.93000E+01	1.93000E+01	1.03000E+02	1.93848E-02	1.93715E-02	1.93673E-02	3.30311E-01	3.30710E-01	3.30671E-01
1.94000E+01	1.94000E+01	1.04000E+02	1.93849E-02	1.93719E-02	1.93677E-02	3.30307E-01	3.30702E-01	3.30665E-01
1.95000E+01	1.95000E+01	1.05000E+02	1.93849E-02	1.93721E-02	1.93680E-02	3.30303E-01	3.30696E-01	3.30660E-01
1.96000E+01	1.96000E+01	1.06000E+02	1.93849E-02	1.93723E-02	1.93683E-02	3.30301E-01	3.30690E-01	3.30654E-01
1.97000E+01	1.97000E+01	1.07000E+02	1.93849E-02	1.93725E-02	1.93686E-02	3.30299E-01	3.30685E-01	3.30649E-01
1.98000E+01	1.98000E+01	1.08000E+02	1.93849E-02	1.93726E-02	1.93688E-02	3.30298E-01	3.30681E-01	3.30644E-01
1.99000E+01	1.99000E+01	1.09000E+02	1.93848E-02	1.93726E-02	1.93691E-02	3.30298E-01	3.30678E-01	3.30639E-01
2.00000E+01	2.00000E+01	1.10000E+02	1.93848E-02	1.93726E-02	1.93692E-02	3.30297E-01	3.30676E-01	3.30634E-01

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   30
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:53
  STRAIGHT PIPE WITH AIR - SS WITH AIR FLOW RAMP - RETRAN-3D SAMPLE PROBLEM                                    CPU TIME =    0.047
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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SYSTEM ELAPSED TIME (SEC)	VOL 10 AVG. PRESS. (PSIA)	JUN 13 FLOW (LB/SEC)
1.90000E+01	7.82758E+01	6.50108E+00
1.91000E+01	7.82758E+01	6.50103E+00
1.92000E+01	7.82757E+01	6.50098E+00
1.93000E+01	7.82758E+01	6.50093E+00
1.94000E+01	7.82758E+01	6.50088E+00
1.95000E+01	7.82759E+01	6.50084E+00
1.96000E+01	7.82760E+01	6.50080E+00
1.97000E+01	7.82761E+01	6.50077E+00
1.98000E+01	7.82762E+01	6.50074E+00
1.99000E+01	7.82763E+01	6.50071E+00
2.00000E+01	7.82763E+01	6.50069E+00

12.0 WATER OVER AIR-STEAM

The water over air-steam sample problem consists of 5 vertically stacked volumes. Initially the top 2 volumes are filled with subcooled water and the bottom three volumes are filled with humid air (100%) and vapor at a total pressure of 60 psia. Figure VII.12-1 shows the noding diagram for the water over air-steam problem.

The transient is started at time 0.0 seconds where the liquid drops through to the bottom 2 nodes as the vapor moves to the top three nodes. The pressure drops due to condensation of the vapor and the temperatures of the vapor-air and liquid equilibrate.

The input listing of the water over steam-air deck and the output from RETRAN-3D at time 0.0 seconds and 50.0 seconds along with the minor edits are given.

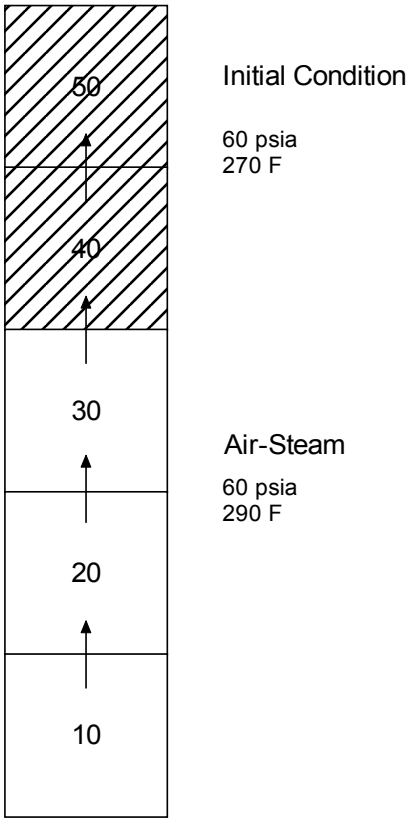


Figure VII.12-1. Water Over Steam-Air Noding Diagram

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```
LISTING OF INPUT DATA FOR CASE  1

    = WATER-OVER-AIR/VAPOR - RETRAN-3D SAMPLE PROBLEM
    *
    ********************************************************************************
    *
    *  PROBLEM DIMENSIONS
    *
    *        1     2     3     4     5     6     7     8     9    10    11    12
    *      TAPE PRNPLT  POW    SS  NVOID GENTRN HTMAP SLIP  5EQ  NCOND  NSOL  PNMTH
    010001   0     0     0     1     0     0     1     5     1     1     3     0
    *
    *
    020000 TIMX  0  NTTS  0
    020001 VOIV 10  VOIV 20  VOIV 30  VOIV 40 VOIV 50  XNC* 10
    020002 WP** 20  PRES 30  COUT -10
    *
    *
    * FORMAT FOR TAPE60
    *
    025000 1
    025001 '(5(1X,1P,E15.7))'
    *
    *
    *3XXX0  TRTG  TMIN  TRST  TMAJ  TDMP  NCHK  DTMAX  TLAST
    030010  0.    0.1   0.    5.0   5.0     0   0.01   0.5
    030020  0.    0.1   0.    5.0   5.0     0   0.01   5.0
    030030  0.    0.5   0.    5.0   5.0     0   0.01  50.0
    030040  0.    0.1   0.    5.0   5.0     0   0.01 200.0
    *
    *
    040010   1  1  0  0  25.0   0.0
    *
    *
    *5XXXY B V  PRES  ENTH  X   VOLUM  HEIGH    L  FLOWA  HYDIA   ELEV    EOVRD
    050101 0 0  0.0     0.  0. .44131  2.87068  0 .15373 .0882150 0.        0.
    050201 0 0  0.0     0.  0. .44131  2.87068  0 .15373 .0882150 2.87068   0.
    050301 0 0  0.0     0.  0. .44131  2.87068  0 .15373 .0882150 5.74136   0.
    050401 0 0  0.0     0.  0. .44131  2.87068  0 .15373 .0882150 8.61204   0.
    050501 0 0  0.0     0.  0. .44131  2.87068  0 .15373 .0882150 11.48272  0.
    *
    *
    080101 10 20 0 0 0. .15373  2.87068  0. 0. 0. 0 -1 2 3 0.088215 0. 0 0  0 0
    080201 20 30 0 0 0. .15373  5.74136  0. 0. 0. 0 -1 2 3 0.088215 0. 0 0  0 0
    080301 30 40 0 0 0. .15373  8.61204  0. 0. 0. 0 -1 2 3 0.088215 0. 0 0  0 0
    080401 40 50 0 0 0. .15373 11.48272  0. 0. 0. 0 -1 2 3 0.088215 0. 0 0  0 0
    *
    *
    * AIR/VAPOR UNDER SUBCOOLED LIQUID
    *
    *       LVOL  PRES   TEMP     ENTH     X        XNCT
    231001   50   60.0   270.0     0.0    0.0       0.0     * TOP
    231002   40   60.0   270.0     0.0    0.0       0.0
    231003   30   60.0   290.0     0.0    1.0       1.0
    231004   20   60.0   290.0     0.0    1.0       1.0
    231005   10   60.0   290.0     0.0    1.0       1.0     * BOTTOM
    *
    *
    702001   1  LIQM 10 1.0  0.0
    702002   2  LIQM 20 1.0  0.0
    702003   3  LIQM 30 1.0  0.0
    702004   4  LIQM 40 1.0  0.0
    702005   5  LIQM 50 1.0  0.0
    *
    703010 -10   SSM    10     0     1.0      0.0     0.0     0.0
    *
    704010  COUT 1 2 3 4 5
    *
    *
    . END TERMINATOR
```


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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page    1
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:55
  WATER-OVER-AIR/VAPOR - RETRAN-3D SAMPLE PROBLEM                                                               CPU TIME =    0.000
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

RETRAN PROBLEM CONTROL AND DESCRIPTION DATA.

    WORD  DESCRIPTION
    ====  ===================================================================
      1   RESTART FILE OPTION (SAVE=-1 / NO SAVE=0) .................... =    0
      2   PRINTER PLOT OPTION (YES=1 / NO=0) ........................... =    0
      3   POWER OPTION (TAPE OPTNS<0 / NO/TBL=0 / PT KIN=1 / 1D=2 / 3D=3) =    0
      4   USE STEADY-STATE SOLUTION (YES=0 / NO=1) ..................... =    1
      5   USE NEUTRON VOID MODEL (YES=1 / NO=0) ........................ =    0
      6   USE GENERALIZED TRANSPORT MODEL (NO=0 / VAP=1 / LIQ=-1) ....... =    0
      7   HEAT TRANSFER MAP OPTION (FORCED=0 / NAT CONV=1) ............. =    1
      8   SLIP OPTION (DYN=1 / Z-L=2 / C-L=3 / Z-L TAUGL=4 / C-L TAUGL=5) =    5
      9   FIVE-EQUATION OPTION (NO= 0 / YES=1) ......................... =    1
     10   NONCONDENSABLE GAS FLOW OPTION (NO=0 / YES=1) ................ =    1
     11   TH MATRIX DIRECT SOLVER OPTION (4-EQ=2 / 6-EQ=3) ............. =    3
     12   TH MATRIX ITERATIVE SOLVER OPTION (NO<=1 / YES=2) ............ =    0

    (DIMENSIONS AND OPTIONS AUTOMATICALLY DETERMINED BY CONTENT OF INPUT DATA)

          NUMBER OF MINOR EDIT SETS (0200XX DATA )...................... =   11
          NUMBER OF TIME-STEP CONTROL SETS (03XXX0 DATA )............... =    4
          NUMBER OF TRIP CONTROL SETS (04XXX0 DATA )..................... =    1
          NUMBER OF CONTROL VOLUME DESCRIPTIONS (05XXXY DATA )........... =    5
          NUMBER OF BUBBLE RISE DESCRIPTIONS (060XXY DATA) ............. =    0
          NUMBER OF TIME DEPENDENT VOLUMES FORM CARDS (07XXYY DATA) ..... =    0
          NUMBER OF JUNCTION DESCRIPTIONS (08XXXY DATA) ................ =    4
          NUMBER OF CENTRIFUGAL PUMP DESCRIPTIONS (090XXY DATA )......... =    0
          NUMBER OF VALVE DESCRIPTIONS (11XXXY DATA) ................... =    0
          NUMBER OF GENERAL DATA TABLE DESCRIPTIONS (12XXYY DATA) ....... =    0
          NUMBER OF FILL DESCRIPTIONS (13XXYY DATA )..................... =    0
          NUMBER OF HEAT CONDUCTOR DESCRIPTIONS (15XXXY DATA) .......... =    0
          NUMBER OF HEAT CONDUCTOR GEOMETRY DESCRIPTIONS (17XXYY DATA) .. =    0
          NUMBER OF HEAT CONDUCTOR MATERIAL DESCRIPTIONS (18XXYY DATA) .. =    0
          NUMBER OF CORE SECTION DESCRIPTIONS (16XXXY DATA) ............ =    0
          NUMBER OF NON-CONDUCTNG HEAT EXCHNGR DESCRIPTIONS (21XXYY DATA) =    0
          NUMBER OF TIME DEP BCS FROM TAPE (IREAD<0 ON 05XXXY DATA) ..... =    0
          NUMBER OF SPECIFIED HEAT TRAN COEF DESCRIPTIONS (015XXX DATA) . =    0
          TWO-REGION NONEQ VOL DESCRIPTIONS (610XXX OR 611XXX DATA) ..... =    0
          TEMP. TRANSPORT DELAY OPTION (MESH>0 ON 05XXXY DATA) .......... =    0
          AUXILIARY DNB MODEL (8001XX DATA INCLUDED) ................... =    0
          CONTROL SYSTEM MODEL (702XXX OR 702XXXX DATA) ................ =    1
          ACCUMULATOR MODEL DESCRIPTIONS (620XXX OR 621XXX DATA)......... =    0
          DYNAMIC GAP CONDUCTANCE MODEL DESCRIPTIONS (225XX0 DATA) ...... =    0
          NUMBER OF HT CONDUCTOR STACK DESCRIPTIONS (2200XY DATA) ....... =    0
          NUMBER OF TURBINE SHAFT DESCRIPTIONS (500XXY DATA) ........... =    0
          NUMBER OF PROFILE FIT DESCRIPTIONS (061XX1 DATA) ............. =    0
          NUMBER OF STEAM-WATER SEPARATOR DESCRIPTIONS (60XXX0 DATA) .... =    0


                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * *                                                  * * *
                   * * *          STEADY-STATE OPTION    =   1            * * *
                   * * *                                                  * * *
                   * * *          SLIP OPTION            =   5            * * *
                   * * *                                                  * * *
                   * * *          NUMERICS OPTION        =   3            * * *
                   * * *                                                  * * *
                   * * *          HEAT TRANSFER OPTION   =   1            * * *
                   * * *                                                  * * *
                   * * *          NEW EQUATIONS OPTION   =   1            * * *
                   * * *                                                  * * *
                   * * *         USING THE 6-EQ SOLVER - SOLVE4           * * *
                   * * *                                                  * * *
                   * * *    USING THE NONCONDENSABLE GAS FLOW OPTION      * * *
                   * * *                                                  * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *


INITIAL THERMAL POWER (MEGAWATTS) =  0.00000E+00


AIR IS THE DEFAULT NONCONDENSABLE GAS.
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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   15
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:55
  WATER-OVER-AIR/VAPOR - RETRAN-3D SAMPLE PROBLEM                                                               CPU TIME =     0.016
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *
```

NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	ENERGY BALANCE (BTU)	TOTAL MASS BALANCE (LBM)	NCG MASS BALANCE (LBM)	AVERAGE TIME STEP (SEC)	CURRENT TIME STEP (SEC)	ELAPSED TIME (SEC)	TIME STEP NUM STANDRD/ACTUL
									0
0.00000E+00	0.00000E+00	0.00000E+00	1.24343E+04	5.14767E+01	1.27387E-02	0.00000E+00	0.00000E+00	0.00000E+00	0

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	VOID FRAC.	POWR TO H2O (BTU/SEC)	NCG QUALITY
10	6.00000E+01	6.33644E-02	1.10996E+03	1.43582E-01	2.90000E+02	1.00000E+00	1.00000E+00	0.00000E+00	6.70132E-02
20	6.00000E+01	6.33644E-02	1.10996E+03	1.43582E-01	2.90000E+02	1.00000E+00	1.00000E+00	0.00000E+00	6.70132E-02
30	6.00000E+01	6.33644E-02	1.10996E+03	1.43582E-01	2.90000E+02	1.00000E+00	1.00000E+00	0.00000E+00	6.70132E-02
40	6.00000E+01	2.56433E+01	2.38811E+02	5.81073E+01	2.70000E+02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
50	6.00000E+01	2.56433E+01	2.38811E+02	5.81073E+01	2.70000E+02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

JUNCTION	CONNECTS	CHOK/	JUN. FLOW	JUN. ENTH.	JUN. SPVL.	P R E S S U R E		D I F F E R E N T I A L S		
NUMBER	VOLUMES	PATH	(LB/SEC)	(BTU/LB)	(FT3/LB)	VEL. PSI	ELEV. PSI	FRIC. PSI	ACCL. PSI	PUMP PSI
10	10 TO 20		0.00000E+00	1.10996E+03	6.96464E+00	0.00000E+00	-2.86236E-03	0.00000E+00	-2.86236E-03	0.00000E+00
20	20 TO 30		0.00000E+00	1.10996E+03	6.96464E+00	0.00000E+00	-2.86236E-03	0.00000E+00	-2.86236E-03	0.00000E+00
30	30 TO 40		0.00000E+00	2.38811E+02	1.72096E-02	0.00000E+00	-5.80623E-01	0.00000E+00	-5.80623E-01	0.00000E+00
40	40 TO 50		0.00000E+00	2.38811E+02	1.72096E-02	0.00000E+00	-1.15838E+00	0.00000E+00	-1.15838E+00	0.00000E+00

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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   18
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:56
  WATER-OVER-AIR/VAPOR - RETRAN-3D SAMPLE PROBLEM                                                              CPU TIME =     0.749
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *
```

SYSTEM ELAPSED TIME (SEC)	SYSTEM ELAPSED TIME (SEC)	TIME STP ACTUAL	VOL 10 VOID FRACTN	VOL 20 VOID FRACTN	VOL 30 VOID FRACTN	VOL 40 VOID FRACTN	VOL 50 VOID FRACTN	VOL 10 NCG QUAITY
0.00000E+00	0.00000E+00	0.00000E+00	1.00000E+00	1.00000E+00	1.00000E+00	0.00000E+00	0.00000E+00	6.70132E-02
1.00000E-01	1.00000E-01	3.00000E+01	1.00000E+00	9.99692E-01	9.90378E-01	1.04168E-02	6.68088E-05	6.68462E-02
2.00000E-01	2.00000E-01	5.30000E+01	9.99991E-01	9.98723E-01	9.68793E-01	3.21695E-02	3.37072E-04	6.69994E-02
3.00000E-01	3.00000E-01	9.60000E+01	9.99869E-01	9.96789E-01	9.40683E-01	6.11103E-02	9.34046E-04	6.72017E-02
4.00000E-01	4.00000E-01	1.06000E+02	9.99451E-01	9.94056E-01	9.08929E-01	9.45378E-02	2.10547E-03	6.74031E-02
5.00000E-01	5.00000E-01	1.17000E+02	9.99001E-01	9.89034E-01	8.70298E-01	1.35871E-01	4.42404E-03	6.83664E-02
6.00000E-01	6.00000E-01	1.30000E+02	9.98421E-01	9.80925E-01	8.27631E-01	1.80302E-01	1.10426E-02	6.88284E-02
7.00000E-01	7.00000E-01	1.44000E+02	9.97170E-01	9.67704E-01	7.73611E-01	2.35445E-01	2.41985E-02	6.85502E-02
8.00000E-01	8.00000E-01	1.55000E+02	9.95232E-01	9.47707E-01	7.24509E-01	2.84478E-01	4.60891E-02	6.78610E-02
9.00000E-01	9.00000E-01	1.65000E+02	9.91619E-01	9.20973E-01	6.85840E-01	3.23768E-01	7.57722E-02	6.60694E-02
1.00000E+00	1.00000E+00	1.75000E+02	9.85461E-01	8.88169E-01	6.58851E-01	3.54401E-01	1.11055E-01	6.42801E-02
1.10000E+00	1.10000E+00	1.85000E+02	9.75762E-01	8.51243E-01	6.41315E-01	3.78751E-01	1.50828E-01	6.23123E-02
1.20000E+00	1.20000E+00	1.95000E+02	9.61272E-01	8.13352E-01	6.30397E-01	3.98882E-01	1.93940E-01	6.04029E-02
1.30000E+00	1.30000E+00	2.05000E+02	9.40609E-01	7.77651E-01	6.22969E-01	4.16705E-01	2.39842E-01	5.88252E-02
1.40000E+00	1.40000E+00	2.15000E+02	9.12371E-01	7.46666E-01	6.16670E-01	4.33225E-01	2.88767E-01	5.79039E-02
1.50000E+00	1.50000E+00	2.25000E+02	8.76280E-01	7.22163E-01	6.10956E-01	4.49673E-01	3.38566E-01	5.69804E-02
1.60000E+00	1.60000E+00	2.35000E+02	8.33509E-01	7.05450E-01	6.07212E-01	4.64814E-01	3.86594E-01	5.56726E-02
1.70000E+00	1.70000E+00	2.45000E+02	7.85314E-01	6.94406E-01	6.04431E-01	4.79559E-01	4.33809E-01	5.44943E-02
1.80000E+00	1.80000E+00	2.55000E+02	7.33835E-01	6.86399E-01	6.02548E-01	4.94694E-01	4.79981E-01	5.36284E-02
1.90000E+00	1.90000E+00	2.65000E+02	6.81236E-01	6.78829E-01	6.01387E-01	5.10248E-01	5.25698E-01	5.31541E-02
2.00000E+00	2.00000E+00	2.75000E+02	6.29861E-01	6.69951E-01	6.01112E-01	5.26253E-01	5.70174E-01	5.27947E-02
2.10000E+00	2.10000E+00	2.85000E+02	5.81550E-01	6.58934E-01	6.01869E-01	5.42453E-01	6.12501E-01	5.24202E-02
2.20000E+00	2.20000E+00	2.95000E+02	5.37086E-01	6.45505E-01	6.03164E-01	5.59018E-01	6.52488E-01	5.20592E-02
2.30000E+00	2.30000E+00	3.05000E+02	4.96537E-01	6.29701E-01	6.04940E-01	5.75985E-01	6.90064E-01	5.17441E-02
2.40000E+00	2.40000E+00	3.45000E+02	4.53571E-01	6.11064E-01	6.02912E-01	5.94557E-01	7.35345E-01	5.31947E-02
2.50000E+00	2.50000E+00	3.95000E+02	4.03166E-01	5.96198E-01	6.04743E-01	6.18371E-01	7.74799E-01	5.96200E-02
2.60000E+00	2.60000E+00	4.07000E+02	3.75667E-01	5.79694E-01	6.08313E-01	6.33997E-01	7.99496E-01	6.04564E-02
2.70000E+00	2.70000E+00	4.17000E+02	3.52001E-01	5.63212E-01	6.11571E-01	6.48477E-01	8.21866E-01	6.10979E-02
2.80000E+00	2.80000E+00	4.27000E+02	3.32743E-01	5.39900E-01	6.15572E-01	6.65087E-01	8.43795E-01	6.17000E-02
2.90000E+00	2.90000E+00	4.37000E+02	3.14542E-01	5.17715E-01	6.18464E-01	6.82444E-01	8.63920E-01	6.26650E-02
3.00000E+00	3.00000E+00	4.47000E+02	2.97239E-01	4.97506E-01	6.20065E-01	7.00317E-01	8.81952E-01	6.37772E-02
3.10000E+00	3.10000E+00	4.57000E+02	2.79932E-01	4.79526E-01	6.20017E-01	7.19885E-01	8.97721E-01	6.51693E-02
3.20000E+00	3.20000E+00	5.03000E+02	2.62669E-01	4.63446E-01	6.16910E-01	7.41267E-01	9.12971E-01	6.76132E-02
3.30000E+00	3.30000E+00	5.18000E+02	2.35655E-01	4.50119E-01	6.22701E-01	7.63532E-01	9.25087E-01	7.33992E-02
3.40000E+00	3.40000E+00	5.34000E+02	2.25370E-01	4.35063E-01	6.21029E-01	7.80141E-01	9.35719E-01	7.42014E-02
3.50000E+00	3.50000E+00	5.83000E+02	1.99343E-01	4.22042E-01	6.28815E-01	8.00996E-01	9.45849E-01	8.27854E-02
3.60000E+00	3.60000E+00	5.93000E+02	1.93612E-01	4.08950E-01	6.25986E-01	8.14772E-01	9.53737E-01	8.36000E-02
3.70000E+00	3.70000E+00	6.03000E+02	1.89916E-01	3.97872E-01	6.20460E-01	8.28428E-01	9.60373E-01	8.37878E-02
3.80000E+00	3.80000E+00	6.13000E+02	1.86288E-01	3.88770E-01	6.14529E-01	8.41557E-01	9.65917E-01	8.40058E-02
3.90000E+00	3.90000E+00	6.23000E+02	1.81587E-01	3.80107E-01	6.11788E-01	8.53258E-01	9.70347E-01	8.44778E-02
4.00000E+00	4.00000E+00	6.33000E+02	1.74840E-01	3.70893E-01	6.14533E-01	8.62928E-01	9.73915E-01	8.56629E-02
4.10000E+00	4.10000E+00	6.43000E+02	1.67600E-01	3.61373E-01	6.20018E-01	8.70890E-01	9.77236E-01	8.72041E-02
4.20000E+00	4.20000E+00	6.53000E+02	1.60894E-01	3.52023E-01	6.26144E-01	8.77933E-01	9.80120E-01	8.87400E-02
4.30000E+00	4.30000E+00	6.63000E+02	1.55089E-01	3.43171E-01	6.31940E-01	8.84394E-01	9.82518E-01	9.00749E-02
4.40000E+00	4.40000E+00	6.73000E+02	1.50182E-01	3.35095E-01	6.36938E-01	8.90262E-01	9.84633E-01	9.11934E-02
4.50000E+00	4.50000E+00	6.83000E+02	1.46102E-01	3.27878E-01	6.41074E-01	8.95190E-01	9.86864E-01	9.20635E-02
4.60000E+00	4.60000E+00	6.93000E+02	1.42559E-01	3.21424E-01	6.44585E-01	8.99773E-01	9.88763E-01	9.27715E-02
4.70000E+00	4.70000E+00	7.03000E+02	1.39735E-01	3.15962E-01	6.46792E-01	9.04179E-01	9.90420E-01	9.32523E-02
4.80000E+00	4.80000E+00	7.13000E+02	1.37751E-01	3.11632E-01	6.47327E-01	9.08489E-01	9.91888E-01	9.33784E-02
4.90000E+00	4.90000E+00	7.23000E+02	1.35953E-01	3.07935E-01	6.47195E-01	9.12700E-01	9.93302E-01	9.34033E-02

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   19
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:56
  WATER-OVER-AIR/VAPOR - RETRAN-3D SAMPLE PROBLEM                                                               CPU TIME =     0.749
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *
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SYSTEM ELAPSED TIME (SEC)	JUN 20 FLOW (LB/SEC)	VOL 30 AVG. PRESS. (PSIA)	CBLK -10 OUTPUT
0.00000E+00	0.00000E+00	6.00000E+01	5.12866E+01
1.00000E-01	-1.13727E-01	6.26861E+01	5.12773E+01
2.00000E-01	-3.49912E-01	6.02537E+01	5.12862E+01
3.00000E-01	-6.00263E-01	5.65871E+01	5.12967E+01
4.00000E-01	-9.98528E-01	5.48231E+01	5.13017E+01
5.00000E-01	-1.76802E+00	5.22448E+01	5.13093E+01
6.00000E-01	-2.79406E+00	5.05194E+01	5.13145E+01
7.00000E-01	-4.49607E+00	4.94234E+01	5.13176E+01
8.00000E-01	-6.66375E+00	4.88008E+01	5.13194E+01
9.00000E-01	-8.76282E+00	4.85757E+01	5.13201E+01
1.00000E+00	-1.09325E+01	4.83772E+01	5.13207E+01
1.10000E+00	-1.26759E+01	4.81449E+01	5.13213E+01
1.20000E+00	-1.39259E+01	4.78228E+01	5.13222E+01
1.30000E+00	-1.47588E+01	4.74293E+01	5.13234E+01
1.40000E+00	-1.54492E+01	4.69902E+01	5.13247E+01
1.50000E+00	-1.53636E+01	4.66439E+01	5.13257E+01
1.60000E+00	-1.51355E+01	4.63093E+01	5.13267E+01
1.70000E+00	-1.51705E+01	4.59700E+01	5.13277E+01
1.80000E+00	-1.52752E+01	4.56170E+01	5.13288E+01
1.90000E+00	-1.54487E+01	4.52922E+01	5.13297E+01
2.00000E+00	-1.53222E+01	4.50279E+01	5.13305E+01
2.10000E+00	-1.50281E+01	4.47825E+01	5.13313E+01
2.20000E+00	-1.45698E+01	4.45327E+01	5.13320E+01
2.30000E+00	-1.42283E+01	4.43374E+01	5.13326E+01
2.40000E+00	-1.82817E+01	4.53966E+01	5.13289E+01
2.50000E+00	-1.08232E+01	4.41973E+01	5.13318E+01
2.60000E+00	-1.03431E+01	4.39529E+01	5.13337E+01
2.70000E+00	-1.05203E+01	4.37674E+01	5.13343E+01
2.80000E+00	-1.07172E+01	4.36081E+01	5.13349E+01
2.90000E+00	-1.00122E+01	4.35424E+01	5.13350E+01
3.00000E+00	-9.25523E+00	4.34993E+01	5.13352E+01
3.10000E+00	-8.69473E+00	4.35213E+01	5.13351E+01
3.20000E+00	-1.19928E+01	4.52783E+01	5.13320E+01
3.30000E+00	-7.11118E+00	4.34067E+01	5.13349E+01
3.40000E+00	-5.97726E+00	4.33208E+01	5.13310E+01
3.50000E+00	-6.39081E+00	4.31770E+01	5.13358E+01
3.60000E+00	-4.25408E+00	4.34262E+01	5.13355E+01
3.70000E+00	-3.31364E+00	4.32958E+01	5.13357E+01
3.80000E+00	-3.21304E+00	4.34036E+01	5.13355E+01
3.90000E+00	-3.67495E+00	4.35528E+01	5.13351E+01
4.00000E+00	-4.24398E+00	4.36538E+01	5.13347E+01
4.10000E+00	-4.31154E+00	4.37131E+01	5.13346E+01
4.20000E+00	-3.92253E+00	4.36803E+01	5.13346E+01
4.30000E+00	-3.53908E+00	4.36505E+01	5.13347E+01
4.40000E+00	-3.13500E+00	4.36518E+01	5.13347E+01
4.50000E+00	-2.75254E+00	4.36309E+01	5.13347E+01
4.60000E+00	-2.38186E+00	4.36097E+01	5.13348E+01
4.70000E+00	-1.78125E+00	4.35171E+01	5.13350E+01
4.80000E+00	-1.51709E+00	4.35133E+01	5.13351E+01
4.90000E+00	-1.34359E+00	4.34986E+01	5.13351E+01

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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   28
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:57
  WATER-OVER-AIR/VAPOR - RETRAN-3D SAMPLE PROBLEM                                                              CPU TIME =    1.872
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

  NORMALIZED    CORE          THERMAL      ENERGY       TOTAL MASS   NCG MASS     AVERAGE      CURRENT      ELAPSED    TIME STEP NUM
  CORE          POWER         POWER        BALANCE      BALANCE      BALANCE      TIME STEP    TIME STEP    TIME       STANDRD/ACTUL
  POWER         (MW)          (BTU/HR)     (BTU)        (LBM)        (LBM)        (SEC)        (SEC)        (SEC)             2500
  0.00000E+00   0.00000E+00   0.00000E+00  1.24343E+04  5.14767E+01  1.27386E-02  1.00000E-02  1.00000E-02  2.50000E+01       2739

VOLUME          AVG. PRES.    TOT. MASS    AVG. ENTH.   AVG. DEN.    AVG. TEMP.   AVG. QUAL.   VOID FRAC.   POWR TO H2O  NCG QUALITY
NUMBER          (PSIA)        (LB)         (BTU/LB)     (LB/FT3)     (DEG. F)                               (BTU/SEC)
    10          4.52436E+01  2.52651E+01  2.39422E+02  5.72501E+01  2.70614E+02  2.80558E-05  1.43799E-02  0.00000E+00  1.00655E-01
    20          4.41912E+01  2.14672E+01  2.40004E+02  4.86443E+01  2.70905E+02  3.59707E-04  1.62677E-01  0.00000E+00  6.25995E-02
    30          4.36018E+01  4.64515E+00  2.47385E+02  1.05258E+01  2.71276E+02  8.19477E-03  8.20200E-01  0.00000E+00  3.80958E-02
    40          4.34956E+01  4.88448E-02  1.06285E+03  1.10681E-01  2.69376E+02  9.62585E-01  9.99929E-01  0.00000E+00  7.58220E-02
    50          4.34934E+01  5.04331E-02  9.91245E+02  1.14281E-01  2.66073E+02  9.60832E-01  9.99923E-01  0.00000E+00  1.47939E-01

JUNCTION   CONNECTS     CHOK/ JUN. FLOW    JUN. ENTH.   JUN. SPVL.   P R E S S U R E    D I F F E R E N T I A L S
NUMBER     VOLUMES      PATH  (LB/SEC)     (BTU/LB)     (FT3/LB)     VEL. PSI     ELEV. PSI    FRIC. PSI    ACCL. PSI    PUMP PSI
    10     10 TO     20     -4.02136E-02  2.39719E+02  1.75148E-02  0.00000E+00 -1.05549E+00  1.65164E-06 -3.17744E-03  0.00000E+00
    20     20 TO     30     -1.37028E-01  2.41520E+02  3.27498E-02  0.00000E+00 -5.89796E-01  1.51759E-05 -3.33690E-04  0.00000E+00
    30     30 TO     40      1.97736E-05  1.13303E+03  9.50885E+00  0.00000E+00 -1.06052E-01 -4.93145E-10  1.15711E-04  0.00000E+00
    40     40 TO     50      1.04254E-05  1.06285E+03  9.03495E+00  0.00000E+00 -2.24234E-03 -6.38412E-09  3.92293E-07  0.00000E+00

VOLUME    FLOW  LIQ. ENTH.   GAS ENTH.    LIQ. TEMP.   GAS TEMP.    IF AREA DEN  IF HT COEFF  IF MASS TRN  TOT MAS TRN  LIQ. HT RT
NUMBER    REG.  (BTU/LB)     (BTU/LB)     (DEG. F)     (DEG. F)     (FT2/FT3)    (B/H-FT2-F)  (LB/SEC)     (LB/SEC)     (BTU/SEC)
    10      2   2.39398E+02  1.07059E+03  2.70614E+02  2.70679E+02  1.80182E+01  2.17348E+01 -3.34395E-06 -3.34395E-06  3.91516E-03
    20      2   2.39691E+02  1.10856E+03  2.70905E+02  2.70921E+02  2.82267E+02  6.48262E+01 -3.86507E-05 -3.86507E-05  4.52559E-02
    30      5   2.40067E+02  1.13303E+03  2.71277E+02  2.71135E+02  4.10642E+01  3.00000E+06  2.29860E+00  2.29860E+00 -2.69158E+03
    40      7   2.38114E+02  1.09491E+03  2.69353E+02  2.69378E+02  4.73807E-02  6.55390E+06 -1.03579E-03 -1.03579E-03  1.21229E+00
    50      7   2.34763E+02  1.02208E+03  2.66050E+02  2.66075E+02  5.09855E-02  6.53688E+06 -1.12307E-03 -1.12307E-03  1.31325E+00

JUNCTION  FLOW  SLIP VEL.    VOID         LIQUID FLOW  GAS FLOW     SLIP CNVCTN  GAS VEL.     LIQ. VEL.    VG/VL        SLIP ACCEL.
NUMBER    REG.  (FT/SEC)     FRACTION     (LB/SEC)     (LB/SEC)     (BTU/SEC)    (FT/SEC)     (FT/SEC)                  (FT/SEC**2)
    10      0  -3.10020E-01  1.69026E-02 -4.03020E-02  8.84152E-05  6.36689E-02  3.04630E-01 -5.39060E-03 -5.65113E+01 -1.01660E-02
    20      0  -1.87664E-01  4.74984E-01 -1.37830E-01  8.01935E-04  4.37905E-01  1.02105E-01 -8.55595E-02 -1.19338E+00  2.47984E-02
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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   29
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:57
  WATER-OVER-AIR/VAPOR - RETRAN-3D SAMPLE PROBLEM                                                               CPU TIME =     1.872
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *
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SYSTEM ELAPSED TIME (SEC)	SYSTEM ELAPSED TIME (SEC)	TIME STP ACTUAL	VOL 10 VOID FRACTN	VOL 20 VOID FRACTN	VOL 30 VOID FRACTN	VOL 40 VOID FRACTN	VOL 50 VOID FRACTN	VOL 10 NCG QUAITY
5.00000E+00	5.00000E+00	7.33000E+02	1.34188E-01	3.04564E-01	6.46744E-01	9.17035E-01	9.94555E-01	9.33961E-02
5.50000E+00	5.50000E+00	7.83000E+02	1.24154E-01	2.88957E-01	6.50911E-01	9.34449E-01	9.98610E-01	9.42564E-02
6.00000E+00	6.00000E+00	8.33000E+02	1.15221E-01	2.78061E-01	6.54507E-01	9.49385E-01	9.99919E-01	9.49939E-02
6.50000E+00	6.50000E+00	8.83000E+02	1.06947E-01	2.69696E-01	6.59010E-01	9.61529E-01	9.99919E-01	9.57890E-02
7.00000E+00	7.00000E+00	9.36000E+02	1.00904E-01	2.65896E-01	6.57097E-01	9.73342E-01	9.99929E-01	9.57384E-02
7.50000E+00	7.50000E+00	9.89000E+02	9.50956E-02	2.62272E-01	6.56175E-01	9.83633E-01	9.99928E-01	9.57959E-02
8.00000E+00	8.00000E+00	1.03900E+03	9.09361E-02	2.61379E-01	6.53741E-01	9.91091E-01	9.99923E-01	9.48659E-02
8.50000E+00	8.50000E+00	1.08900E+03	8.67038E-02	2.59417E-01	6.55081E-01	9.95942E-01	9.99923E-01	9.42310E-02
9.00000E+00	9.00000E+00	1.13900E+03	8.27201E-02	2.56998E-01	6.58646E-01	9.98776E-01	9.99923E-01	9.36068E-02
9.50000E+00	9.50000E+00	1.18900E+03	7.88043E-02	2.53429E-01	6.64981E-01	9.99928E-01	9.99923E-01	9.30833E-02
1.00000E+01	1.00000E+01	1.23900E+03	7.47065E-02	2.49056E-01	6.73454E-01	9.99928E-01	9.99923E-01	9.29834E-02
1.05000E+01	1.05000E+01	1.28900E+03	7.06679E-02	2.44483E-01	6.82068E-01	9.99928E-01	9.99923E-01	9.30943E-02
1.10000E+01	1.10000E+01	1.33900E+03	6.67681E-02	2.39925E-01	6.90528E-01	9.99928E-01	9.99923E-01	9.33380E-02
1.15000E+01	1.15000E+01	1.38900E+03	6.30499E-02	2.35509E-01	6.98664E-01	9.99928E-01	9.99923E-01	9.36611E-02
1.20000E+01	1.20000E+01	1.43900E+03	5.95240E-02	2.31258E-01	7.06443E-01	9.99928E-01	9.99923E-01	9.40371E-02
1.25000E+01	1.25000E+01	1.48900E+03	5.62065E-02	2.27234E-01	7.13787E-01	9.99928E-01	9.99923E-01	9.44312E-02
1.30000E+01	1.30000E+01	1.53900E+03	5.30930E-02	2.23430E-01	7.20706E-01	9.99928E-01	9.99923E-01	9.48246E-02
1.35000E+01	1.35000E+01	1.58900E+03	5.01729E-02	2.19825E-01	7.27233E-01	9.99928E-01	9.99923E-01	9.52086E-02
1.40000E+01	1.40000E+01	1.63900E+03	4.74334E-02	2.16395E-01	7.33405E-01	9.99928E-01	9.99923E-01	9.55791E-02
1.45000E+01	1.45000E+01	1.68900E+03	4.48616E-02	2.13117E-01	7.39256E-01	9.99928E-01	9.99923E-01	9.59339E-02
1.50000E+01	1.50000E+01	1.73900E+03	4.24448E-02	2.09973E-01	7.44818E-01	9.99928E-01	9.99923E-01	9.62725E-02
1.55000E+01	1.55000E+01	1.78900E+03	4.01714E-02	2.06949E-01	7.50117E-01	9.99928E-01	9.99923E-01	9.65953E-02
1.60000E+01	1.60000E+01	1.83900E+03	3.80334E-02	2.04047E-01	7.55158E-01	9.99928E-01	9.99923E-01	9.68972E-02
1.65000E+01	1.65000E+01	1.88900E+03	3.60169E-02	2.01232E-01	7.59991E-01	9.99928E-01	9.99923E-01	9.71864E-02
1.70000E+01	1.70000E+01	1.93900E+03	3.41139E-02	1.98499E-01	7.64629E-01	9.99928E-01	9.99923E-01	9.74634E-02
1.75000E+01	1.75000E+01	1.98900E+03	3.23166E-02	1.95843E-01	7.69083E-01	9.99928E-01	9.99923E-01	9.77287E-02
1.80000E+01	1.80000E+01	2.03900E+03	3.06179E-02	1.93259E-01	7.73367E-01	9.99928E-01	9.99923E-01	9.79830E-02
1.85000E+01	1.85000E+01	2.08900E+03	2.90115E-02	1.90742E-01	7.77492E-01	9.99928E-01	9.99923E-01	9.82266E-02
1.90000E+01	1.90000E+01	2.13900E+03	2.74913E-02	1.88287E-01	7.81468E-01	9.99928E-01	9.99923E-01	9.84603E-02
1.95000E+01	1.95000E+01	2.18900E+03	2.60521E-02	1.85892E-01	7.85303E-01	9.99928E-01	9.99923E-01	9.86846E-02
2.00000E+01	2.00000E+01	2.23900E+03	2.46888E-02	1.83552E-01	7.89007E-01	9.99929E-01	9.99923E-01	9.89000E-02
2.05000E+01	2.05000E+01	2.28900E+03	2.33969E-02	1.81265E-01	7.92587E-01	9.99929E-01	9.99923E-01	9.91069E-02
2.10000E+01	2.10000E+01	2.33900E+03	2.21721E-02	1.79028E-01	7.96050E-01	9.99929E-01	9.99923E-01	9.93058E-02
2.15000E+01	2.15000E+01	2.38900E+03	2.10107E-02	1.76838E-01	7.99402E-01	9.99929E-01	9.99923E-01	9.94972E-02
2.20000E+01	2.20000E+01	2.43900E+03	1.99089E-02	1.74694E-01	8.02649E-01	9.99929E-01	9.99923E-01	9.96815E-02
2.25000E+01	2.25000E+01	2.48900E+03	1.88635E-02	1.72592E-01	8.05797E-01	9.99929E-01	9.99923E-01	9.98590E-02
2.30000E+01	2.30000E+01	2.53900E+03	1.78713E-02	1.70533E-01	8.08849E-01	9.99929E-01	9.99923E-01	1.00030E-01
2.35000E+01	2.35000E+01	2.58900E+03	1.69294E-02	1.68513E-01	8.11812E-01	9.99929E-01	9.99923E-01	1.00195E-01
2.40000E+01	2.40000E+01	2.63900E+03	1.60352E-02	1.66531E-01	8.14689E-01	9.99929E-01	9.99923E-01	1.00354E-01
2.45000E+01	2.45000E+01	2.68900E+03	1.51862E-02	1.64586E-01	8.17483E-01	9.99929E-01	9.99923E-01	1.00507E-01
2.50000E+01	2.50000E+01	2.73900E+03	1.43799E-02	1.62677E-01	8.20200E-01	9.99929E-01	9.99923E-01	1.00655E-01

~~PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390~~

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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   30
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis             11:57:57
  WATER-OVER-AIR/VAPOR - RETRAN-3D SAMPLE PROBLEM                                                               CPU TIME =    1.872
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *
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SYSTEM ELAPSED TIME (SEC)	JUN 20 FLOW (LB/SEC)	VOL 30 AVG. PRESS. (PSIA)	CBLK -10 OUTPUT
5.00000E+00	-1.30557E+00	4.35043E+01	5.13351E+01
5.50000E+00	-8.38209E-01	4.34723E+01	5.13352E+01
6.00000E+00	-8.25695E-01	4.35443E+01	5.13350E+01
6.50000E+00	-8.84485E-01	4.35783E+01	5.13348E+01
7.00000E+00	-4.04474E-01	4.36177E+01	5.13337E+01
7.50000E+00	-3.67079E-01	4.35917E+01	5.13348E+01
8.00000E+00	-2.43366E-01	4.33823E+01	5.13354E+01
8.50000E+00	-3.08244E-01	4.33669E+01	5.13354E+01
9.00000E+00	-3.38139E-01	4.33484E+01	5.13355E+01
9.50000E+00	-4.23710E-01	4.33650E+01	5.13355E+01
1.00000E+01	-4.39956E-01	4.33760E+01	5.13354E+01
1.05000E+01	-4.38689E-01	4.33878E+01	5.13354E+01
1.10000E+01	-4.25549E-01	4.34001E+01	5.13354E+01
1.15000E+01	-4.06434E-01	4.34126E+01	5.13353E+01
1.20000E+01	-3.87161E-01	4.34261E+01	5.13353E+01
1.25000E+01	-3.64665E-01	4.34379E+01	5.13352E+01
1.30000E+01	-3.43702E-01	4.34491E+01	5.13352E+01
1.35000E+01	-3.24593E-01	4.34597E+01	5.13352E+01
1.40000E+01	-3.07327E-01	4.34696E+01	5.13351E+01
1.45000E+01	-2.91755E-01	4.34790E+01	5.13351E+01
1.50000E+01	-2.77644E-01	4.34879E+01	5.13351E+01
1.55000E+01	-2.63564E-01	4.34956E+01	5.13351E+01
1.60000E+01	-2.52513E-01	4.35037E+01	5.13350E+01
1.65000E+01	-2.42155E-01	4.35113E+01	5.13350E+01
1.70000E+01	-2.32472E-01	4.35186E+01	5.13350E+01
1.75000E+01	-2.23441E-01	4.35256E+01	5.13350E+01
1.80000E+01	-2.15013E-01	4.35323E+01	5.13350E+01
1.85000E+01	-2.07127E-01	4.35386E+01	5.13349E+01
1.90000E+01	-1.99734E-01	4.35448E+01	5.13349E+01
1.95000E+01	-1.92801E-01	4.35506E+01	5.13349E+01
2.00000E+01	-1.86265E-01	4.35562E+01	5.13349E+01
2.05000E+01	-1.80110E-01	4.35616E+01	5.13349E+01
2.10000E+01	-1.74275E-01	4.35668E+01	5.13349E+01
2.15000E+01	-1.68757E-01	4.35718E+01	5.13348E+01
2.20000E+01	-1.63517E-01	4.35766E+01	5.13348E+01
2.25000E+01	-1.58548E-01	4.35812E+01	5.13348E+01
2.30000E+01	-1.53823E-01	4.35856E+01	5.13348E+01
2.35000E+01	-1.49323E-01	4.35899E+01	5.13348E+01
2.40000E+01	-1.45033E-01	4.35940E+01	5.13348E+01
2.45000E+01	-1.40939E-01	4.35980E+01	5.13348E+01
2.50000E+01	-1.37028E-01	4.36018E+01	5.13347E+01

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13.0 LOSS OF RESIDUAL HEAT REMOVAL

The Loss of Residual Heat Removal (LRHR) transient models an LRHR event that occurs in a PWR operating at mid-loop conditions. "Mid-loop" refers to the condition commonly found during refueling, in which the reactor is shut down and the water level is drawn down to the middle of the recirculation loops. The recirculation pumps are stopped, the system is quiescent, and the small amount of decay heat is removed by the Residual Heat Removal (RHR) system. The head may then be removed from the pressure vessel without spilling coolant into the containment, and refueling can proceed. However, these conditions beg the question, "What if the RHR system should fail? How fast will the reactor coolant heat up, and what might the consequences be?"

The analysis presented here describes the early portion of such a transient. The system is at low pressure, the reactor coolant is slightly subcooled, and air fills the space above the water level. Steady-state initialization was not used.

As the transient begins, the core heats up, and shortly it begins to boil. The water vapor created rises into the space above the water level and mixes with the air. Because the pressure vessel head is assumed to be still in place, the RCS begins a gradual pressurization. Because this analysis is a "demonstration" type of analysis, it was terminated at 30 seconds to reduce run time.

The corresponding noding diagram is shown in Figure VII.13-1. The associated input and selected output are given below.

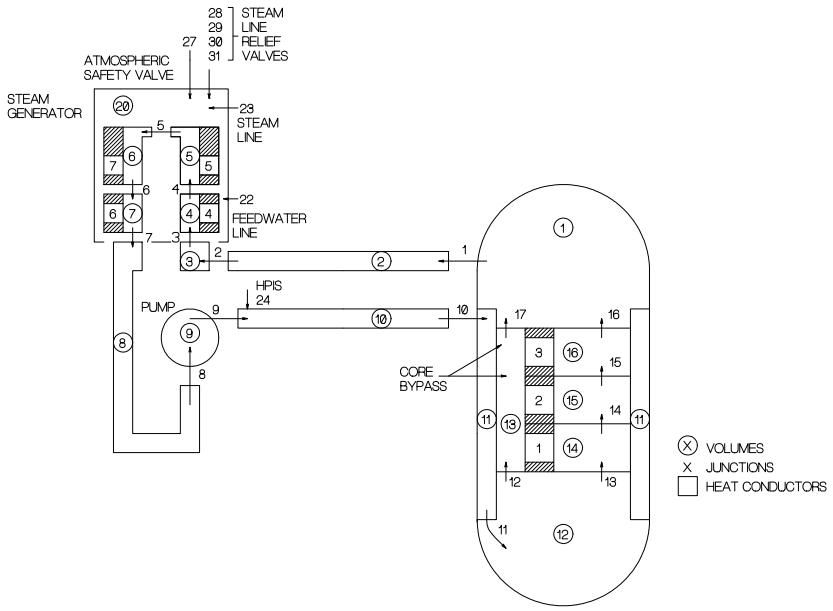


Figure VII.13-1. Loss of Residual Heat Removal Noding Diagram

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LISTING OF INPUT DATA FOR CASE  1

    1    = REDUCED INVENTORY SYSTEM MODEL - RETRAN-3D SAMPLE PROBLEM
    2    *
    3    ********************************************************************************
    4    *
    5    *  PROBLEM DIMENSIONS
    6    *
    7    *        1     2     3     4     5     6     7     8     9    10    11    12
    8    *      TAPE PRNPLT  POW    SS  NVOID GENTRN HTMAP SLIP  5EQ  NCOND  NSOL  PNMTH
    9    010001   0     0     0     1     0     0     1     1     1     1     3     0
   10    *
   11    *
   12    *  POWER
   13    010005  2244.
   14    *
   15    *
   16    *  MINOR EDITS
   17    *
   18    020000  TIMX  0   NTTS  0
   19    020001  PNRM  0   TEMP  2   TEMP  10  WP**   1
   20    +       WP**  10  VOIV   1  VOIV  14  VOIV  15
   21    +       VOIV  16
   22    *
   23    *
   24    * FORMAT FOR TAPE60
   25    *
   26    025000 1
   27    025001 '(5(1X,1P,E15.7))'
   28    *
   29    *
   30    *  TIME-STEP CONTROL
   31    *
   32    *3XXX0  TRTG  TMIN  TRST  TMAJ  TDMP  NCHK  DTMAX  TLAST
   33    030010  0.    0.01  0.    100.  100.    2   0.0001   0.1
   34    030020  0.    0.05  0.    100.  100.    2   0.0001   0.3
   35    030030  0.    0.1   0.    100.  100.    2   0.00025  3.0
   36    030040  0.    0.1   0.    100.  100.    2   0.0002   5.0
   37    030050  0.    0.1   0.    100.  500.    2   0.01    10.0
   38    030060  0.    0.1   0.    500.  500.    2   0.01    30.0
   39    030070  0.    0.1   0.    500.  500.    2   0.01    50.0
   40    030080  0.    0.1   0.    100.  100.    2   0.01    1.E+6
   41    *
   42    *       EPSI COURNT EPSIU   CONDT  EPMDOT
   43    030011  .001  5.0   .005   1.1892   10.
   44    030021  .001  5.0   .005   1.1892   10.
   45    030031  .001  5.0   .005   1.1892   10.
   46    030041  .005  5.0   .005   1.1892   10.
   47    030051  .005  5.0   .005   1.1892   10.
   48    030061  .005  5.0   .005   1.1892   10.
   49    030071  .005  5.0   .005   1.1892   10.
   50    030081  .005  5.0   .005   1.1892   10.
   51    *
   52    *
   53    ********************************************************************************
   54    *
   55    *  TRIP CONTROLS    ** TRIP ACTION IDENTIFICATION
   56    *                        1 = END OF PROBLEM TIME TRIP
   57    *                        2 = LOW STEAM GENERATOR LEVEL
   58    *                        3 = FLOW MISMATCH
   59    *                        4 = TURBINE TRIP
   60    *                        5 = SAFETY INJECTION SYSTEM
   61    *                        6 = LOW PRESSURIZER PRESSURE
   62    *                        7 = LOW PRESSURIZER LEVEL
   63    *                        8 = HIGH STEAM FLOW
   64    *                        9 = LOW TAVG
   65    *                       10 = LOW STEAM PRESSURE
   66    *                       11 = FEEDWATER ISOLATION
   67    *                       12 = PRESSURIZER POWER RELIEF VALVES
   68    *                       13 = PRESSURIZER SAFTEY VALVES
   69    *                       14 = STEAM LINE SAFTEY VALVES
   70    *                       15 = STEAM LINE RELIEF VALVE 1
   71    *                       16 = REACTOR SCRAM
   72    *                       17 = STEAM LINE RELIEF VALVE 2
   73    *                       18 = STEAM LINE RELIEF VALVE 3
   74    *                       19 = STEAM LINE RELIEF VALVE 4
   75    *                       20 = MISC GENL TIME  0.0  TRIP  START FILL TABLES ETC
   76    *                       21 = REACTOR COOLANT PUMP
   77    *                       22 = PRESSURIZER CONTROL HEATERS 1
   78    *                       23 = PRESSURIZER BACKUP  HEATERS 1
   79    *                       24 = PRESSURIZER CONTROL HEATERS 2
   80    *                       25 = NORMALIZED POWER
   81    *
   82    *      IDTRP IDSIG IX1 IX2    SETPT    DELAY  DESCRIPTION
   83    040010   1     1    0   0       30.00   0.0   "PROBLEM END TIME              "
   84    040020   4     1    0   0        1.+9   0.0   "TURBINE TRIP MANUAL           "
   85    *
   86    * DISABLE ALL SYSTEM TRIPS
   87    040030   6    -4   18   0     1860.0   1.0E6  "LOW PRESSURIZER PRESS         "
   88    040040   7    -6   18   0       13.31  1.0E6  "LOW PRESSURIZER LEVEL         "
   89    040050   5    13    6   7        0.0   1.0E6  "LOW PRESS AND LEVEL           "
   90    040060   9   -14   -2   0      531.0   1.0E6  "LOW TAVG                      "
   91    040070  16     6   18   0       42.45  1.0E6  "HIGH PRESSURIZER LEVEL        "
   92    040080  16    12    6   0        0.0   1.0E6  "LOW PRESSURIZER PRESS         "
   93    040090  16     4   18   0     2425.0   1.0E6  "HIGH PRESSURIZER PRESS        "
   94    040100  16     2    0   0        1.18  1.0E6  "NUCLEAR OVERPOWER             "
   95    040110  16    14   -9   0        0.0   1.0E6  "OVER TEMPERATURE DELTA T      "
   96    040120  16    14  -16   0        0.0   1.0E6  "OVER POWER DELTA T            "
   97    040130  16    -9    9   0    24528.8   1.0E6  "LOW COOLANT FLOW ALL PUMPS    "
   98    040140  16    12    4   0        0.0   1.0E6  "SCRAM FROM TURBINE TRIP       "
   99    040150  16    12    5   0        0.0   1.0E6  "SCRAM FROM SIS                "
  100    040160   5    12   16   0        0.0   1.0E6  "TURBINE TRIP FROM SCRAM       "
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040170  11    13    9  16        0.0   1.0E6  "FW ISOLATION SRAM AND TAVG    "
040180  11    12    5   0        0.0   1.0E6  "FW ISOLATION FROM SIS         "
040190  21     1    0   0        1+9   1.0E6  "RECIRC PUMP TRIP         SS   "
040200  13     4   18   0     2500.0   1.0E6  "OPEN PRES SAFETY VALVE        "
040210 -13    -4   18   0     2400.0   1.0E6  "CLOSE PRES SAFETY VALVE       "
040220  12     4   18   0     2350.0   1.0E6  "OPEN  PRES RELIEF VALVE       "
040230 -12    -4   18   0     2250.    1.0E6  "CLOSE PRES RELIEF VALVE       "
040240  14     4   20   0     1050.0   1.0E6  "OPEN  S.L. SAFETY VALVES      "
040250 -14    -4   20   0      950.    1.0E6  "CLOSE S.L. SAFETY VALVES      "
040260  15     4   20   0     1100.    1.0E6  "OPEN  S.L. RELIEF VALVE  1    "
040270 -15    -4   20   0     1000.    1.0E6  "CLOSE S.L. RELIEF VALVE  1    "
040280  17     4   20   0     1115.    1.0E6  "OPEN  S.L. RELIEF VALVE  2    "
040290 -17    -4   20   0     1015.    1.0E6  "CLOSE S.L. RELIEF VALVE  2    "
040300  18     4   20   0     1130.    1.0E6  "OPEN  S.L. RELIEF VALVE  3    "
040310 -18    -4   20   0     1030.    1.0E6  "CLOSE S.L. RELIEF VALVE  3    "
040320  19     4   20   0     1145.    1.0E6  "OPEN  S.L. RELIEF VALVE  4    "
040330 -19    -4   20   0     1045.    1.0E6  "CLOSE S.L. RELIEF VALVE  4    "
040340  20     1    0   0        0.     0.    "GENL MISC TRIP AT TIME 0.     "
040350  22    -4   18   0     2235.    1.0E6  "PRESSUR HEATERS  CONTROL  ON  "
040360 -22    +4   18   0     2235.    1.0E6  "PRESSUR HEATERS  CONTROL OFF  "
040370  23    -4   18   0     2195.    1.0E6  "PRESSUR HEATERS BACKUP    ON  "
040380 -23    +4   18   0     2195.    1.0E6  "PRESSUR HEATERS  BACKUP  OFF  "
040390  24    -4   18   0     2213.    1.0E6  "PRESSUR HEATERS  CONTROL  ON  "
040400 -24    +4   18   0     2227.    1.0E6  "PRESSUR HEATERS CONTROL  OFF  "
040410  16     1    0   0      1+9     1.0E6  "SCRAM ON TIME LOSS PUMP POWER "
040420  25     1    0   0        0.     0.    "NORMALIZED POWER TABLE        "
*
*
*  VOLUME DATA
*       IB IV PRES  ENTH  QUAL  VOLUM HEIGH  FL  FLOWA  HYDIA   ELEVAT
050011  0  0  0.0   0.0   0.0  984.3  11.58  0   1.+9    .5     -4.71  * UP PLEN
050021  0  0  0.0   0.0   0.0  295.2   2.82  0  13.77   2.42    -1.21  * HOT L57
050031  0  0  0.0   0.0   0.0  405.9   5.05  0 113.6    6.       1.61  * S7 PLEN
050041  0  0  0.0   0.0   0.0  607.5  14.87  0  40.84    .05     6.66  * SG T
050051  0  0  0.0   0.0   0.0  607.5  14.87  0  40.84    .05    21.53  * SG TUB
050061  0  0  0.0   0.0   0.0  607.5  14.87  0  40.84    .05    21.53  * SG TU 3
050071  0  0  0.0   0.0   0.0  607.5  14.87  0  40.84    .05     6.66  * SG TUB4
050081  0  0  0.0   0.0   0.0  801.6  16.46  0  15.72   2.58    -9.8   * PMP SUC
050091  0  0  0.0   0.0   0.0  576.    5.19  0   1.+9   1.+9    -4.04  * PMPS
050101  0  0  0.0   0.0   0.0  247.8   2.3   0  12.36   2.29    -1.15  * CL4 L5G
050111  0  0  0.0   0.0   0.0  789.9  26.77  0  29.51   1.45   -19.9   * DN3MR
050121  0  0  0.0   0.0   0.0  806.2   9.85  0   1.+9    .5     -26.55  * LW PLEN
050131  0  0  0.0   0.0   0.0   42.7  12.    0   3.52    .026  -16.7   * BYPASS
050141  0  0  0.0   0.0   0.0  167.4   4.    0  43.75    .0412 -16.7   * BTM COR
050151  0  0  0.0   0.0   0.0  167.4   4.    0  43.75    .0412 -12.7   * MID COR
050161  0  0  0.0   0.0   0.0  167.4   4.    0  43.75    .0412  -8.7   * TOP COR
050181  0  0  0.0   0.0   0.0 1300.   33.77  0  38.48   7.0      8.78  * PRZR
050191  0  0  0.0   0.0   0.0   28.6   8.78  0    .7213  .9538   0.0   * SURGE
050201  1  0  0.0   0.0   0.0 8543.   63.0   0   33.9    .112    6.66  * SG SC
*
*  VOLUME DATA (SET 2)
*5XXXY   EOVRD   MESH   IHTGL   IMAP
050022    0.0     0       0      1
050102    0.0     0       0      1
*
*
*  BUBBLE RISE DATA
*       ALPH  VBUB
060011   0.  14.07 49.5          * STEAM GENERATOR  SECONDARY
*
*
*  JUNCTION DATA CARDS - CARD 1 (WORDS 1-10)
*8XXX1 VI VO PP VV  FLOWRT    AREA   ELEV   INERT    FLOSS  RLOSS
080011  1  2  0  0      0.0   13.77   0.     2.4     .4187   0.0 * SG ENTR
080021  2  3  0  0      0.0   13.77   1.61   1.19    .7534   0.0
080031  3  4  0  0      0.0   32.04   6.66    .49   1.0645   0.0 * S7 TUBE ENTR
080041  4  5  0  0      0.0   32.04  21.53    .75    .3984   0.0 * SG TUBE
080051  5  6  0  0      0.0   32.04  36.3     .75    .5470   0.0 * SG BEND
080061  6  7  0  0      0.0   32.04  21.53    .75    .2983   0.0 * SG TUBE
080071  7  8  0  0      0.0   15.72   6.66   2.8     .3463   0.0 * SG TUBE EXIT
080081  8  9 -1  0      0.0   12.36  -4.04   2.54    .0712   0.0 * PUMP ENTR
080091  9 10  1  0      0.0   12.36   0.     1.32   0.122    0.122 * LOSS
080101 10 11  0  0      0.0   12.36   0.     1.67   1.1502   0.0 * VESSEL ENTR
080111 11 12  0  0      0.0   19.69 -19.9     .59    .9106   .88 * LOWER PLENUM
080121 12 13  0  0      0.0    1.5  -16.7    1.8   16.938    0.0 * BY PASS IN
080131 12 14  0  0      0.0   43.75 -16.7     .18   8.9129   0.0 * CORE ENTRY
080141 14 15  0  0      0.0   43.75 -12.7     .09   2.8927   0.0 * CORE
080151 15 16  0  0      0.0   43.75  -8.7     .09   2.7894   0.0 * CORE
080161 16  1  0  0      0.0   43.75  -4.7     .05   7.7418   0.0 * CORE EXIT
080171 13  1  0  0      0.0    1.5   -4.7    1.8   14.26    14.26 * LOSS
080201 19 18  0  0      0.0  .6013    8.78   0.0    2.8      2.3 * PRESS EXIT
080211  2 19  0  0      0.0  .6013    0.0    0.0    2.3      2.8 * FW TO SG
080221  0 20  4  9      0.0    3.     6.66   0.0    0.0      0.0
080231  0 20  5 10      0.0    3.    69.66   0.0    0.0      0.0 * SG TO STMLINE
080241  0 10  6  0      0.0    4.     0.0    0.0    0.0      0.0 * HPIS 4 PUMPS
080251  0 18  1  2      0.0    2.    41.7    0.0    0.0      0.0 * PRZR POW RV
080261  0 18  2  3      0.0    3.    41.7    0.0    0.0      0.0 * PRZR SV  3 EA
080271  0 20  3  4      0.0    3.    62.2    0.0    0.0      0.0 * STMLINE ATM S
080281  0 20  7  5      0.0    3.    62.2    0.0    0.0      0.0 * STMLINE RV
080291  0 20  7  6      0.0    3.    62.2    0.0    0.0      0.0
080301  0 20  7  7      0.0    3.    62.2    0.0    0.0      0.0
080311  0 20  7  8      0.0    3.    62.2    0.0    0.0      0.0
080501  0  1  8  0      0.0    1.0    6.87   0.0    0.0      0.0
*
*   JUNCTION CARDS - CARD 2 (WORDS 11-20)
*8XXX1  V  C  CL M     HDI     CON    IFRJ   JTPMJ   IHQCOR   ISP  ANGL1  ANGL2
080012  0 -1  0  0      0.     1.     -2      0        0      0
080022  0 -1  0  0      0.     1.     -2      0        0      0
080032  0 -1  0  0      0.     1.     -2      0        0      0
080042  0 -1  0  0      0.     1.     -2      0        0      0
080052  0 -1  0  0      0.     1.     -2      0        0      0
080062  0 -1  0  0      0.     1.     -2      0        0      0
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080072  0 -1  0  0      0.     1.     -2      0        0      0
080082  0 -1  0  0      0.     1.     -2      0        0      0
080092  0 -1  0  0      0.     1.     -2      0        0      0
080102  0 -1  0  0      0.     1.     -2      0        0      0
080112  0 -1  0  0      0.     1.     -2      0        0      0
080122  0 -1  0  0      0.     1.     -2      0        0      0
080132  0 -1  0  0      0.     1.     -2      0        0      0
080142  0 -1  0  0      0.     1.     -2      0        0      0
080152  0 -1  0  0      0.     1.     -2      0        0      0
080162  0 -1  0  0      0.     1.     -2      0        0      0
080172  0 -1  0  0      0.     1.     -2      0        0      0
080202  2 -1  2  0      0.     1.     -2      0        0      0
080212  0 -1  2  3      0.     1.     -2      0        0      0
080222  0  0  0  0      0.     1.    -99      0        0      0
080232  0  0  0  3      0.     1.    -99      0        0      0   0.   180.
080242  0  0  0  0      0.     1.    -99      0        0      0
080252  0  0  0  0      0.     1.    -99      0        0      0   0.   180.
080262  0  0  0  0      0.     1.    -99      0        0      0   0.   180.
080272  0  0  0  0      0.     1.    -99      0        0      0   0.   180.
080282  0  0  0  0      0.     1.    -99      0        0      0   0.   180.
080292  0  0  0  0      0.     1.    -99      0        0      0   0.   180.
080302  0  0  0  0      0.     1.    -99      0        0      0   0.   180.
080312  0  0  0  0      0.     1.    -99      0        0      0   0.   180.
080502  0  0  2  3      0.     1.      0      0        0      0
*
*
*  PUMP DATA CARDS
*     PUMP CURVE INPUT OPTION
100000    2    0
*
*  PUMP DESCRIPTION
*   RATED CONDITIONS 1180. 1. 265500. 260. 77535. 210000. 47.66 3606. 0.
*   RATED TORQUE EFFICIENCY = 77 PER CENT   TIME CONST = 6.5 SEC
*  PUMPS INITIAL OFF (IDT = -21) SPEED RATIO AND RATED TORQUE = 0.0
*       TR P RV 2P MT RPM   SR  FLOW   HEAD TORQUE INERTIA  DENS  MT  FRIC
090011  1 -21 0  1  0 1180. 0. 265500. 260. 59319. 210000. 47.66 3606. 0.
*
*     PUMP HEAD AND TORQUE MULTIPLIER
*      NPTS  PHDM------
091011  11   0.00 0.00   0.10 0.00   0.15 0.05   0.24 0.80   0.30 0.96  *HEAD
091012       0.40 0.98   0.60 0.97   0.80 0.90   0.90 0.80   0.96 0.50
091013       1.00 0.00
*      NPTS  PTKM-----
092011   2   0.00 0.00   1.00 0.00     * TORQUE
*
*
*  VALVE DATA
*       ITCV  IACV IACV2 PCV CV1 CV2 CV3
110010  1000  -19    0    0.  0.  0.  0.  * PRESSURIZER SPRAY VALVE
110020  -12     1    0    0.  0.  0.  0.  * PRESS  POWER RELIEF VALVES   2 EACH
110030  -13     2    0    0.  0.  0.  0.  * PRESS SAFETY VALVE    3 EACH
110040  -14     3    0    0.  0.  0.  0.  * ATM. SAFETY VALVE
110050  -15     4    0    0.  0.  0.  0.  * STM LINE RELIEF VALVE 1
110060  -17     5    0    0.  0.  0.  0.  * STM LINE RELIEF VALVE 2
110070  -18     6    0    0.  0.  0.  0.  * STM LINE RELIEF VALVE 3
110080  -19     7    0    0.  0.  0.  0.  * STM LINE RELIEF VALVE 4
110090   11     0    0    0.  0.  0.  0.  * FEEDWATER FLOW VALVE
110100    4     0    0    0.  0.  0.  0.  * STEAM LINE ISOLATION VALVE
*
*
*  AREA TABLES
*      NAREA        TAREA-------
120101  -3          0. 0.   .1 1.   1+9 1.   * PRESS POWER RELIEF VALVE
120201  -3          0. 0.   .1 1.   1+9 1.   * PRESS SAFETY VALVE
120301  -3          0. 0.   .1 1.   1+9 1.   * STM LINE ATM. SAFETY VALVE
120401  -3          0. 0.   .1 1.   1+9 1.   * STM LINE RELIEF VALVE 1
120501  -3          0. 0.   .1 1.   1+9 1.   * STM LINE RELIEF VALVE 2
120601  -3          0. 0.   .1 1.   1+9 1.   * STM LINE RELIEF VALVE 3
120701  -3          0. 0.   .1 1.   1+9 1.   * STM LINE RELIEF VALVE 4
*
*  FUNCTION GENERATOR TABLE
120801  4   0.0 7.886-4    25. 7.886-4    40. 1.    1.+9 1.
*
*
*  FILL DATA
*
*        PRES POWER RELIEF VALVE         PSIA VS LMB/SEC
130101  -2  20  1  0
130102               2250. -54.255 1100. 2250.
130103               2350. -58.333 1100. 2350.
*        PRESS SAFTEY VALVES           PRES(PSIA) VS  FLOW(LBM/SEC)  EACH VALVE
130201  -2  20  1  0
130202               2400. -74.407 1100. 2400.
130203               2500. -80.    1100. 2400.
*        ATMOSPHERIC SAFTEY VALVES     PRES(PSIA) VS FLOW (LBM/SEC)  EACH VALVE
130301  -2  20  1  0
130302                950. -25.0206 1100.  950.
130303               1050. -27.972  1100. 1050.
*
*
* NO SG FW OR STEAM FLOW
130401  -2  20  0  0    *        SG FEEDWATER
130402                .0    0.0     415.503  853.4
130403               1.+9   0.0     415.503  853.4
*
130501  -2  20  0  0    *        SG STEAM FLOW
130502                .0    0.0     1100.  500.
130503               1.+9   0.0     1100.  500.
*
*        HPIS              PRESSURE (PSIA)  VS  FLOW (GPM)  EACH PUMP
130601  -2  4  1  1
130602               100. 100. 100. 100.
```

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130603              101. 100. 100. 100.
*        STEAMLINE RELIEF VALVES     PSIA VS LBM/SEC     4 EACH
130701  -2  20  1  0
130702              1100. -227.173  1100.  1100.
130703              1145. -236.473  1100.  1145.
*
*
* NO FLOW OF AIR
*     NFL  ID JX JY TYPE  TIME  FLOW  ENTHALPY   PRESSURE
130800 -6  25  0 -11
130801                     0.0     0.0   131.76   15.0
130802                     1.0     0.0   131.76   15.0
130803                    10.0     0.0   131.76   15.0  *
130804                    60.0     0.0   131.76   15.0  *
130805                    61.0     0.0   131.76   15.0
130806                   1.0E6     0.0   131.76   15.0
*
*
*  NORMALIZED POWER TABLE
*      PTS  TRP  IDUM  TIME POWER  TIME   POWER  TIME   POWER
141001  3    25    0    0.   0.005    1.0   0.005 1.0E6   0.005
*
*
*  HEAT CONDUCTOR DATA
*      IVSL IVSR IGOM CELEV IMCL IMCR   ASUL    ASUR    VOLS    HDML
150011  0    14   1   -16.7   2    2       0.  14153.  124.43  0.
150021  0    15   1   -12.7   2    2       0.  14153.  124.43  0.
150031  0    16   1    -8.7   2    2       0.  14153.  124.43  0.
150041  4    20   2     6.66  2    2   29514.  33322.  131.    0.0646
150051  5    20   2     6.66  2    2   29514.  33322.  131.    0.0646
150061  7    20   2     6.66  2    2   29514.  33322.  131.    0.0646
150071  6    20   2     6.66  2    2   29514.  33322.  131.    0.0646
*
*       HDMR    DHEL    DHER    CHNL    CHNR    IHXQF
150012  .04    0.       .047     0.      4.       0
150022  .04    0.       .047     0.     48.       0
150032  .04    0.       .047     0.     12.       0
150042  .112    .0646   .112    14.87   14.87     1
150052  .112    .0646   .112    29.75   29.75     1
150062  .112    .0646   .112    59.5    29.75     1
150072  .112    .0646   .112    44.62   14.87     1
*
*
*  CORE DATA
*      ISLB           CLTI    QFRAC
160010  1              0.       0.282
160020  2              0.       0.436
160030  3              0.       0.282
*
* GEOMETRY DATA
170101  2   3   1   4    .0   .01529     1.    *  FUEL PELLET
170102  1       4   1        3.35-4      0.    *  GAP
170103  0       2   3        1.958-3     0.    *  CLAD
170201  2   1   3   3  .0323  .00417     0.    *  S. G. TUBES
*
*
*  THERMAL CONDUCTIVITY DATA
*
*        THERM COND  UO2  REF GEAP-5591 LYONS ET AL (1968)   95 PCT TH DEN   93
*18XXYY
180101  -15                                                    * THERM COND  UO2  1
180102    32. 5.49  212. 4.40   392. 3.67   752. 2.76         * THERM COND  UO2  2
180103  1112. 2.23  1472. 1.88  1832. 1.65  2192. 1.48        * THERM COND  UO2  3
180104  2500. 1.40  3000. 1.33  3500. 1.33  4000. 1.39        * THERM COND  UO2  4
180105  4500. 1.51  4800. 1.61  5100. 1.73                    * THERM COND  UO2  5
*
*        THERMAL COND  ZR-4  REF  BRASSFIELD(1968)GEMP-482 RECOM... LWR LOCA
180201  -8      0.   8.    1490. 12.32  2150. 17.5          * THERM COND ZR-4   1
180202  2372. 19.7   2552. 21.8   2732. 24.0   3292. 28.9  * THERM COND ZR-4   2
180203  3360. 33.1                                          * THERM COND ZR-4   3
*
180301  -3       212.  10.     752.  11.   1832.  18.      * INCONEL-600
*
* GAP
180400   1          0.  .136
*
*
*  VOLUMETRIC HEAT CAPACITY
*
* SPEC HEAT  U02  REF  BRASSFIELD(1968)GEMP-482 RECOM...LWR LOCA
* SPEC HEAT  U02  95 PCT  TH DEN AT 1000F  642 LB/FT3
* SPEC HEAT  U02  REF  BRASSFIELD(1968)GEMP-482 TOULOUKIAN SAME TO 3750 F
*
190101  -19                                                   * VOL HT CAP U02    1
190102    77. 36.22        100. 37.12        200. 40.05       * VOL HT CAP U02    2
190103   300. 41.98        400. 43.88        600. 45.18       * VOL HT CAP U02    3
190104   800. 46.41       1000. 47.32                         * VOL HT CAP U02    4
190105                                      2400. 50.77       * VOL HT CAP U02    5
190106  2600. 51.43       2800. 52.61       3000. 54.57       * VOL HT CAP U02    6
190107  3200. 57.42       3400. 61.23       3600. 65.93       * VOL HT CAP U02    7
190108  4600. 95.15       4800. 99.31       5000. 101.57      * VOL HT CAP U02    8
190109  5074. 101.76                                          * VOL HT CAP UO2    9
*
*        SPEC HEAT  ZR-2   REF BMI-1803 ELDR1DGE ET AL (1967)            DEN 4
190201   15                                                  * VOL HT CAP  ZR-2      1
190202    32.  28.75      932.  32.56   1112.  34.40  * VOL HT CAP  ZR-2      2
190203  1184.  35.22    1490.  35.22   1508.  49.14  * VOL HT CAP  ZR-2      3
190204  1544.  57.74    1580.  60.20   1616.  70.43  * VOL HT CAP  ZR-2      4
190205  1652.  79.85    1688.  75.35   1724.  59.38  * VOL HT CAP  ZR-2      5
190206  1760.  45.86    1787.  34.81   3300.  34.81  * VOL HT CAP  ZR-2      6
*
*        INCONEL-600, CP....REF. NUCLEAR SYSTEMS MATERIALS HANDBOOK, SEC. 3.
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190301 -8  200. 57.2600   400. 60.1409   450. 60.6320   500. 61.1216*INCONEL-600
190302     550. 61.6216   600. 62.0564   800. 64.1549  1000. 67.2913
*
* GAP
*        SPEC HEAT  HELIUM  REF  KREITH  AT 1 ATM  DEN 0.012 LB/FT3
190401  -2      32. .0149       3400. .0149               * VOL HT CAP HELIUM 1
*
*
*  COEF OF LINEAR THERMAL EXPANSION
*
*        THERM EXPAN COEF  U02  REF  GEMP-482
200101  -2   0. 3.72-6   4082. 11.0-6                     * EXPAN COEF  U02   1
*
*        THERM EXPAN COEF  ZR-4  REF  GEMP-482 (1968)
200201   -4                                               * THERM EXPAN ZR-4  1
200202     0.  3.10-6   1580.  4.64-6   1584.  5.4-6       * THERM EXPAN ZR-4  2
200203  3400.  5.40-6                                     * THERM EXPAN ZR-4  3
*
200300  -2   0. 0.  2000. 0.            *  INCONEL 600
*
* GAP
200400  -2
200401     0.0    0.0    2000.  0.
*
*
*  HEAT EXCHANGER DATA   FOR  PRESSURIZER HEATERS
*21XXYY  IHTX TRIP  VOL TYPE    KW  TC
210101   0   22   18   5     200. 1.-9    *  CONTROL HEATER
210201   0   23   18   5     900. 30.     * 2 BACKUP HEATERS  450 KW EACH
210301   0   24   18   5     200. 30.     *  CONTROL HEATER
*
*
*********************************************************************************
* WATER ONLY INPUT WITH TRACE AMOUNT OF AIR
*********************************************************************************
*
* VOLUME INITIAL CONDITIONS
*
*        LVOL    PRES   TEMP      ENTH     QUAL       HUM
231001     1     50.0   275.0       0.0     1.0        1.0
231002     2     50.0   275.0       0.0     1.0        1.0
231003     3     50.0   275.0       0.0     1.0        1.0
231004     4     50.0   275.0       0.0     1.0        1.0
231005     5     50.0   275.0       0.0     1.0        1.0
231006     6     50.0   275.0       0.0     1.0        1.0
231007     7     50.0   275.0       0.0     1.0        1.0
231008     8     50.0   275.0    -275.0     1.9E-3     1.0
231009     9     50.0   275.0    -275.0     1.121E-1   1.0
231010    10     50.0   275.0    -275.0     1.543E-2   1.0
231011    11     50.0   275.0    -275.0     7.0E-4     1.0
231012    12     50.0   275.0       0.0     0.0        0.0
231013    13     50.0   275.0       0.0     0.0        0.0
231014    14     50.0   275.0       0.0     0.0        0.0
231015    15     50.0   275.0       0.0     0.0        0.0
231016    16     50.0   275.0    -275.0     1.0E-7     1.0
231018    18     50.0   275.0       0.0     1.0        1.0
231019    19     50.0   275.0       0.0     1.0        1.0
231020    20     15.0     0.0       0.0     0.0        0.0
*
*
*  CONTROL SYSTEM DATA
*
* OVER TEMPERATURE DELTA-T TRIP CONTROL SYSTEM
*702XXX    IDC    VAR    REG   GAIN    CIC
702001      1     TEMP,   2     1.0    606.5      * HOT LEG TEMPERATURE
702002      2     TEMP,   8     1.0    549.51     * COLD LEG TEMPERATURE
702003      3     PRES,  18     1.0   2220.0      * PRESSURIZER  PRESS
702004      4     CONS,   0     1.0      1.0      * CONSTANT BLOCK  1.0
702005      5     CONS,   0    56.99    56.99     * CONSTANT BLOCK 56.99
*
*703XXX   IDC ITYPE  INC1  INC2   CGAIN   CP1    CP2    CIC    CMIN    CMAX
703001    -1   SUM,   1     2       1.0   1.0   -1.0   56.99
703002    -2   SUM,   1     2       0.5   1.0    1.0  578.005
703003    -3   SUM,  -2     4    -0.0107  1.0  -578.005  0.0
703004    -4   SUM,   3     4   0.000453  1.0  -2220.    0.0
703005    -5   SUM,  -4     4       1.0   1.0    0.0     0.0
703006    -6   SUM,  -3    -5       1.0   1.0    1.0     0.0
703007    -7   SUM,  -6     4       1.0   1.0   1.095   1.095
703008    -8   MUL,   5    -7       1.0   0.0    0.0   62.404
703009    -9   SUM,  -8    -1       1.0  -1.0    1.0   -5.414
* OVER POWER DELTA-T TRIP CONTROL SYSTEM
703010   -10   DER,  -2     0       0.2   0.0    0.0     0.0   0.0     1.+9
703011   -11   SUM, -10     4       1.0  -1.0    0.0     0.0
703012   -12   SUM,  -2     4   0.00068   1.0  -578.005  0.0   0.0     1.+9
703013   -13   SUM, -12     4       1.0  -1.0    1.11    1.11
703014   -14   SUM, -11   -13       1.0   1.0    1.0     1.11
703015   -15   MUL, -14     5       1.0   0.0    0.0   63.259
703016   -16   SUM, -15    -1       1.0  -1.0    1.0   -6.269
* PRESSURIZER SPRAY CONTROL SYSTEM
703017   -17   SUM,   3     4       1.0   1.0  -2220.    0.0     0.0   1.+9
703018   -18   FNG, -17     8       1.0   0.0    0.0     7.886-4
703019   -19   LAG, -18     0       1.0   1.0    0.0     7.886-4
*
*
* CORE AND SG AVE HEAT TRANSFER COEFFICIENTS CALCULATORS
*
*702XXX    IDC    VAR    REG   GAIN    CIC
702031     31     WQCR,   1    1.0     0.0   * CORE HEAT TRANSFER
702032     32     WQCR,   2    1.0     0.0   * CORE HEAT TRANSFER
702033     33     WQCR,   3    1.0     0.0   * CORE HEAT TRANSFER
702034     34     WQCL,   4    1.0     0.0   * SG HEAT TRANSFER
702035     35     WQCL,   5    1.0     0.0   * SG HEAT TRANSFER
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702036     36     WQCL,   6    1.0     0.0   * SG HEAT TRANSFER
702037     37     WQCL,   7    1.0     0.0   * SG HEAT TRANSFER
*
*703XXX   IDC ITYPE  INC1  INC2   CGAIN   CP1    CP2    CIC    CMIN    CMAX
703030   -30   SUM,  31    32       1.0   1.0    1.0    0.0
703031   -31   SUM, -30    33   2.931E-7  1.0    1.0    0.0  * CORE HT (MW)
703032   -32   SUM,  34    35       1.0   1.0    1.0    0.0
703033   -33   SUM,  36    37       1.0   1.0    1.0    0.0
703034   -34   SUM, -32   -33  -2.931E-7  1.0    1.0    0.0  * SG  HT (MW)
*
702050    50   GASM  4   1.0   0.0
702051    51   AIRM  4   1.0   0.0
702052    52   FMAS  4   1.0   0.0
703050   -50   SUM   50  51  1.0   1.0  -1.0  0.0  * VAPOR MASS VOL 4
703051   -51   DIV  -50  52  1.0   0.0   0.0  0.0  * VAP MASS FRAC VOL 4
*
702060  60  AIRM   1  1.0  0.0
702061  61  AIRM   2  1.0  0.0
702062  62  AIRM   3  1.0  0.0
702063  63  AIRM   4  1.0  0.0
702064  64  AIRM   5  1.0  0.0
702065  65  AIRM   6  1.0  0.0
702066  66  AIRM   7  1.0  0.0
702067  67  AIRM   8  1.0  0.0
702068  68  AIRM   9  1.0  0.0
702069  69  AIRM  10  1.0  0.0
702070  70  AIRM  11  1.0  0.0
702071  71  AIRM  12  1.0  0.0
702072  72  AIRM  13  1.0  0.0
702073  73  AIRM  14  1.0  0.0
702074  74  AIRM  15  1.0  0.0
702075  75  AIRM  16  1.0  0.0
702076  76  AIRM  18  1.0  0.0
702077  77  AIRM  19  1.0  0.0
702078  78  AIRM  20  1.0  0.0
*
703060 -60  SUM  60  61  1.0  1.0  1.0  0.0
703061 -61  SUM -60  62  1.0  1.0  1.0  0.0
703062 -62  SUM -61  63  1.0  1.0  1.0  0.0
703063 -63  SUM -62  64  1.0  1.0  1.0  0.0
703064 -64  SUM -63  65  1.0  1.0  1.0  0.0
703065 -65  SUM -64  66  1.0  1.0  1.0  0.0
703066 -66  SUM -65  67  1.0  1.0  1.0  0.0
703067 -67  SUM -66  68  1.0  1.0  1.0  0.0
703068 -68  SUM -67  69  1.0  1.0  1.0  0.0
703069 -69  SUM -68  70  1.0  1.0  1.0  0.0
703070 -70  SUM -69  71  1.0  1.0  1.0  0.0
703071 -71  SUM -70  72  1.0  1.0  1.0  0.0
703072 -72  SUM -71  73  1.0  1.0  1.0  0.0
703073 -73  SUM -72  74  1.0  1.0  1.0  0.0
703074 -74  SUM -73  75  1.0  1.0  1.0  0.0
703075 -75  SUM -74  76  1.0  1.0  1.0  0.0
703076 -76  SUM -75  77  1.0  1.0  1.0  0.0
703077 -77  SUM -76  78  1.0  1.0  1.0  0.0     * SUM AIR MASS
*
*
. ENDECK
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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page    1
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:59
  REDUCED INVENTORY SYSTEM MODEL - RETRAN-3D SAMPLE PROBLEM                                                    CPU TIME =    0.000
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

RETRAN PROBLEM CONTROL AND DESCRIPTION DATA.

    WORD  DESCRIPTION
    ====  ======================================================================
      1   RESTART FILE OPTION (SAVE=-1 / NO SAVE=0) .................... =    0
      2   PRINTER PLOT OPTION (YES=1 / NO=0) ........................... =    0
      3   POWER OPTION (TAPE OPTNS<0 / NO/TBL=0 / PT KIN=1 / 1D=2 / 3D=3) =    0
      4   USE STEADY-STATE SOLUTION (YES=0 / NO=1) ..................... =    1
      5   USE NEUTRON VOID MODEL (YES=1 / NO=0) ........................ =    0
      6   USE GENERALIZED TRANSPORT MODEL (NO=0 / VAP=1 / LIQ=-1) ....... =    0
      7   HEAT TRANSFER MAP OPTION (FORCED=0 / NAT CONV=1) ............. =    1
      8   SLIP OPTION (DYN=1 / Z-L=2 / C-L=3 / Z-L TAUGL=4 / C-L TAUGL=5) =    1
      9   FIVE-EQUATION OPTION (NO= 0 / YES=1) ......................... =    1
     10   NONCONDENSABLE GAS FLOW OPTION (NO=0 / YES=1) ................ =    1
     11   TH MATRIX DIRECT SOLVER OPTION (4-EQ=2 / 6-EQ=3) ............. =    3
     12   TH MATRIX ITERATIVE SOLVER OPTION (NO<=1 / YES=2) ............ =    0

    (DIMENSIONS AND OPTIONS AUTOMATICALLY DETERMINED BY CONTENT OF INPUT DATA)

          NUMBER OF MINOR EDIT SETS (0200XX DATA )...................... =   11
          NUMBER OF TIME-STEP CONTROL SETS (03XXX0 DATA )............... =    8
          NUMBER OF TRIP CONTROL SETS (04XXX0 DATA ).................... =   42
          NUMBER OF CONTROL VOLUME DESCRIPTIONS (05XXXY DATA ).......... =   19
          NUMBER OF BUBBLE RISE DESCRIPTIONS (060XXY DATA) ............. =    1
          NUMBER OF TIME DEPENDENT VOLUMES FORM CARDS (07XXYY DATA) ..... =    0
          NUMBER OF JUNCTION DESCRIPTIONS (08XXXY DATA) ................ =   30
          NUMBER OF CENTRIFUGAL PUMP DESCRIPTIONS (090XXY DATA )........ =    1
          NUMBER OF VALVE DESCRIPTIONS (11XXXY DATA) ................... =   10
          NUMBER OF GENERAL DATA TABLE DESCRIPTIONS (12XXYY DATA) ....... =    8
          NUMBER OF FILL DESCRIPTIONS (13XXYY DATA ).................... =    8
          NUMBER OF HEAT CONDUCTOR DESCRIPTIONS (15XXXY DATA) .......... =    7
          NUMBER OF HEAT CONDUCTOR GEOMETRY DESCRIPTIONS (17XXYY DATA) .. =    2
          NUMBER OF HEAT CONDUCTOR MATERIAL DESCRIPTIONS (18XXYY DATA) .. =    4
          NUMBER OF CORE SECTION DESCRIPTIONS (16XXXY DATA) ............ =    3
          NUMBER OF NON-CONDUCTNG HEAT EXCHNGR DESCRIPTIONS (21XXYY DATA) =    3
          NUMBER OF TIME DEP BCS FROM TAPE (IREAD<0 ON 05XXXY DATA) ..... =    0
          NUMBER OF SPECIFIED HEAT TRAN COEF DESCRIPTIONS (015XXX DATA) . =    0
          TWO-REGION NONEQ VOL DESCRIPTIONS (610XXX OR 611XXX DATA) ..... =    0
          TEMP. TRANSPORT DELAY OPTION (MESH>0 ON 05XXXY DATA) .......... =    0
          AUXILIARY DNB MODEL (8001XX DATA INCLUDED) ................... =    0
          CONTROL SYSTEM MODEL (702XXX OR 702XXXX DATA) ................ =    1
          ACCUMULATOR MODEL DESCRIPTIONS (620XXX OR 621XXX DATA)......... =    0
          DYNAMIC GAP CONDUCTANCE MODEL DESCRIPTIONS (225XX0 DATA) ...... =    0
          NUMBER OF HT CONDUCTOR STACK DESCRIPTIONS (2200XY DATA) ....... =    0
          NUMBER OF TURBINE SHAFT DESCRIPTIONS (500XXY DATA) ........... =    0
          NUMBER OF PROFILE FIT DESCRIPTIONS (061XX1 DATA) ............. =    0
          NUMBER OF STEAM-WATER SEPARATOR DESCRIPTIONS (60XXX0 DATA) .... =    0


                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * *                                                * * *
                   * * *          STEADY-STATE OPTION    =   1          * * *
                   * * *                                                * * *
                   * * *          SLIP OPTION            =   1          * * *
                   * * *                                                * * *
                   * * *          NUMERICS OPTION        =   3          * * *
                   * * *                                                * * *
                   * * *          HEAT TRANSFER OPTION   =   1          * * *
                   * * *                                                * * *
                   * * *          NEW EQUATIONS OPTION   =   1          * * *
                   * * *                                                * * *
                   * * *         USING THE 6-EQ SOLVER - SOLVE4         * * *
                   * * *                                                * * *
                   * * *    USING THE NONCONDENSABLE GAS FLOW OPTION    * * *
                   * * *                                                * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *


INITIAL THERMAL POWER (MEGAWATTS) =  2.24400E+03


AIR IS THE DEFAULT NONCONDENSABLE GAS.
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PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE -- NRC APPROVED VERSION 29/08/14 Page 34
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis 11:57:59
REDUCED INVENTORY SYSTEM MODEL - RETRAN-3D SAMPLE PROBLEM CPU TIME = 0.047
* *

NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	ENERGY BALANCE (BTU)	TOTAL MASS BALANCE (LBM)	NCG MASS BALANCE (LBM)	AVERAGE TIME STEP (SEC)	CURRENT TIME STEP (SEC)	ELAPSED TIME (SEC)	TIME STEP NUM STANDRD/ACTUL
5.00000E-03	1.12200E+01	3.82939E+07	1.07647E+08	5.41965E+05	1.18280E+02	0.00000E+00	0.00000E+00	0.00000E+00	0 / 0

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	VOID FRAC.	POWR TO H2O (BTU/SEC)	NCG QUALITY
1	5.00000E+01	1.22727E+02	1.03320E+03	1.24684E-01	2.75000E+02	1.00000E+00	1.00000E+00	0.00000E+00	1.39536E-01
2	5.00000E+01	3.68069E+01	1.03320E+03	1.24684E-01	2.75000E+02	1.00000E+00	1.00000E+00	0.00000E+00	1.39536E-01
3	5.00000E+01	5.06094E+01	1.03320E+03	1.24684E-01	2.75000E+02	1.00000E+00	1.00000E+00	0.00000E+00	1.39536E-01
4	5.00000E+01	7.57458E+01	1.03320E+03	1.24684E-01	2.75000E+02	1.00000E+00	1.00000E+00	-1.16091E+05	1.39536E-01
5	5.00000E+01	7.57458E+01	1.03320E+03	1.24684E-01	2.75000E+02	1.00000E+00	1.00000E+00	-1.04768E+05	1.39536E-01
6	5.00000E+01	7.57458E+01	1.03320E+03	1.24684E-01	2.75000E+02	1.00000E+00	1.00000E+00	-9.86187E+04	1.39536E-01
7	5.00000E+01	7.57458E+01	1.03320E+03	1.24684E-01	2.75000E+02	1.00000E+00	1.00000E+00	-9.44515E+04	1.39536E-01
8	5.00000E+01	2.46921E+04	2.45366E+02	3.08036E+01	2.75000E+02	1.90000E-03	4.69399E-01	0.00000E+00	1.39536E-01
9	5.00000E+01	6.29926E+02	3.32351E+02	1.09362E+00	2.75000E+02	1.12100E-01	9.83242E-01	0.00000E+00	1.39536E-01
10	5.00000E+01	1.76064E+03	2.56046E+02	7.10509E+00	2.75000E+02	1.54300E-02	8.79272E-01	0.00000E+00	1.39536E-01
11	5.00000E+01	3.45535E+04	2.44419E+02	4.37442E+01	2.75000E+02	7.00000E-04	2.45587E-01	0.00000E+00	1.39536E-01
12	5.00000E+01	4.67143E+04	2.43867E+02	5.79438E+01	2.75000E+02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
13	5.00000E+01	2.47420E+03	2.43867E+02	5.79438E+01	2.75000E+02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
14	5.00000E+01	9.69979E+03	2.43867E+02	5.79438E+01	2.75000E+02	0.00000E+00	0.00000E+00	2.99959E+03	0.00000E+00
15	5.00000E+01	9.69979E+03	2.43867E+02	5.79438E+01	2.75000E+02	0.00000E+00	0.00000E+00	4.63767E+03	0.00000E+00
16	5.00000E+01	9.69934E+03	2.43867E+02	5.79411E+01	2.75000E+02	1.00000E-07	4.64702E-05	2.99959E+03	1.39536E-01
18	5.00000E+01	1.62090E+02	1.03320E+03	1.24684E-01	2.75000E+02	1.00000E+00	1.00000E+00	0.00000E+00	1.39536E-01
19	5.00000E+01	3.56598E+00	1.03320E+03	1.24684E-01	2.75000E+02	1.00000E+00	1.00000E+00	0.00000E+00	1.39536E-01
20	1.50000E+01	4.01363E+05	1.81378E+02	4.69815E+01	2.12968E+02	1.73768E-04	2.14286E-01	4.13901E+05	0.00000E+00

JUNCTION NUMBER	CONNECTS VOLUMES	CHOK/ PATH	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E VEL. PSI	ELEV. PSI	D I F F E R E N T I A L S FRIC. PSI	ACCL. PSI	PUMP PSI
1	1 TO 2		0.00000E+00	1.03320E+03	8.02024E+00	0.00000E+00	7.61961E-04	0.00000E+00	7.61961E-04	0.00000E+00
2	2 TO 3		0.00000E+00	1.03320E+03	8.02024E+00	0.00000E+00	-3.40718E-03	0.00000E+00	-3.40718E-03	0.00000E+00
3	3 TO 4		0.00000E+00	1.03320E+03	8.02024E+00	0.00000E+00	-8.62401E-03	0.00000E+00	-8.62401E-03	0.00000E+00
4	4 TO 5		0.00000E+00	1.03320E+03	8.02024E+00	0.00000E+00	-1.28754E-02	0.00000E+00	-1.28754E-02	0.00000E+00
5	5 TO 6		0.00000E+00	1.03320E+03	8.02024E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
6	6 TO 7		0.00000E+00	1.03320E+03	8.02024E+00	0.00000E+00	1.28754E-02	0.00000E+00	1.28754E-02	0.00000E+00
7	7 TO 8		0.00000E+00	1.03320E+03	8.02024E+00	0.00000E+00	1.76695E+00	0.00000E+00	1.76695E+00	0.00000E+00
8	8 TO 9		0.00000E+00	2.45366E+02	3.24638E-02	0.00000E+00	5.08659E-01	0.00000E+00	5.08659E-01	0.00000E+00
9	9 TO 10		0.00000E+00	2.56046E+02	1.40744E-01	0.00000E+00	-1.09742E-02	0.00000E+00	-1.09742E-02	0.00000E+00
10	10 TO 11		0.00000E+00	2.56046E+02	1.40744E-01	0.00000E+00	1.97912E+00	0.00000E+00	1.97912E+00	0.00000E+00
11	11 TO 12		0.00000E+00	2.44419E+02	2.28602E-02	0.00000E+00	4.76020E+00	0.00000E+00	4.76020E+00	0.00000E+00
12	12 TO 13		0.00000E+00	2.43867E+02	1.72581E-02	0.00000E+00	-4.39608E+00	0.00000E+00	-4.39608E+00	0.00000E+00
13	12 TO 14		0.00000E+00	2.43867E+02	1.72581E-02	0.00000E+00	-2.78653E+00	0.00000E+00	-2.78653E+00	0.00000E+00
14	14 TO 15		0.00000E+00	2.43867E+02	1.72581E-02	0.00000E+00	-1.60955E+00	0.00000E+00	-1.60955E+00	0.00000E+00
15	15 TO 16		0.00000E+00	2.43867E+02	1.72589E-02	0.00000E+00	-1.60951E+00	0.00000E+00	-1.60951E+00	0.00000E+00
16	16 TO 1		0.00000E+00	1.03320E+03	8.02024E+00	0.00000E+00	-8.09742E-01	0.00000E+00	-8.09742E-01	0.00000E+00
17	13 TO 1		0.00000E+00	1.03320E+03	8.02024E+00	0.00000E+00	-2.41933E+00	0.00000E+00	-2.41933E+00	0.00000E+00
20	19 TO 18		0.00000E+00	1.03320E+03	8.02024E+00	0.00000E+00	-1.84213E-02	0.00000E+00	-1.84213E-02	0.00000E+00
21	2 TO 19		0.00000E+00	1.03320E+03	8.02024E+00	0.00000E+00	-3.62797E-03	0.00000E+00	-3.62797E-03	0.00000E+00
50	0 TO 1		0.00000E+00	1.03320E+03	8.02024E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
31	0 TO 20		0.00000E+00	1.15083E+03	2.62481E+01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
30	0 TO 20		0.00000E+00	1.15083E+03	2.62481E+01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
29	0 TO 20		0.00000E+00	1.15083E+03	2.62481E+01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
28	0 TO 20		0.00000E+00	1.15083E+03	2.62481E+01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
27	0 TO 20		0.00000E+00	1.15083E+03	2.62481E+01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
26	0 TO 18		0.00000E+00	1.03320E+03	8.02024E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
25	0 TO 18		0.00000E+00	1.03320E+03	8.02024E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
24	0 TO 10		0.00000E+00	2.56046E+02	1.40744E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
23	0 TO 20		0.00000E+00	1.15083E+03	2.62481E+01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
22	0 TO 20		0.00000E+00	1.81209E+02	1.67268E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

VOLUME NUMBER	FLOW REG.	LIQ. ENTH. (BTU/LB)	GAS ENTH. (BTU/LB)	LIQ. TEMP. (DEG. F)	GAS TEMP. (DEG. F)	IF AREA DEN (FT2/FT3)	IF HT COEFF (B/H-FT2-F)	IF MASS TRN (LB/SEC)	TOT MAS TRN (LB/SEC)	LIQ. HT RT (BTU/SEC)
8	0	2.43867E+02	1.03320E+03	2.75000E+02	2.75000E+02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
9	0	2.43867E+02	1.03320E+03	2.75000E+02	2.75000E+02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
10	0	2.43867E+02	1.03320E+03	2.75000E+02	2.75000E+02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
11	0	2.43867E+02	1.03320E+03	2.75000E+02	2.75000E+02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
16	0	2.43867E+02	1.03320E+03	2.75000E+02	2.75000E+02	0.00000E+00	0.00000E+00	0.00000E+00	3.19098E+00	-7.40834E+02

BUBL SET NUMB.	VOL. NUMB.	BUBBLE GRADIENT PARAMETER	BUBBLE VELOCITY (FT/SEC)	MIXTURE LEVEL (FT)	MIXTURE QUALITY	BUBBLE MASS (LB)
1	20	0.00000E+00	1.40700E+01	4.95000E+01	0.00000E+00	0.00000E+00

PUMP NUMB.	VOL. NUMB.	PUMP SPEED (RPM)	NORM. PUMP TORQUE	NORM. FRIC. TORQUE	NORM. MOT. TORQUE	POWER TO H2O (BTU/HR)
1	9	0.00000E+00	0.00000E+00	0.00000E+00	1.00000E+00	0.00000E+00

HEAT COND. NUMBER	VOL. NUM.	HT TRAN MODE-COR	SURF. FLUX (BTU/HR-FT2)	CRIT. FLUX (BTU/HR-FT2)	H.T. COEF. (BTU/H-F2-F)	SURF. TEMP. (DEG. F)	MASS FLUX (LBM/HR-FT2)	STORD ENRGY (BTU)	POWR TO H2O (BTU/HR)	DRYOUT PNT ()
1 RGHT	14	20-DB-T	7.62985E+02	9.00000E+04	9.42645E+01	2.83094E+02	0.00000E+00	1.34421E+06	1.07985E+07	
2 RGHT	15	20-DB-T	1.17965E+03	9.00000E+04	1.37694E+02	2.83567E+02	0.00000E+00	1.35426E+06	1.66956E+07	
3 RGHT	16	20-DB-T	7.62985E+02	9.00000E+04	4.01679E+02	2.76899E+02	0.00000E+00	1.31171E+06	1.07985E+07	
4 LEFT	4	23-CARP	-1.41604E+04	9.00000E+04	2.91825E+02	2.26477E+02	0.00000E+00		-4.17929E+08	
RGHT	20	2-THOM	1.25413E+04	9.00000E+04	1.57401E+03	2.20936E+02	0.00000E+00	1.68718E+06	4.17900E+08	
5 LEFT	5	23-CARP	-1.27792E+04	9.00000E+04	2.58365E+02	2.25538E+02	0.00000E+00		-3.77165E+08	
RGHT	20	2-THOM	1.13180E+04	9.00000E+04	1.49528E+03	2.20537E+02	0.00000E+00	1.68194E+06	3.77139E+08	
6 LEFT	7	23-CARP	-1.15208E+04	9.00000E+04	2.28878E+02	2.24664E+02	0.00000E+00		-3.40025E+08	
RGHT	20	2-THOM	1.02035E+04	9.00000E+04	1.41975E+03	2.20155E+02	0.00000E+00	1.67701E+06	3.40002E+08	
7 LEFT	6	23-CARP	-1.20291E+04	9.00000E+04	2.40676E+02	2.25019E+02	0.00000E+00		-3.55027E+08	
RGHT	20	2-THOM	1.06537E+04	9.00000E+04	1.45073E+03	2.20312E+02	0.00000E+00	1.67902E+06	3.55003E+08	

CORE NUMB.	COND. NUMB.	DEPTH REAC. EXT. ZR-H2O (FT)	DEPTH REAC. INT. ZR-H2O (FT)	HEAT GEN. ZR-H2O (BTU/HR)	COND. HEAT-ING RATE (BTU/HR)	DIR. MODER-ATOR HT RT (BTU/HR)	AVG. METAL TEMPERATURE (DEG. F)	CENTERLINE TEMPERATURE (DEG. F)	FUEL ENTHALPY (CAL/GM)
1	1	0.00000E+00	0.00000E+00	0.00000E+00	1.07989E+07	0.00000E+00	2.86186E+02	2.87030E+02	0.00000E+00
2	2	0.00000E+00	0.00000E+00	0.00000E+00	1.66961E+07	0.00000E+00	2.88349E+02	2.89657E+02	0.00000E+00
3	3	0.00000E+00	0.00000E+00	0.00000E+00	1.07989E+07	0.00000E+00	2.79988E+02	2.80827E+02	0.00000E+00

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

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 HEAT EXCGR.   VOLUME   POWR TO H2O
 NUMBER        NUMBER   (BTU/HR)
     1            18    0.00000E+00
     2            18    0.00000E+00
     3            18    0.00000E+00
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PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   41
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:58:28
  REDUCED INVENTORY SYSTEM MODEL - RETRAN-3D SAMPLE PROBLEM                                                     CPU TIME =    22.558
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *
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SYSTEM ELAPSED TIME (SEC)	SYSTEM ELAPSED TIME (SEC)	TIME STP ACTUAL	SYSTEM NORM. POWER	VOL 2 AVG. TEMP. (DEG F)	VOL 10 AVG. TEMP. (DEG F)	JUN 1 FLOW (LB/SEC)	JUN 10 FLOW (LB/SEC)	VOL 1 VOID FRACTN
0.00000E+00	0.00000E+00	0.00000E+00	5.00000E-03	2.75000E+02	2.75000E+02	0.00000E+00	0.00000E+00	1.00000E+00
1.00000E-02	1.00000E-02	1.45000E+02	5.00000E-03	2.74990E+02	2.75000E+02	1.00913E-02	5.47568E+01	1.00000E+00
2.00000E-02	2.00000E-02	2.97000E+02	5.00000E-03	2.74632E+02	2.74999E+02	1.43758E+00	1.08300E+02	9.99986E-01
3.00000E-02	3.00000E-02	6.73000E+02	5.00000E-03	2.73265E+02	2.74998E+02	1.21427E+01	1.59555E+02	9.99986E-01
4.00000E-02	4.00000E-02	9.36000E+02	5.00000E-03	2.71222E+02	2.74996E+02	4.52414E+01	2.07941E+02	9.99985E-01
5.00000E-02	5.00000E-02	1.06200E+03	5.00000E-03	2.67839E+02	2.74994E+02	1.03230E+02	2.52957E+02	9.99984E-01
6.00000E-02	6.00000E-02	1.18100E+03	5.00000E-03	2.68588E+02	2.74993E+02	1.68920E+02	2.94744E+02	9.99982E-01
7.00000E-02	7.00000E-02	1.28100E+03	5.00000E-03	2.69123E+02	2.74991E+02	2.19435E+02	3.33031E+02	9.99979E-01
8.00000E-02	8.00000E-02	1.38100E+03	5.00000E-03	2.67928E+02	2.74989E+02	2.48282E+02	3.68207E+02	9.99939E-01
9.00000E-02	9.00000E-02	1.61300E+03	5.00000E-03	2.63959E+02	2.74987E+02	2.65680E+02	3.99563E+02	9.99839E-01
1.00000E-01	1.00000E-01	1.71700E+03	5.00000E-03	2.58948E+02	2.74986E+02	2.84386E+02	4.27210E+02	9.99626E-01
1.50000E-01	1.50000E-01	3.12000E+03	5.00000E-03	2.52114E+02	2.74985E+02	5.13085E+02	5.59228E+02	9.94960E-01
2.00000E-01	2.00000E-01	3.64600E+03	5.00000E-03	2.58355E+02	2.74979E+02	9.97639E+02	7.04105E+02	9.85013E-01
2.50000E-01	2.50000E-01	4.14600E+03	5.00000E-03	2.59438E+02	2.74962E+02	1.62189E+03	7.79943E+02	9.74940E-01
3.00000E-01	3.00000E-01	4.64600E+03	5.00000E-03	2.59859E+02	2.74950E+02	2.22614E+03	7.72521E+02	9.66509E-01
4.00000E-01	4.00000E-01	5.09600E+03	5.00000E-03	2.60062E+02	2.74940E+02	3.23910E+03	6.88358E+02	9.52975E-01
5.00000E-01	5.00000E-01	6.12200E+03	5.00000E-03	2.61070E+02	2.74916E+02	3.97502E+03	4.91667E+02	9.40324E-01
6.00000E-01	6.00000E-01	9.00800E+03	5.00000E-03	2.62011E+02	2.74915E+02	4.50837E+03	2.90704E+02	9.27695E-01
7.00000E-01	7.00000E-01	1.41600E+04	5.00000E-03	2.62922E+02	2.74909E+02	4.91218E+03	2.31694E+02	9.15656E-01
8.00000E-01	8.00000E-01	1.48030E+04	5.00000E-03	2.63745E+02	2.74899E+02	5.22816E+03	2.38022E+02	9.04292E-01
9.00000E-01	9.00000E-01	1.54100E+04	5.00000E-03	2.64538E+02	2.74891E+02	5.48478E+03	3.24832E+02	8.93486E-01
1.00000E+00	1.00000E+00	1.59730E+04	5.00000E-03	2.65247E+02	2.74870E+02	5.70219E+03	4.62478E+02	8.83239E-01
1.10000E+00	1.10000E+00	1.63730E+04	5.00000E-03	2.65944E+02	2.74837E+02	5.89367E+03	5.71708E+02	8.73384E-01
1.20000E+00	1.20000E+00	1.67730E+04	5.00000E-03	2.66543E+02	2.74791E+02	6.06351E+03	6.46119E+02	8.63925E-01
1.30000E+00	1.30000E+00	1.71730E+04	5.00000E-03	2.67108E+02	2.74723E+02	6.21640E+03	5.79099E+02	8.54951E-01
1.40000E+00	1.40000E+00	1.76000E+04	5.00000E-03	2.67598E+02	2.74664E+02	6.35650E+03	2.64133E+02	8.46489E-01
1.50000E+00	1.50000E+00	1.80000E+04	5.00000E-03	2.68051E+02	2.74643E+02	6.48643E+03	2.67698E+02	8.38528E-01
1.60000E+00	1.60000E+00	1.84000E+04	5.00000E-03	2.68446E+02	2.74595E+02	6.60977E+03	1.80869E+02	8.31075E-01
1.70000E+00	1.70000E+00	1.88440E+04	5.00000E-03	2.68823E+02	2.74587E+02	6.72946E+03	4.67324E+01	8.24162E-01
1.80000E+00	1.80000E+00	1.93080E+04	5.00000E-03	2.69152E+02	2.74565E+02	6.84675E+03	2.86104E+02	8.17834E-01
1.90000E+00	1.90000E+00	1.97650E+04	5.00000E-03	2.69456E+02	2.74501E+02	6.96279E+03	3.91101E+02	8.12132E-01
2.00000E+00	2.00000E+00	2.02140E+04	5.00000E-03	2.69725E+02	2.74417E+02	7.07988E+03	4.93121E+02	8.07073E-01
2.10000E+00	2.10000E+00	2.06140E+04	5.00000E-03	2.70011E+02	2.74307E+02	7.19182E+03	5.63225E+02	8.02655E-01
2.20000E+00	2.20000E+00	2.10140E+04	5.00000E-03	2.70301E+02	2.73544E+02	7.29141E+03	1.78511E+02	7.98833E-01
2.30000E+00	2.30000E+00	2.14140E+04	5.00000E-03	2.70535E+02	2.72034E+02	7.34069E+03	-3.97897E+02	7.95506E-01
2.40000E+00	2.40000E+00	2.18140E+04	5.00000E-03	2.70721E+02	2.69505E+02	7.31781E+03	-1.33200E+03	7.92511E-01
2.50000E+00	2.50000E+00	2.22980E+04	5.00000E-03	2.70871E+02	2.67637E+02	7.24846E+03	-2.72021E+03	7.89735E-01
2.60000E+00	2.60000E+00	2.29670E+04	5.00000E-03	2.70997E+02	2.67839E+02	7.16833E+03	-4.23631E+03	7.87171E-01
2.70000E+00	2.70000E+00	2.35320E+04	5.00000E-03	2.71106E+02	2.68906E+02	7.09523E+03	-5.46861E+03	7.84896E-01
2.80000E+00	2.80000E+00	2.40000E+04	5.00000E-03	2.71204E+02	2.69796E+02	7.02425E+03	-6.28251E+03	7.83006E-01
2.90000E+00	2.90000E+00	2.44030E+04	5.00000E-03	2.71289E+02	2.70391E+02	6.94161E+03	-6.73104E+03	7.81577E-01
3.00000E+00	3.00000E+00	2.48030E+04	5.00000E-03	2.71364E+02	2.70858E+02	6.84078E+03	-6.98916E+03	7.80650E-01
3.10000E+00	3.10000E+00	2.53030E+04	5.00000E-03	2.71428E+02	2.71358E+02	6.72730E+03	-7.24965E+03	7.80248E-01
3.20000E+00	3.20000E+00	2.61510E+04	5.00000E-03	2.71481E+02	2.71835E+02	6.61158E+03	-7.34895E+03	7.80676E-01
3.30000E+00	3.30000E+00	2.67510E+04	5.00000E-03	2.71518E+02	2.72152E+02	6.48950E+03	-7.11440E+03	7.83816E-01
3.40000E+00	3.40000E+00	2.72530E+04	5.00000E-03	2.71531E+02	2.72338E+02	6.34555E+03	-6.53650E+03	7.88785E-01
3.50000E+00	3.50000E+00	2.78190E+04	5.00000E-03	2.71514E+02	2.72436E+02	6.17314E+03	-5.92396E+03	7.94796E-01
3.60000E+00	3.60000E+00	2.83280E+04	5.00000E-03	2.71479E+02	2.72484E+02	6.00209E+03	-5.59446E+03	7.97662E-01
3.70000E+00	3.70000E+00	2.88750E+04	5.00000E-03	2.71446E+02	2.72451E+02	5.87436E+03	-5.47463E+03	7.99065E-01
3.80000E+00	3.80000E+00	2.93810E+04	5.00000E-03	2.71417E+02	2.72470E+02	5.79529E+03	-5.41468E+03	8.00964E-01

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   42
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:58:28
  REDUCED INVENTORY SYSTEM MODEL - RETRAN-3D SAMPLE PROBLEM                                                     CPU TIME =   22.558
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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SYSTEM ELAPSED TIME (SEC)	VOL 14 VOID FRACTN	VOL 15 VOID FRACTN	VOL 16 VOID FRACTN
0.00000E+00	0.00000E+00	0.00000E+00	4.64702E-05
1.00000E-02	0.00000E+00	0.00000E+00	2.62601E-04
2.00000E-02	0.00000E+00	0.00000E+00	3.19682E-04
3.00000E-02	0.00000E+00	0.00000E+00	6.78717E-04
4.00000E-02	0.00000E+00	0.00000E+00	8.76939E-04
5.00000E-02	0.00000E+00	0.00000E+00	1.34961E-03
6.00000E-02	0.00000E+00	0.00000E+00	1.72553E-03
7.00000E-02	0.00000E+00	0.00000E+00	2.23734E-03
8.00000E-02	0.00000E+00	0.00000E+00	2.91308E-03
9.00000E-02	0.00000E+00	0.00000E+00	3.92513E-03
1.00000E-01	0.00000E+00	3.02868E-04	5.33421E-03
1.50000E-01	0.00000E+00	6.24926E-03	2.79645E-02
2.00000E-01	0.00000E+00	1.34421E-02	7.83394E-02
2.50000E-01	0.00000E+00	1.63691E-02	1.30749E-01
3.00000E-01	0.00000E+00	1.41479E-02	1.75363E-01
4.00000E-01	0.00000E+00	0.00000E+00	2.44507E-01
5.00000E-01	0.00000E+00	0.00000E+00	2.82195E-01
6.00000E-01	0.00000E+00	0.00000E+00	3.09752E-01
7.00000E-01	0.00000E+00	0.00000E+00	3.26847E-01
8.00000E-01	5.23367E-03	0.00000E+00	3.32714E-01
9.00000E-01	1.12018E-02	0.00000E+00	3.35002E-01
1.00000E+00	1.71193E-02	4.28991E-03	3.32979E-01
1.10000E+00	2.44662E-02	1.38340E-02	3.26916E-01
1.20000E+00	3.20981E-02	2.48212E-02	3.22648E-01
1.30000E+00	3.92701E-02	3.60503E-02	3.21313E-01
1.40000E+00	4.67067E-02	4.78359E-02	3.21888E-01
1.50000E+00	5.48325E-02	6.09396E-02	3.24083E-01
1.60000E+00	6.32417E-02	7.54728E-02	3.28610E-01
1.70000E+00	7.18236E-02	9.07394E-02	3.36084E-01
1.80000E+00	8.08950E-02	1.06786E-01	3.46439E-01
1.90000E+00	8.97324E-02	1.23834E-01	3.59402E-01
2.00000E+00	9.80771E-02	1.41140E-01	3.74458E-01
2.10000E+00	1.06406E-01	1.58454E-01	3.90589E-01
2.20000E+00	1.14333E-01	1.75887E-01	4.06807E-01
2.30000E+00	1.22886E-01	1.93928E-01	4.22248E-01
2.40000E+00	1.33055E-01	2.14226E-01	4.36707E-01
2.50000E+00	1.43770E-01	2.37537E-01	4.50816E-01
2.60000E+00	1.55756E-01	2.63121E-01	4.65349E-01
2.70000E+00	1.69848E-01	2.91087E-01	4.80714E-01
2.80000E+00	1.86249E-01	3.22181E-01	4.97132E-01
2.90000E+00	2.06608E-01	3.56546E-01	5.14775E-01
3.00000E+00	2.30066E-01	3.94269E-01	5.33566E-01
3.10000E+00	2.49930E-01	4.34819E-01	5.53409E-01
3.20000E+00	2.04821E-01	4.98800E-01	5.89771E-01
3.30000E+00	2.16031E-01	5.05883E-01	6.32357E-01
3.40000E+00	2.17211E-01	5.09956E-01	6.71611E-01
3.50000E+00	2.41437E-01	5.29386E-01	6.77667E-01
3.60000E+00	2.32654E-01	6.08817E-01	6.73120E-01
3.70000E+00	2.41913E-01	6.68216E-01	6.86382E-01
3.80000E+00	2.75015E-01	6.98992E-01	7.06232E-01

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE -- NRC APPROVED VERSION 29/08/14 Page 57
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis 11:58:37
REDUCED INVENTORY SYSTEM MODEL - RETRAN-3D SAMPLE PROBLEM CPU TIME = 29.640
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NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	ENERGY BALANCE (BTU)	TOTAL MASS BALANCE (LBM)	NCG MASS BALANCE (LBM)	AVERAGE TIME STEP (SEC)	CURRENT TIME STEP (SEC)	ELAPSED TIME (SEC)	TIME STEP NUM STANDRD/ACTUL
									26300
5.00000E-03	1.12200E+01	3.82939E+07	1.07960E+08	5.41965E+05	1.18245E+02	1.00000E-02	1.00000E-02	3.00000E+01	38461

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	VOID FRAC.	POWR TO H2O (BTU/SEC)	NCG QUALITY
1	4.13697E+01	1.24596E+03	3.09535E+02	1.26583E+00	2.69698E+02	7.63613E-02	9.79881E-01	0.00000E+00	1.31431E-03
2	4.15112E+01	4.36481E+02	2.99540E+02	1.47859E+00	2.70046E+02	6.53847E-02	9.76215E-01	0.00000E+00	3.12389E-03
3	4.15315E+01	1.11206E+03	2.70385E+02	2.73974E+00	2.69578E+02	3.45304E-02	9.54485E-01	0.00000E+00	4.06518E-03
4	3.88221E+01	3.20119E+04	2.03745E+02	5.26946E+01	2.35244E+02	2.47028E-04	1.09616E-01	-3.50547E+04	5.26100E-01
5	3.53081E+01	1.03594E+04	1.94895E+02	1.70524E+01	2.24746E+02	4.69972E-03	7.14589E-01	-2.50646E+01	5.79775E-01
6	3.47996E+01	4.25855E+03	1.96267E+02	7.00996E+00	2.22675E+02	1.40719E-02	8.83890E-01	8.53206E+00	5.94072E-01
7	3.67894E+01	1.89007E+04	1.94270E+02	3.11123E+01	2.25266E+02	1.80650E-03	4.77628E-01	-4.09790E+03	5.96123E-01
8	4.07149E+01	2.90188E+04	2.23818E+02	3.62011E+01	2.54494E+02	1.16348E-03	3.82848E-01	0.00000E+00	2.90127E-01
9	4.08963E+01	6.55389E+03	2.45002E+02	1.13783E+01	2.69875E+02	6.95085E-03	8.05542E-01	0.00000E+00	1.66012E-02
10	4.06646E+01	2.67271E+03	2.45092E+02	1.07857E+01	2.69532E+02	7.36244E-03	8.15780E-01	0.00000E+00	8.44686E-03
11	4.10909E+01	9.21334E+03	2.43961E+02	1.16639E+01	2.68964E+02	6.74143E-03	8.00719E-01	0.00000E+00	5.94092E-03
12	4.24911E+01	2.37631E+04	2.41461E+02	2.94755E+01	2.71103E+02	1.69317E-03	4.93251E-01	0.00000E+00	1.97779E-03
13	4.14944E+01	1.25949E+02	2.68455E+02	2.94963E+00	2.70035E+02	3.19037E-02	9.50852E-01	0.00000E+00	2.44007E-03
14	4.14731E+01	1.44085E+02	3.44857E+02	8.60724E-01	2.70628E+02	1.13371E-01	9.86861E-01	6.07263E+02	1.40216E-03
15	4.14524E+01	1.10075E+02	3.77753E+02	6.57558E-01	2.70451E+02	1.48822E-01	9.90364E-01	3.14892E+03	8.28837E-04
16	4.14322E+01	1.19331E+02	3.66581E+02	7.12852E-01	2.70176E+02	1.37076E-01	9.89412E-01	2.38430E+03	6.81549E-04
18	4.12654E+01	5.19310E+02	4.39995E+02	3.99470E-01	2.63524E+02	2.58830E-01	9.94922E-01	0.00000E+00	1.34119E-01
19	4.14080E+01	3.67807E+01	2.99514E+02	1.28604E+00	2.65302E+02	7.82208E-02	9.79650E-01	0.00000E+00	9.79849E-02
20	1.83777E+01	4.01363E+05	1.91951E+02	4.69815E+01	2.23468E+02	2.06502E-04	2.10536E-01	4.10992E+04	0.00000E+00

JUNCTION NUMBER	CONNECTS VOLUMES	CHOK/ PATH	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E VEL. PSI	ELEV. PSI	D I F F E R E N T I A L S FRIC. PSI	ACCL. PSI	PUMP PSI
1	1 TO 2		1.19596E+02	3.09496E+02	7.89528E-01	-7.13581E-03	7.44483E-03	-3.30204E-03	-1.42191E-01	0.00000E+00
2	2 TO 3		1.33041E+02	2.99510E+02	6.76018E-01	6.03001E-03	-6.25273E-02	-5.86082E-03	-8.18379E-02	0.00000E+00
3	3 TO 4		1.38664E+02	2.70387E+02	3.64980E-01	6.41082E-05	-2.76853E+00	-5.00556E-03	-6.35706E-02	0.00000E+00
4	4 TO 5		-1.43480E+02	1.93414E+02	2.32615E-02	2.73165E-04	-3.60092E+00	8.30471E-04	-8.14476E-02	0.00000E+00
5	5 TO 6		-1.58969E+02	1.96264E+02	1.42595E-01	2.48932E-05	-5.11378E-01	6.32946E-03	-2.77266E-03	0.00000E+00
6	6 TO 7		1.79869E+01	1.94006E+02	8.52029E-02	-3.95107E-05	1.96812E+00	-4.80164E-04	-2.19817E-02	0.00000E+00
7	7 TO 8		-3.95612E+02	2.23814E+02	2.76251E-02	-1.24140E-02	3.67491E+00	3.64051E-03	-2.62147E-01	0.00000E+00
8	8 TO 9		-5.64064E+02	2.45002E+02	8.78920E-02	1.85336E-03	4.15879E-01	3.56851E-03	2.54299E-01	1.18872E-02
9	9 TO 10		-6.03168E+02	2.45091E+02	9.26988E-02	-1.90307E-02	-1.14171E-01	4.72356E-03	1.14878E-01	1.18872E-02
10	10 TO 11		-5.56545E+02	2.43961E+02	8.57215E-02	2.33921E-02	5.27791E-01	2.39944E-02	1.46978E-01	0.00000E+00
11	11 TO 12		-4.18424E+02	2.41462E+02	3.39210E-02	3.34086E-03	1.43749E+00	1.64384E-03	4.20558E-02	0.00000E+00
12	12 TO 13		-2.06027E+01	2.68424E+02	3.38681E-01	-4.16832E-04	-1.13129E+00	1.34574E-01	2.56644E-05	0.00000E+00
13	12 TO 14		-1.17533E+01	2.96399E+02	6.21365E-01	-3.17426E-05	-1.02025E+00	1.99935E-04	-1.91995E-03	0.00000E+00
14	14 TO 15		1.90288E+01	3.44643E+02	1.15934E+00	-1.20661E-04	-2.11289E-02	-1.31992E-03	-1.78996E-03	0.00000E+00
15	15 TO 16		3.84860E+01	3.77519E+02	1.51810E+00	-2.18272E-04	-1.90623E-02	-3.54856E-03	-2.44123E-03	0.00000E+00
16	16 TO 1		5.38127E+01	3.66432E+02	1.40102E+00	1.36860E-04	-6.07525E-02	-3.93577E-03	-1.81115E-03	0.00000E+00
17	13 TO 1		-7.78705E+00	3.09496E+02	7.89528E-01	1.25266E-03	-1.73866E-01	4.73938E-02	-3.14226E-04	0.00000E+00
20	19 TO 18		5.04254E+00	2.99513E+02	7.77768E-01	1.16682E-06	-8.60330E-02	-1.79063E-02	3.80487E-02	0.00000E+00
21	2 TO 19		5.92813E+00	2.99510E+02	6.76018E-01	0.00000E+00	-3.71424E-02	-1.77899E-02	4.79565E-02	0.00000E+00
50	0 TO 1		0.00000E+00	3.09496E+02	7.89528E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
31	0 TO 20		0.00000E+00	1.15467E+03	2.17012E+01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
30	0 TO 20		0.00000E+00	1.15467E+03	2.17012E+01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
29	0 TO 20		0.00000E+00	1.15467E+03	2.17012E+01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
28	0 TO 20		0.00000E+00	1.15467E+03	2.17012E+01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
27	0 TO 20		0.00000E+00	1.15467E+03	2.17012E+01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
26	0 TO 18		0.00000E+00	4.40007E+02	2.50356E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
25	0 TO 18		0.00000E+00	4.40007E+02	2.50356E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
24	0 TO 10		0.00000E+00	2.45091E+02	9.26988E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
23	0 TO 20		0.00000E+00	1.15467E+03	2.17012E+01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
22	0 TO 20		0.00000E+00	1.91753E+02	1.68385E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

VOLUME NUMBER	FLOW REG.	LIQ. ENTH. (BTU/LB)	GAS ENTH. (BTU/LB)	LIQ. TEMP. (DEG. F)	GAS TEMP. (DEG. F)	IF AREA DEN (FT2/FT3)	IF HT COEFF (B/H-FT2-F)	IF MASS TRN (LB/SEC)	TOT MAS TRN (LB/SEC)	LIQ. HT RT (BTU/SEC)
1	5	2.38471E+02	1.16910E+03	2.69709E+02	2.69409E+02	7.91906E+00	3.00000E+06	2.12464E+03	2.12464E+03	-2.48670E+06
2	19	2.38830E+02	1.16735E+03	2.70063E+02	2.69546E+02	3.71428E-01	1.13763E+00	1.93651E-05	1.93651E-05	-2.26660E-02
3	4	2.38339E+02	1.16641E+03	2.69579E+02	2.69539E+02	4.55952E+01	2.03038E+04	5.72236E+00	5.72236E+00	-6.69775E+03
4	2	2.03638E+02	6.36732E+02	2.35244E+02	2.34912E+02	1.63687E+02	2.63430E+03	2.51028E+01	-1.15701E+01	-2.16476E+04
5	4	1.93074E+02	5.80528E+02	2.24746E+02	2.24734E+02	6.55905E+00	1.02567E+05	3.15279E+00	3.15279E+00	-3.66693E+03
6	5	1.90994E+02	5.65716E+02	2.22676E+02	2.22512E+02	7.52103E+01	3.00000E+06	6.54589E+03	6.54590E+03	-7.55609E+06
7	3	1.93600E+02	5.64463E+02	2.25266E+02	2.25208E+02	2.81872E+01	4.86034E+03	1.40613E+00	-2.85490E+00	-7.99632E+02
8	3	2.23057E+02	8.77082E+02	2.54494E+02	2.54646E+02	1.90971E+02	5.93904E+02	-4.14440E+00	-4.14440E+00	4.83058E+03
9	5	2.38643E+02	1.15347E+03	2.69880E+02	2.68102E+02	8.60601E-05	5.83439E+05	1.53658E-02	1.53658E-02	-1.79779E+01
10	19	2.38294E+02	1.16158E+03	2.69537E+02	2.68081E+02	7.12097E-01	4.10171E+00	3.14968E-04	3.14968E-04	-3.68508E-01
11	3	2.37714E+02	1.16431E+03	2.68965E+02	2.68814E+02	2.14954E+01	6.71185E+03	5.13471E+00	5.13471E+00	-6.00875E+03
12	3	2.39888E+02	1.16896E+03	2.71103E+02	2.71019E+02	6.05408E+05	1.44967E+06	1.78279E+07	1.78279E+07	-2.08751E+10
13	5	2.38810E+02	1.16803E+03	2.70043E+02	2.69548E+02	1.50014E+02	3.00000E+06	2.83206E+03	2.83206E+03	-3.31480E+06
14	5	2.39468E+02	1.16906E+03	2.70692E+02	2.69558E+02	9.64459E+01	3.00000E+06	1.65708E+04	1.65715E+04	-1.93957E+07
15	4	2.39299E+02	1.16963E+03	2.70525E+02	2.69550E+02	9.10567E+01	1.05664E+06	4.74653E+03	4.74991E+03	-5.55642E+06
16	4	2.38994E+02	1.16977E+03	2.70225E+02	2.69526E+02	9.04805E+01	9.62542E+05	3.11267E+03	3.11523E+03	-3.64384E+06
18	4	2.32189E+02	1.03505E+03	2.63516E+02	2.63572E+02	9.20688E-01	1.99803E+03	-3.86577E-02	-3.86577E-02	4.51724E+01
19	4	2.33995E+02	1.07160E+03	2.65298E+02	2.65423E+02	1.31200E+01	1.53896E+04	-2.12632E-01	-2.12632E-01	2.48593E+02

JUNCTION NUMBER	FLOW REG.	SLIP VEL. (FT/SEC)	VOID FRACTION	LIQUID FLOW (LB/SEC)	GAS FLOW (LB/SEC)	SLIP CNVCTN (BTU/SEC)	GAS VEL. (FT/SEC)	LIQ. VEL. (FT/SEC)	VG/VL	SLIP ACCEL. (FT/SEC**2)
2	-2	1.11250E-01	9.76204E-01	1.24485E+02	8.55603E+00	-1.25620E+02	6.42747E+00	6.53872E+00	9.82986E-01	6.09454E-01
3	-2	-1.47087E+00	9.54483E-01	1.29572E+02	9.09167E+00	3.99485E+03	2.99966E+00	1.52879E+00	1.96212E+00	-2.75138E+00
4	-2	-7.98980E-01	2.77631E-01	-1.44051E+02	5.70658E-01	1.47881E+02	5.40326E-01	-2.58654E-01	-2.08899E+00	-5.29697E-03
5	-2	-5.40053E-01	8.83841E-01	-1.58415E+02	-5.53151E-01	6.27974E+02	-1.75037E-01	-7.15090E-01	2.44777E-01	5.52233E-01
6	-2	8.07925E-01	8.04414E-01	2.01649E+01	-2.17804E+00	-5.39101E+02	-7.18175E-01	8.97501E-02	-8.00194E+00	-6.01506E-02
7	-2	9.78892E-01	3.82885E-01	-3.94504E+02	-1.10785E+00	-4.23575E+02	-1.67297E+00	-6.94078E-01	2.41035E+00	-2.95911E-02
9	-2	-4.50493E-01	8.15747E-01	-5.99167E+02	-4.00082E+00	4.04990E+02	-4.07652E+00	-4.52701E+00	9.00488E-01	-2.55914E-02
10	-2	4.02358E-01	8.00689E-01	-5.52406E+02	-4.13965E+00	-3.60667E+02	-4.25951E+00	-3.85715E+00	1.10431E+00	-9.66389E-02
11	-2	9.19789E-01	4.93168E-01	-4.16814E+02	-1.61042E+00	-8.38227E+02	-1.63907E+00	-7.19284E-01	2.27876E+00	-3.99516E-03
12	-2	-1.00899E+00	9.50801E-01	-2.00839E+01	-5.18723E-01	1.28146E+02	-3.67498E+00	-4.68397E+00	7.84587E-01	5.06365E-02
13	-2	-1.39349E+00	9.73987E-01	-1.60000E+01	4.24677E+00	2.65470E+03	9.84978E-01	-4.08513E-01	-2.41113E+00	1.13721E+00
14	-2	-2.06893E-01	9.86829E-01	1.60928E+01	2.93599E+00	7.30415E+02	6.87734E-01	4.80841E-01	1.43027E+00	2.93132E-01
15	-2	-1.99763E-01	9.90344E-01	3.20404E+01	6.44560E+00	6.80641E+02	1.50552E+00	1.30576E+00	1.15299E+00	4.21834E-01
16	-2	-4.96177E-01	9.89396E-01	4.46150E+01	9.19765E+00	1.70696E+03	2.15151E+00	1.65533E+00	1.29975E+00	3.33854E-01

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    17     -2  -4.10651E-01  9.79868E-01 -7.24778E+00 -5.39275E-01  5.12335E+01 -3.71942E+00 -4.13007E+00  9.00571E-01  1.17270E-01
    20     -2  -1.77044E-01  9.79655E-01  4.63814E+00  4.04405E-01  8.24920E+00  6.68561E+00  6.50857E+00  1.02720E+00 -4.90950E-01
    21     -2  -1.66707E-01  9.76204E-01  5.53166E+00  3.96470E-01  8.39456E+00  6.82057E+00  6.65387E+00  1.02505E+00  2.91492E-01

 BUBL          BUBBLE       BUBBLE       MIXTURE      MIXTURE      BUBBLE
 SET    VOL.   GRADIENT     VELOCITY     LEVEL        QUALITY      MASS
 NUMB.  NUMB.  PARAMETER    (FT/SEC)     (FT)                      (LB)
    1     20   0.00000E+00  1.40700E+01  4.98288E+01  1.44210E-06  5.78686E-01

 PUMP   VOL.   PUMP SPEED   NORM. PUMP   NORM. FRIC.  NORM. MOT.   POWER TO H2O
 NUMB.  NUMB.  (RPM)        TORQUE       TORQUE       TORQUE       (BTU/HR)
    1      9   0.00000E+00  2.58712E-03  0.00000E+00  0.00000E+00  0.00000E+00

HEAT COND.   VOL. HT TRAN   SURF. FLUX   CRIT. FLUX   H.T. COEF.   SURF. TEMP.  MASS FLUX    STORD ENRGY  POWR TO H20  DRYOUT PNT
NUMBER       NUM. MODE-COR  (BTU/HR-FT2) (BTU/HR-FT2) (BTU/H-F2-F) (DEG. F)     (LBM/HR-FT2) (BTU)        (BTU/HR)     ()
    1 RGHT     14   3-SG    1.54465E+02  9.00000E+04  2.10557E+01  2.77977E+02  3.55287E+02  1.31576E+06  2.18615E+06
    2 RGHT     15   3-SG    8.00969E+02  9.00000E+04  1.16599E+02  2.77334E+02  2.45235E+03  1.32388E+06  1.13361E+07
    3 RGHT     16   3-SG    6.06479E+02  9.00000E+04  1.67846E+02  2.73806E+02  3.91297E+03  1.29809E+06  8.58350E+06
    4 LEFT      4  23-CARP -4.27584E+03  9.00000E+04  8.00724E+02  2.29582E+02  2.80027E+02               -1.26197E+08
      RGHT     20   2-THOM  3.87687E+03  9.00000E+04  8.77493E+02  2.27885E+02  0.00000E+00  1.72790E+06  1.29185E+08
    5 LEFT      5  33-COLA -3.05728E+00  9.00000E+04  2.63157E+01  2.24630E+02  1.31084E+04               -9.02325E+04
      RGHT     20   2-THOM  2.31747E+02  9.00000E+04  2.14551E+02  2.24548E+02  0.00000E+00  1.69509E+06  7.72227E+06
    6 LEFT      7  23-CARP -4.99845E+02  9.00000E+04  1.91866E+03  2.24943E+02  1.63926E+04               -1.47524E+07
      RGHT     20   2-THOM  3.37663E+02  9.00000E+04  2.58965E+02  2.24771E+02  0.00000E+00  1.69716E+06  1.12516E+07
    7 LEFT      6  17-T-SG  1.04071E+00  9.00000E+04  8.57613E+00  2.22554E+02  6.14899E+03                3.07154E+04
      RGHT     20  22-CH-S -6.05596E+00  9.00000E+04  6.64047E+00  2.22555E+02  0.00000E+00  1.67887E+06 -2.01797E+05

 CORE   COND.  DEPTH REAC.  DEPTH REAC.  HEAT GEN.    COND. HEAT-  DIR. MODER-  AVG. METAL   CENTERLINE   FUEL
 NUMB.  NUMB.  EXT. ZR-H2O  INT. ZR-H2O  ZR-H2O       ING RATE     ATOR HT RT   TEMPERATURE  TEMPERATURE  ENTHALPY
               (FT)         (FT)         (BTU/HR)     (BTU/HR)     (BTU/HR)     (DEG. F)     (DEG. F)     (CAL/GM)
    1       1  0.00000E+00  0.00000E+00  0.00000E+00  1.07989E+07  0.00000E+00  2.80717E+02  2.81640E+02  0.00000E+00
    2       2  0.00000E+00  0.00000E+00  0.00000E+00  1.66961E+07  0.00000E+00  2.82654E+02  2.84301E+02  0.00000E+00
    3       3  0.00000E+00  0.00000E+00  0.00000E+00  1.07989E+07  0.00000E+00  2.77473E+02  2.78601E+02  0.00000E+00

HEAT EXCGR.   VOLUME   POWR TO H2O
NUMBER        NUMBER   (BTU/HR)
    1            18    0.00000E+00
    2            18    0.00000E+00
    3            18    0.00000E+00
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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   58
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:58:37
  REDUCED INVENTORY SYSTEM MODEL - RETRAN-3D SAMPLE PROBLEM                                                     CPU TIME =   29.656
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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SYSTEM ELAPSED TIME (SEC)	SYSTEM ELAPSED TIME (SEC)	TIME STP ACTUAL	SYSTEM NORM. POWER	VOL 2 AVG. TEMP. (DEG F)	VOL 10 AVG. TEMP. (DEG F)	JUN 1 FLOW (LB/SEC)	JUN 10 FLOW (LB/SEC)	VOL 1 VOID FRACTN
2.89000E+01	2.89000E+01	3.83510E+04	5.00000E-03	2.70145E+02	2.69658E+02	3.18717E+02	-9.99587E+02	9.77675E-01
2.90000E+01	2.90000E+01	3.83610E+04	5.00000E-03	2.70133E+02	2.69646E+02	3.08421E+02	-9.65425E+02	9.77915E-01
2.91000E+01	2.91000E+01	3.83710E+04	5.00000E-03	2.70122E+02	2.69633E+02	2.95057E+02	-9.27489E+02	9.78153E-01
2.92000E+01	2.92000E+01	3.83810E+04	5.00000E-03	2.70112E+02	2.69621E+02	2.79360E+02	-8.85669E+02	9.78385E-01
2.93000E+01	2.93000E+01	3.83910E+04	5.00000E-03	2.70103E+02	2.69609E+02	2.62389E+02	-8.40303E+02	9.78610E-01
2.94000E+01	2.94000E+01	3.84010E+04	5.00000E-03	2.70094E+02	2.69597E+02	2.44877E+02	-7.93051E+02	9.78827E-01
2.95000E+01	2.95000E+01	3.84110E+04	5.00000E-03	2.70086E+02	2.69585E+02	2.26934E+02	-7.47296E+02	9.79034E-01
2.96000E+01	2.96000E+01	3.84210E+04	5.00000E-03	2.70077E+02	2.69573E+02	2.08399E+02	-7.05773E+02	9.79231E-01
2.97000E+01	2.97000E+01	3.84310E+04	5.00000E-03	2.70067E+02	2.69562E+02	1.88884E+02	-6.68446E+02	9.79417E-01
2.98000E+01	2.98000E+01	3.84410E+04	5.00000E-03	2.70059E+02	2.69551E+02	1.68537E+02	-6.32879E+02	9.79587E-01
2.99000E+01	2.99000E+01	3.84510E+04	5.00000E-03	2.70052E+02	2.69541E+02	1.45703E+02	-5.96156E+02	9.79743E-01
3.00000E+01	3.00000E+01	3.84610E+04	5.00000E-03	2.70046E+02	2.69532E+02	1.19596E+02	-5.56545E+02	9.79881E-01

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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   59
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:58:37
  REDUCED INVENTORY SYSTEM MODEL - RETRAN-3D SAMPLE PROBLEM                                                     CPU TIME =   29.656
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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SYSTEM ELAPSED TIME (SEC)	VOL 14 VOID FRACTN	VOL 15 VOID FRACTN	VOL 16 VOID FRACTN
2.89000E+01	9.82376E-01	9.86865E-01	9.85870E-01
2.90000E+01	9.82755E-01	9.87306E-01	9.86332E-01
2.91000E+01	9.83116E-01	9.87713E-01	9.86767E-01
2.92000E+01	9.83481E-01	9.88089E-01	9.87175E-01
2.93000E+01	9.83872E-01	9.88439E-01	9.87552E-01
2.94000E+01	9.84304E-01	9.88767E-01	9.87901E-01
2.95000E+01	9.84788E-01	9.89077E-01	9.88222E-01
2.96000E+01	9.85304E-01	9.89372E-01	9.88516E-01
2.97000E+01	9.85755E-01	9.89650E-01	9.88782E-01
2.98000E+01	9.86156E-01	9.89910E-01	9.89023E-01
2.99000E+01	9.86525E-01	9.90150E-01	9.89235E-01
3.00000E+01	9.86861E-01	9.90364E-01	9.89412E-01

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14.0 EIGHT-CHANNEL ROD EJECTION SAMPLE PROBLEM

The rod ejection accident scenario assumes a mechanical failure of a control rod mechanism where the component is exposed to the reactor coolant system pressure and ejected from the core. The rod ejection sample problem is a very simple representation of that situation and ejects a single control rod from a location. The multidimensional kinetics model is used to analyze the event and the problem layout is given in Figure VII.14-1. The neutronics model is a simple quarter-core model with 56 active fuel regions. The grid is a 10x10 with symmetry, that is reflection at the north and west boundaries. There are 12 axial powered and two axial reflectors on each end node in the model. There are eight thermal-hydraulic channels mapped onto the neutronics mesh. The upper and lower plenums are modeled as a single volume.

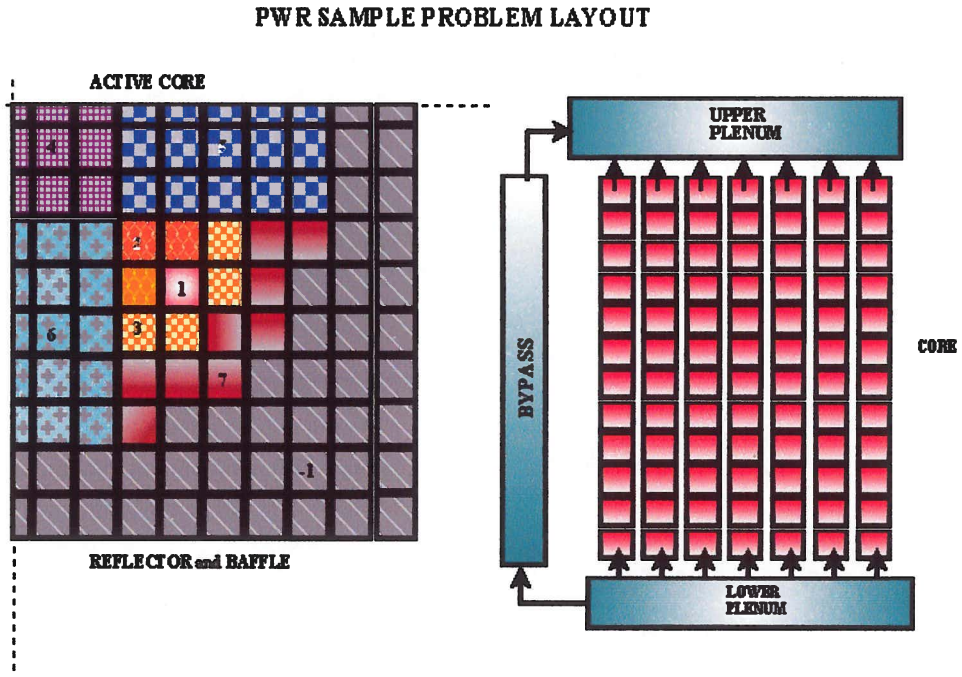


Figure VII.14-1. PWR Sample Problem Layout

This sample problem uses the channel model. When the channel model is used, the problem dimension card, control volumes, junctions, and conductor data are user-specified for the thermal-hydraulic model external to the core. The core model, including all of the conductors, volumes, and junctions and the problem dimensions for the core are computed internally by RETRAN-3D. In order to perform this, the user must supply an auxiliary file, the CDI file. For this reason, the sample problem consists of an input file for RETRAN-3D, a multidimensional kinetics cross-section library, and a CDI file. This problem also uses the improved Purdue numerical methods option for both neutronics and thermal-hydraulic solutions.

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The RETRAN model consists of eight thermal-hydraulic channels that are overlaid on the 10x10 neutronics grid. Channel 8 is designated as the 'bypass' channel which means in this model, the flow through the bypass is 'noncore' flow. Many neutronics models typically use this type of flow path to account for any flow that is not associated with core cooling such as leakage, bypass, or water channel flow.

All of the information required to initialize the core is contained in the CDI file. This includes loss coefficients and normalized flow fractions for the flow through the channels. The flow fractions are determined from the upstream calculation in CORETRAN that generated the CDI file. The total core flow specified on Record 670001 is then distributed to the channels via the flow fractions. The user may alternatively use the flow split option in RETRAN-3D to specify the flow, but this option is not used in the sample problem.

The RETRAN-3D channel model internally generates the flow paths beginning in channel one. The first junction in this channel is assigned 1010 for Channel 1, Junction 1. The second junction is 1020 and the last junction in Channel 1 is 1120. In a similar manner, Channel 7 begins with Junction 7010. Since the bypass channel is not part of the internal channel model, the junctions and volumes are part of the conventional numbering system, and the volume and junction data for this channel have to be supplied in the input file.

The sample problem consists of an initial, coupled, neutronic, and thermal-hydraulic steady-state solution followed by a transient calculation that is initiated by a rapidly withdrawn control rod. The rod is moved according to the rod position versus time information supplied via control block - 1 to neutronics rod group 1. The worth of the ejected rod is about two dollars.

The rod ejection transient is terminated at .3 second which is the time required for the ejected rod to insert a positive reactivity and the fuel temperature to begin to respond. The total power provided to the conductors is 852.8 MW at steady-state initialization and the initial total mass flow is 17395.0 lb/sec with an inlet temperature of 523.3 °F.

The input listing and selected output are given below.

```
 LISTING OF INPUT DATA FOR CASE  1

    1    =REA FOR PWR - RETRAN3D SAMPLE PROBLEM - 1/4 CORE, 7 TH CHAN/ 1 BYP, NO ADFS
    2    *
    3    ********************************************************************************
    4    *
    5    *  PROBLEM DIMENSIONS
    6    *
    7    *        1     2     3     4     5     6     7     8     9    10    11    12
    8    *      TAPE PRNPLT  POW   SS  NVOID GENTRN HTMAP SLIP  5EQ  NCOND  NSOL  PNMTH
    9    010001   0     0     3     0     0     0     1     0     0     0     2     2
   10    *
   11    *
   12    *       POWER MW
   13    010005   852.8
   14    *
   15    *
   16    020000 'TIMX'   0 'NTTS'   0 'PNRM'   0 'COUT'  -1
   17    020001 'RHOA'   0 'CTRA'   0 'DOPA'   0
   18    020002 'TAVG'   6 'TAVG'  16 'TAVG'  30
   19    020003 'TAVG'  42 'TAVG'  54 'TAVG'  66
   20    *
   21    *
   22    * FORMAT FOR TAPE60
   23    *
   24    025000 1
   25    025001 '(5(1X,1P,E15.7))'
   26    *
   27    *
   28    *30010  TRTG  TMIN  TRST  TMAJ  TDMP  NCHK  DELTM  TLAST
   29    030010  0.    0.01  0.    0.1   0.30    0   0.005  10.0
   30    *
   31    *30010  TRTG  TMIN  TRST  TMAJ  TDMP  NCHK  DELTM  TLAST
   32    030010  0.    0.01  0.    0.1   0.30    0   0.0005  10.0
+                                                                                *** THIS CARD IS A REPLACEMENT CARD. ***
   33    *
   34    040010    1      1     0    0    0.5    0.      ' TERMINATION'
   35    040020    2      1     0    0    0.0    0.      ' START THE FILL'
   36    040030    3      1     0    0    0.1    0.      ' TRIP  RODS'
   37    *
   38    ********************************************************************
   39    *
   40    *  LOWER PLENUM, INACTIVE CORE, BYPASS AND UPPER PLENUM CARDS
   41    *
   42    *       B  IRD   PRESSURE   ENTHALPY   QLTY     VOLUME
   43    050081  0   1      0.0        0.0      0.0     1157.3800    * UPPER PLENUM
   44    050391  0   0      0.0        0.0      0.0       37.71      * INACTIVE CORE
   45    050381  0   0      0.0        0.0      0.0       37.71      * INACTIVE CORE
   46    050371  0   0      0.0        0.0      0.0       37.71      * INACTIVE CORE
   47    *
   48    *       HEIGHT   MIXTLVL  FLOWL  FLOWAREA  HYDIAM     VOLELEV
   49    050082   5.60             5.60    206.675  16.2       30.026  * UPPER PLENUM
   50    050392   0.4920           0.4920   69.827    .048338  17.534  * INACTIVE CORE
   51    050382   0.4920           0.4920   69.827    .048338  17.042  * INACTIVE CORE
   52    050372   0.4920           0.4920   69.827    .048338  16.550  * INACTIVE CORE
   53    *
   54    *          TIME       PRESS     TEMP    QUALITY    MIXL
   55    070101  3   0.0       2250.0    546.96    0.000     5.60
   56    070102     10.0       2250.0    546.96    0.000     5.60
   57    070103    100.0       2250.0    546.96    0.000     5.60
   58    *
   59    *       FM  TO  PUMP VLV FLOWRATE  JUNAREA  JUNELEV  INERT
   60    080381  38  39   0   0    0.0    69.827     17.534    0.0
   61    080371  37  38   0   0    0.0    69.827     17.042    0.0
   62    080361   0  37   1   0    0.0    82.42145   16.550    0.1036
   63    *
   64    *       FLOSC   RLOSC   JVT JCK JCL MVMX  HYDIAM  CNC IFR TP
   65    080382   0.28     0.28   0   -1   2   0   0.048338 1.0  0  0
   66    080372   0.28     0.28   0   -1   2   0   0.048338 1.0  0  0
   67    080362   30.9     30.9   0   -1   0   0   0.048338 1.0  0  0
   68    *
   69    *   INLET FILL
   70    *       PTS  TRIP  JX  LBM/SEC  TIME   FLOW     HP    PRES
   71    130101   1    2     0    -1      0.0  17395.000  514.2 2250.0
   72    *
   73    *
   74    ********************************************************************
   75    *
   76    * THERM COND  UO2 (REF. GEMP-482  FIG-13 86 W/CM)
   77    180101   -11                                          *THERM COND UO2 1
   78    180102   212.  4.28   392.  3.47   752.  2.66  1112.  2.20   *THERM COND UO2 2
   79    180103  1472.  1.88  1832.  1.62  2192.  1.44  2912.  1.21   *THERM COND UO2 3
   80    180104  3632.  1.16  5072.  1.16  5500.  1.16                *THERM COND UO2 4
   81    *
   82    * SET GAP CONDUCTANCE
   83    180201    -2
   84    180202   100.  0.542  * H = 1000.0 BTU/HR-FT**2-F
   85    180203  5100.  0.542
   86    *
   87    * THERM COND  ZR-4  (REF. BRASSFIELD(1968) GEMP-482 RECOM...LWR LOCA)
   88    180301    -8                                           *THERM COND ZR-4 1
   89    180302     0.  8.    1490.  12.32  2150.  17.50  2372.  19.7 *THERM COND ZR-4 2
   90    180303  2552. 21.8   2732.  24.0   3292.  28.9   3360.  33.1 *THERM COND ZR-4 3
   91    *
   92    190101   -19                                            *VOL HT CAP UO2 1
   93    190102    77.  36.22  100.  37.12  200.  40.05   300.  41.98  *VOL HT CAP UO2 2
   94    190103   400.  43.88  600.  45.18  800.  46.41  1000.  47.32  *VOL HT CAP UO2 3
   95    190104                                          2400.  50.77  *VOL HT CAP UO2 4
   96    190105  2600.  51.43 2800.  52.61 3000.  54.57  3200.  57.42  *VOL HT CAP UO2 5
   97    190106  3400.  61.23 3600.  65.93 4600.  95.15 4800.  99.31   *VOL HT CAP UO2 6
   98    190107  5000. 101.57 5074. 101.76
   99    *
```

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```
100    * SPEC HEAT  HELIUM (REF  KREITH  AT 1 ATM  DEN 0.012 LB/FT3)
101    190201   -2                                    * VOL HT CAP HELIUM 1
102    190202    32.   .0149   3400.  .0149           * VOL HT CAP HELIUM 2
103    *
104    * SPEC HEAT  ZR-2  (REF BMI-1803 ELDR1DGE ET AL (1967))
105    190301   -15                                              *VOL HT CAP ZR-2 1
106    190302    32.  28.75  932.  32.56 1112.  34.40  1184.  35.22  *VOL HT CAP ZR-2 2
107    190303  1490.  35.22 1508.  49.14 1544.  57.74  1580.  60.20  *VOL HT CAP ZR-2 3
108    190304  1616.  70.43 1652.  79.85 1688.  75.35  1724.  59.38  *VOL HT CAP ZR-2 4
109    190305  1760.  45.86 1787.  34.81 3300.  34.81                *VOL HT CAP ZR-2 5
110    *
111    *
112    *      LCOUNT ACEPSI  HEPSI  EPSIM  VEPSI  EPSIMG
113    230000  -20    1.E-5  1.E-5  1.E-5  1.E-5
114    *
115    *
116    ************************************************************************
117    * 3-Dimensional Kinetics:
118    *
119    *
120    *670001 NCHANL NBYPSS NCROSS JENTH JTPM IMC QPMD QDMD QBMD EW WCORE  IHTGL
121    670001    7      1      0      1    0    0  0.0  0.0  0.0  0  9299.82 0
122    *
123    *670010 NED1 NED2 NED3 NED4 NED5 NED8 NED9 NED11 NED14
124    670010   1    1    1    0    0    0    0     0     0
125    *
126    *670020 NOTERS MAXOUT MAXFB NCNCRS NCNCRT  IPURDU
127    670020    10    200    50       4      2      1
128    *
129    *670021 NSERCH NBORON NFREEZ NADJNT ISPECK IEXPAN IFXISP
130    670021     0   -2000     0      1      0     -1      2
131    *
132    *670030    CONEIG    CONDEG    CONSRS   CONSRT    CONPOW
133    670030    1.E-005   5.E-005   5.E-005   5.E-005   1.E-004
134    *
135    *  PNM Neutronics Numerics Option - Iteration control variables
136    *
137    *670040 IFUPD  NODOPT NEMCY  IFSACC ICHEB0 IRAGGED
138    670040  0      2      5      0      3      0
139    *
140    *670041 EPSNEM EPSXEC EPSL2  EPSINF EPSR2  EPSERF  ESHIFT CETAK
141    670041  0.001  0.001   .00001 .0001  .001   .005    .04    1.0
142    *
143    ********************************************************************************
144    * assembly -to- channel mapping
145    *
146    671011    4  4  4  5  5  5  5  5 -1 -1
147    671021    4  4  4  5  5  5  5  5 -1 -1
148    671031    4  4  4  5  5  5  5  5 -1 -1
149    671041    6  6  6  2  2  3  7  7 -1 -1
150    671051    6  6  6  2  1  3  7 -1 -1 -1
151    671061    6  6  6  3  3  7  7 -1 -1 -1
152    671071    6  6  6  7  7  7 -1 -1 -1 -1
153    671081    6  6  6  7 -1 -1 -1 -1 -1 -1
154    671091   -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
155    671101   -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
156    *
157    *
158    *   ONE ROD GROUP
159    *6740YY NGSP COUT ...
160    674001   1  -1
161    *
162    ************************************************************************
163    *
164    *        ROD MODEL REQUIRES ADDITIONAL CONTROL BLOCKS
165    *        AND TRIP MONITOR
166    *
167    *        THE INITIAL ROD POSITION IS SPECIFIED ON THE CDI FILE.
168    *        THIS SYSTEM PROVIDES A RELATIVE ROD INSERTION DISTANCE
169    *        FROM THAT MARK.  THAT IS, THE TOTAL ROD INSERTION IS THE
170    *        CDI FILE  INITIAL POSITION PLUS THE DISTANCE PROVIDED BY
171    *        CONTROL BLOCK -1
172    *
173    *      IDC  VAR   REG  GAIN      CIC
174    702001  1   TRIP   3    1.0      1.0
175    702002  2   CONS   0    0.0      0.0
176    *
177    *      IDC  TYPE  INC1 INC2  GAIN   CP1   CP2   CIC
178    703001 -1   SUM    2   -2    1.0   1.0   1.0   0.0  *
179    703002 -2   FNG   -3    1    1.0   0.0   0.0   0.0  *
180    703003 -3   INT    1    0    1.0   0.0   0.0   0.0
181    *
182    *       TABLE 1 - GROUP 1 ROD POSITION VS TIME - EJECTED ROD
183    120100 -3   0.0   0.0   0.2  120.00   20.0  120.00  * TRAVEL DIST = 1.2m
184    *
185    ************************************************************************
186    *
187    *675XXY  VOL NODE ...
188    675011   39 1 192 2 193 3 194 4 195 5 196 6 197 7
189    675012  198 8 199 9  200 10 201 11 202 12 203 13 8 14
190    *
191    *BYPASS CHANNEL
192    051921  0   0      0.0        0.0      0.0       21.10848 * BYP   1
193    051931  0   0      0.0        0.0      0.0       21.10848 * BYP   2
194    051941  0   0      0.0        0.0      0.0       21.10848 * BYP   3
195    051951  0   0      0.0        0.0      0.0       21.10848 * BYP   4
196    051961  0   0      0.0        0.0      0.0       21.10848 * BYP   5
197    051971  0   0      0.0        0.0      0.0       21.10848 * BYP   6
198    051981  0   0      0.0        0.0      0.0       21.10848 * BYP   7
199    051991  0   0      0.0        0.0      0.0       21.10848 * BYP   8
200    052001  0   0      0.0        0.0      0.0       21.10848 * BYP   9
201    052011  0   0      0.0        0.0      0.0       21.10848 * BYP  10
```


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```
052021  0   0      0.0        0.0      0.0       21.10848 * BYP  11
052031  0   0      0.0        0.0      0.0       21.10848 * BYP  12
*
* BYPASS CHANNEL (2)
051922      1.00000     1.00000    11.12151    .0077920    18.02600 * BYP   1
051932      1.00000     1.00000    11.12151    .0077920    19.02600 * BYP   2
051942      1.00000     1.00000    11.12151    .0077920    20.02600 * BYP   3
051952      1.00000     1.00000    11.12151    .0077920    21.02600 * BYP   4
051962      1.00000     1.00000    11.12151    .0077920    22.02600 * BYP   5
051972      1.00000     1.00000    11.12151    .0077920    23.02600 * BYP   6
051982      1.00000     1.00000    11.12151    .0077920    24.02600 * BYP   7
051992      1.00000     1.00000    11.12151    .0077920    25.02600 * BYP   8
052002      1.00000     1.00000    11.12151    .0077920    26.02600 * BYP   9
052012      1.00000     1.00000    11.12151    .0077920    27.02600 * BYP  10
052022      1.00000     1.00000    11.12151    .0077920    28.02600 * BYP  11
052032      1.00000     1.00000    11.12151    .0077920    29.02600 * BYP  12
*
* BYPASS CHANNEL
081921  39 192   0   0  8095.18000    11.12151    18.02600  0.0 * BYP  0 TO  1
081931 192 193   0   0      .00000    11.12151    19.02600  0.0 * BYP  1 TO  2
081941 193 194   0   0      .00000    11.12151    20.02600  0.0 * BYP  2 TO  3
081951 194 195   0   0      .00000    11.12151    21.02600  0.0 * BYP  3 TO  4
081961 195 196   0   0      .00000    11.12151    22.02600  0.0 * BYP  4 TO  5
081971 196 197   0   0      .00000    11.12151    23.02600  0.0 * BYP  5 TO  6
081981 197 198   0   0      .00000    11.12151    24.02600  0.0 * BYP  6 TO  7
081991 198 199   0   0      .00000    11.12151    25.02600  0.0 * BYP  7 TO  8
082001 199 200   0   0      .00000    11.12151    26.02600  0.0 * BYP  8 TO  9
082011 200 201   0   0      .00000    11.12151    27.02600  0.0 * BYP  9 TO 10
082021 201 202   0   0      .00000    11.12151    28.02600  0.0 * BYP 10 TO 11
082031 202 203   0   0      .00000    11.12151    29.02600  0.0 * BYP 11 TO 12
082041 203   8   0   0      .00000    11.12151    30.02600  0.0 * BYP 12 TO 13
*
* BYPASS CHANNEL (2)
081922     .0000     .0000   0 -1  2  0     .0077920 1.0     0  0 * BYP  0 TO  1
081932     .0000     .0000   0 -1  2  0     .0077920 1.0     0  0 * BYP  1 TO  2
081942     .0000     .0000   0 -1  2  0     .0077920 1.0     0  0 * BYP  2 TO  3
081952     .0000     .0000   0 -1  2  0     .0077920 1.0     0  0 * BYP  3 TO  4
081962     .0000     .0000   0 -1  2  0     .0077920 1.0     0  0 * BYP  4 TO  5
081972     .0000     .0000   0 -1  2  0     .0077920 1.0     0  0 * BYP  5 TO  6
081982     .0000     .0000   0 -1  2  0     .0077920 1.0     0  0 * BYP  6 TO  7
081992     .0000     .0000   0 -1  2  0     .0077920 1.0     0  0 * BYP  7 TO  8
082002     .0000     .0000   0 -1  2  0     .0077920 1.0     0  0 * BYP  8 TO  9
082012     .0000     .0000   0 -1  2  0     .0077920 1.0     0  0 * BYP  9 TO 10
082022     .0000     .0000   0 -1  2  0     .0077920 1.0     0  0 * BYP 10 TO 11
082032     .0000     .0000   0 -1  2  0     .0077920 1.0     0  0 * BYP 11 TO 12
082042    2.13876   2.13876  0 -1  2  0     .0077920 1.0     0  0 * Channel Exit
*
*
*672XXX INLET OUTLET KFLAG WNORM  IGAP  IVFIT  IFRIC
*
672001    39    8    2
672002    39    8    2
672003    39    8    2
672004    39    8    2
672005    39    8    2
672006    39    8    2
672007    39    8    2
*
*
**************************************************************************
*
*  PNM T/H numerics
*  note only fueled channels are counted as core domain here
*  (volume number>1000) so there are only 7 channels.
*
*
*380000 NESTED ITERATIVE SOLUTION METHOD DATA CARDS
*
* IPROPT=0  one channel per subdomain
*       =1  2X2-channel subdomains
*       =2  3X3-channel subdomains
*       =3  4X4-channel subdomains
*
*        NAXL  NCHN  NROW  ITYP  MITR  IPROP  NSUB  ISUB  EPS    EPSR
380000    12     7     1     1    80      0     0     1   1.E-8   0.1
*
*
*3801XX NUMBER OF CHANNELS IN EACH ROW (CORE LAYOUT)
*
380101     7
*
**************************************************************************
*
.  ENDECK
```


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```
RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    -- NRC APPROVED VERSION        29/08/14  Page    1
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:58:54
 REA FOR PWR - RETRAN3D SAMPLE PROBLEM - 1/4 CORE, 7 TH CHAN/ 1 BYP, NO ADFS                                    CPU TIME =     0.016
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

RETRAN PROBLEM CONTROL AND DESCRIPTION DATA.

    WORD  DESCRIPTION
    ====  ===================================================================
      1   RESTART FILE OPTION (SAVE=-1 / NO SAVE=0) .................... =    0
      2   PRINTER PLOT OPTION (YES=1 / NO=0) ........................... =    0
      3   POWER OPTION (TAPE OPTNS<0 / NO/TBL=0 / PT KIN=1 / 1D=2 / 3D=3) =    3
      4   USE STEADY-STATE SOLUTION (YES=0 / NO=1) ..................... =    0
      5   USE NEUTRON VOID MODEL (YES=1 / NO=0) ........................ =    0
      6   USE GENERALIZED TRANSPORT MODEL (NO=0 / VAP=1 / LIQ=-1) ....... =    0
      7   HEAT TRANSFER MAP OPTION (FORCED=0 / NAT CONV=1) ............. =    1
      8   SLIP OPTION (DYN=1 / Z-L=2 / C-L=3 / Z-L TAUGL=4 / C-L TAUGL=5) =    0
      9   FIVE-EQUATION OPTION (NO= 0 / YES=1) ......................... =    0
     10   NONCONDENSABLE GAS FLOW OPTION (NO=0 / YES=1) ................ =    0
     11   TH MATRIX DIRECT SOLVER OPTION (4-EQ=2 / 6-EQ=3) ............. =    2
     12   TH MATRIX ITERATIVE SOLVER OPTION (NO<=1 / YES=2) ............ =    2

    (DIMENSIONS AND OPTIONS AUTOMATICALLY DETERMINED BY CONTENT OF INPUT DATA)

          NUMBER OF MINOR EDIT SETS (0200XX DATA )...................... =   13
          NUMBER OF TIME-STEP CONTROL SETS (03XXX0 DATA )............... =    1
          NUMBER OF TRIP CONTROL SETS (04XXX0 DATA ).................... =    3
          NUMBER OF CONTROL VOLUME DESCRIPTIONS (05XXXY DATA )........... =   16
          NUMBER OF BUBBLE RISE DESCRIPTIONS (060XXY DATA) ............. =    0
          NUMBER OF TIME DEPENDENT VOLUMES FORM CARDS (07XXYY DATA) ..... =    1
          NUMBER OF JUNCTION DESCRIPTIONS (08XXXY DATA) ................ =   16
          NUMBER OF CENTRIFUGAL PUMP DESCRIPTIONS (090XXY DATA )......... =    0
          NUMBER OF VALVE DESCRIPTIONS (11XXXY DATA) ................... =    0
          NUMBER OF GENERAL DATA TABLE DESCRIPTIONS (12XXYY DATA) ....... =    1
          NUMBER OF FILL DESCRIPTIONS (13XXYY DATA ).................... =    1
          NUMBER OF HEAT CONDUCTOR DESCRIPTIONS (15XXXY DATA) ........... =    0
          NUMBER OF HEAT CONDUCTOR GEOMETRY DESCRIPTIONS (17XXYY DATA) .. =    0
          NUMBER OF HEAT CONDUCTOR MATERIAL DESCRIPTIONS (18XXYY DATA) .. =    3
          NUMBER OF CORE SECTION DESCRIPTIONS (16XXXY DATA) ............ =    0
          NUMBER OF NON-CONDUCTNG HEAT EXCHNGR DESCRIPTIONS (21XXYY DATA) =    0
          NUMBER OF TIME DEP BCS FROM TAPE (IREAD<0 ON 05XXXY DATA) ..... =    0
          NUMBER OF SPECIFIED HEAT TRAN COEF DESCRIPTIONS (015XXX DATA) . =    0
          TWO-REGION NONEQ VOL DESCRIPTIONS (610XXX OR 611XXX DATA) ..... =    0
          TEMP. TRANSPORT DELAY OPTION (MESH>0 ON 05XXXY DATA) ......... =    0
          AUXILIARY DNB MODEL (8001XX DATA INCLUDED) ................... =    0
          CONTROL SYSTEM MODEL (702XXX OR 702XXXX DATA) ................ =    1
          ACCUMULATOR MODEL DESCRIPTIONS (620XXX OR 621XXX DATA)......... =    0
          DYNAMIC GAP CONDUCTANCE MODEL DESCRIPTIONS (225XX0 DATA) ...... =    0
          NUMBER OF HT CONDUCTOR STACK DESCRIPTIONS (2200XY DATA) ....... =    0
          NUMBER OF TURBINE SHAFT DESCRIPTIONS (500XXY DATA) ........... =    0
          NUMBER OF PROFILE FIT DESCRIPTIONS (061XX1 DATA) ............. =    0
          NUMBER OF STEAM-WATER SEPARATOR DESCRIPTIONS (60XXX0 DATA) .... =    0


                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * *                                                * * *
                   * * *          STEADY-STATE OPTION    =   0          * * *
                   * * *                                                * * *
                   * * *          SLIP OPTION            =   0          * * *
                   * * *                                                * * *
                   * * *          NUMERICS OPTION        =   2          * * *
                   * * *                                                * * *
                   * * *          HEAT TRANSFER OPTION   =   1          * * *
                   * * *                                                * * *
                   * * *          NEW EQUATIONS OPTION   =   0          * * *
                   * * *                                                * * *
                   * * *         USING THE 4-EQ SOLVER - SOLVE3         * * *
                   * * *                                                * * *
                   * * *     USING STANDARD STEADY-STATE SOLUTION       * * *
                   * * *                                                * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *


INITIAL THERMAL POWER (MEGAWATTS) =  8.52800E+02


AIR IS THE DEFAULT NONCONDENSABLE GAS.
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PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE -- NRC APPROVED VERSION 29/08/14 Page 44
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis 11:58:55
REA FOR PWR - RETRAN3D SAMPLE PROBLEM - 1/4 CORE, 7 TH CHAN/ 1 BYP, NO ADFS CPU TIME = 0.328
* *

NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	ENERGY BALANCE (BTU)	TOTAL MASS BALANCE (LBM)	NCG MASS BALANCE (LBM)	AVERAGE TIME STEP (SEC)	CURRENT TIME STEP (SEC)	ELAPSED TIME (SEC)	TIME STEP NUM STANDRD/ACTUL
									0
1.00000E+00	8.52800E+02	2.91061E+09	4.20477E+07	7.95021E+04	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	VOID FRAC.	POWR TO H2O (BTU/SEC)
8	2.25000E+03	5.46555E+04	5.43222E+02	4.72235E+01	5.46960E+02	0.00000E+00	0.00000E+00	0.00000E+00
37	2.29220E+03	1.83675E+03	5.14200E+02	4.87073E+01	5.23322E+02	0.00000E+00	0.00000E+00	0.00000E+00
38	2.29197E+03	1.83675E+03	5.14200E+02	4.87072E+01	5.23322E+02	0.00000E+00	0.00000E+00	0.00000E+00
39	2.29184E+03	1.83675E+03	5.14200E+02	4.87071E+01	5.23322E+02	0.00000E+00	0.00000E+00	0.00000E+00
192	2.28902E+03	1.02810E+03	5.14200E+02	4.87057E+01	5.23318E+02	0.00000E+00	0.00000E+00	0.00000E+00
193	2.28582E+03	1.02807E+03	5.14200E+02	4.87040E+01	5.23314E+02	0.00000E+00	0.00000E+00	0.00000E+00
194	2.28262E+03	1.02803E+03	5.14200E+02	4.87024E+01	5.23309E+02	0.00000E+00	0.00000E+00	0.00000E+00
195	2.27943E+03	1.02800E+03	5.14200E+02	4.87007E+01	5.23305E+02	0.00000E+00	0.00000E+00	0.00000E+00
196	2.27623E+03	1.02796E+03	5.14200E+02	4.86991E+01	5.23301E+02	0.00000E+00	0.00000E+00	0.00000E+00
197	2.27303E+03	1.02793E+03	5.14200E+02	4.86974E+01	5.23297E+02	0.00000E+00	0.00000E+00	0.00000E+00
198	2.26984E+03	1.02789E+03	5.14200E+02	4.86958E+01	5.23292E+02	0.00000E+00	0.00000E+00	0.00000E+00
199	2.26664E+03	1.02786E+03	5.14200E+02	4.86941E+01	5.23288E+02	0.00000E+00	0.00000E+00	0.00000E+00
200	2.26344E+03	1.02782E+03	5.14200E+02	4.86925E+01	5.23284E+02	0.00000E+00	0.00000E+00	0.00000E+00
201	2.26024E+03	1.02779E+03	5.14200E+02	4.86908E+01	5.23279E+02	0.00000E+00	0.00000E+00	0.00000E+00
202	2.25705E+03	1.02775E+03	5.14200E+02	4.86892E+01	5.23275E+02	0.00000E+00	0.00000E+00	0.00000E+00
203	2.25385E+03	1.02772E+03	5.14200E+02	4.86875E+01	5.23271E+02	0.00000E+00	0.00000E+00	0.00000E+00

JUNCTION NUMBER	CONNECTS VOLUMES	CHOK/ PATH	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E VEL. PSI	ELEV. PSI	D I F F E R E N T I A L S FRIC. PSI	ACCL. PSI	PUMP PSI
37	37 TO 38		1.73950E+04	5.14200E+02	2.05308E-02	6.11667E-05	-1.66416E-01	-6.12667E-02	-2.35895E-13	0.00000E+00
38	38 TO 39		1.73950E+04	5.14200E+02	2.05309E-02	9.99817E-02	-1.66416E-01	-6.12668E-02	3.41394E-15	0.00000E+00
192	39 TO 192		8.09518E+03	5.14200E+02	2.05309E-02	-1.13643E+00	-2.52325E-01	-1.43230E+00	2.64122E-13	0.00000E+00
193	192 TO 193		8.09518E+03	5.14200E+02	2.05315E-02	-7.47785E-05	-3.38228E-01	-2.85889E+00	5.61773E-14	0.00000E+00
194	193 TO 194		8.09518E+03	5.14200E+02	2.05322E-02	-7.94717E-05	-3.38217E-01	-2.85895E+00	-2.56684E-13	0.00000E+00
195	194 TO 195		8.09518E+03	5.14200E+02	2.05329E-02	-7.94931E-05	-3.38205E-01	-2.85901E+00	1.05249E-13	0.00000E+00
196	195 TO 196		8.09518E+03	5.14200E+02	2.05336E-02	-7.95144E-05	-3.38194E-01	-2.85907E+00	-2.03393E-13	0.00000E+00
197	196 TO 197		8.09518E+03	5.14200E+02	2.05343E-02	-7.95357E-05	-3.38182E-01	-2.85913E+00	4.12559E-13	0.00000E+00
198	197 TO 198		8.09518E+03	5.14200E+02	2.05350E-02	-7.95570E-05	-3.38171E-01	-2.85919E+00	-8.80962E-14	0.00000E+00
199	198 TO 199		8.09518E+03	5.14200E+02	2.05357E-02	-7.95783E-05	-3.38159E-01	-2.85926E+00	-1.14297E-13	0.00000E+00
200	199 TO 200		8.09518E+03	5.14200E+02	2.05364E-02	-7.95996E-05	-3.38148E-01	-2.85932E+00	1.09024E-13	0.00000E+00
201	200 TO 201		8.09518E+03	5.14200E+02	2.05371E-02	-7.96209E-05	-3.38136E-01	-2.85938E+00	-1.01474E-13	0.00000E+00
202	201 TO 202		8.09518E+03	5.14200E+02	2.05378E-02	-7.96422E-05	-3.38125E-01	-2.85944E+00	-6.35048E-14	0.00000E+00
203	202 TO 203		8.09518E+03	5.14200E+02	2.05385E-02	-7.96635E-05	-3.38113E-01	-2.85950E+00	-8.99281E-15	0.00000E+00
204	203 TO 8		8.09518E+03	5.14200E+02	2.05391E-02	1.18129E+00	-1.08729E+00	-3.94151E+00	3.23581E-11	0.00000E+00
CHANNEL JUNCTIONS										
1010	39 TO 1010	CHI	1.92742E+02	5.14200E+02	2.05309E-02	-1.18541E+00	-2.51995E-01	-2.37560E-01	-6.42732E-09	
1130	1120 TO 8	CHX	1.92742E+02	6.23369E+02	2.35427E-02	1.39471E+00	-1.06632E+00	-2.03604E+01	6.08889E-06	
2010	39 TO 2010	CHI	5.78227E+02	5.14200E+02	2.05309E-02	-1.18641E+00	-2.51927E-01	-2.37583E-01	-8.16828E-09	
2130	2120 TO 8	CHX	5.78227E+02	6.35105E+02	2.39933E-02	1.41868E+00	-1.06369E+00	-2.02536E+01	-1.00035E-06	
3010	39 TO 3010	CHI	7.70970E+02	5.14200E+02	2.05309E-02	-1.18490E+00	-2.52030E-01	-2.37601E-01	-6.57195E-09	
3130	3120 TO 8	CHX	7.70970E+02	6.10947E+02	2.30995E-02	1.37005E+00	-1.06906E+00	-2.04704E+01	-5.65204E-07	
4010	39 TO 4010	CHI	1.20464E+03	5.14200E+02	2.05309E-02	-1.18694E+00	-2.51891E-01	-2.37655E-01	-1.20041E-08	
4130	4120 TO 8	CHX	1.20464E+03	6.24373E+02	2.35800E-02	1.39473E+00	-1.06621E+00	-2.03558E+01	-2.14889E-06	
5010	39 TO 5010	CHI	2.40928E+03	5.14200E+02	2.05309E-02	-1.18519E+00	-2.52010E-01	-2.37891E-01	-7.40996E-09	
5130	5120 TO 8	CHX	2.40928E+03	6.02282E+02	2.28092E-02	1.35314E+00	-1.07096E+00	-2.05425E+01	-8.74854E-07	
6010	39 TO 6010	CHI	2.40928E+03	5.14200E+02	2.05309E-02	-1.18520E+00	-2.52010E-01	-2.37891E-01	-7.40654E-09	
6130	6120 TO 8	CHX	2.40928E+03	6.02532E+02	2.28174E-02	1.35359E+00	-1.07091E+00	-2.05405E+01	-5.13371E-07	
7010	39 TO 7010	CHI	1.73468E+03	5.14200E+02	2.05309E-02	-1.18270E+00	-2.52181E-01	-2.37744E-01	-8.19657E-10	
7130	7120 TO 8	CHX	1.73468E+03	5.63323E+02	2.16693E-02	1.28994E+00	-1.07869E+00	-2.08316E+01	8.80873E-07	
36	0 TO 37		1.73950E+04	5.14200E+02	2.05400E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

RETRAN CHANNEL EDIT - (VOLUMES AND CONDUCTORS ARE IDENTICALLY NUMBERED)

VOLUME NUMBER	MODERATOR TEMPERATURE (DEG. F)	MODERATOR DENSITY (LBM/FT**3)	MODERATOR ENTHALPY (BTU/LBM)	HEAT TRANSFER MODE	POWER DENSITY	FUEL TEMPERATURE (DEG. F)	FUEL ENTHALPY (CAL/GM)	HEAT FLUX (BTU/HR/FT**2)	CONDUCTOR HEATING RATE (BTU/HR)	DIR. MOD HEATING RATE (BTU/HR)
CHANNEL 1										
1010	5.24966E+02	4.86107E+01	5.16176E+02	1	3.62419E-03	7.73802E+02	0.00000E+00	1.06082E+05	2.74211E+06	0.00000E+00
1020	5.29666E+02	4.83323E+01	5.21850E+02	1	6.78289E-03	1.02887E+03	0.00000E+00	1.98539E+05	5.13203E+06	0.00000E+00
1030	5.36352E+02	4.79246E+01	5.30002E+02	1	8.16863E-03	1.15739E+03	0.00000E+00	2.39100E+05	6.18051E+06	0.00000E+00
1040	5.43784E+02	4.74548E+01	5.39181E+02	1	8.66699E-03	1.21107E+03	0.00000E+00	2.53688E+05	6.55758E+06	0.00000E+00
1050	5.51445E+02	4.69482E+01	5.48790E+02	1	8.95696E-03	1.24694E+03	0.00000E+00	2.62175E+05	6.77697E+06	0.00000E+00
1060	5.59254E+02	4.64090E+01	5.58740E+02	1	9.29354E-03	1.28795E+03	0.00000E+00	2.72027E+05	7.03163E+06	0.00000E+00
1070	5.67248E+02	4.58281E+01	5.69116E+02	1	9.73714E-03	1.34026E+03	0.00000E+00	2.85011E+05	7.36727E+06	0.00000E+00
1080	5.75478E+02	4.51982E+01	5.80009E+02	1	1.02420E-02	1.39886E+03	0.00000E+00	2.99790E+05	7.74929E+06	0.00000E+00
1090	5.83891E+02	4.45189E+01	5.91385E+02	1	1.06249E-02	1.44678E+03	0.00000E+00	3.10996E+05	8.03895E+06	0.00000E+00
1100	5.92183E+02	4.38076E+01	6.02870E+02	1	1.04399E-02	1.43858E+03	0.00000E+00	3.05582E+05	7.89900E+06	0.00000E+00
1110	5.99585E+02	4.31367E+01	6.13367E+02	1	8.81217E-03	1.29112E+03	0.00000E+00	2.57937E+05	6.66742E+06	0.00000E+00
1120	6.04694E+02	4.26490E+01	6.20770E+02	1	4.76683E-03	9.48548E+02	0.00000E+00	1.39528E+05	3.60665E+06	0.00000E+00
CHANNEL 2										
2010	5.25304E+02	4.85910E+01	5.16582E+02	1	4.36943E-03	8.30606E+02	0.00000E+00	1.27895E+05	9.91792E+06	0.00000E+00
2020	5.30796E+02	4.82647E+01	5.23219E+02	1	7.80369E-03	1.11856E+03	0.00000E+00	2.28418E+05	1.77132E+07	0.00000E+00
2030	5.38297E+02	4.78037E+01	5.32392E+02	1	9.01989E-03	1.23705E+03	0.00000E+00	2.64017E+05	2.04737E+07	0.00000E+00
2040	5.46384E+02	4.72860E+01	5.42423E+02	1	9.37958E-03	1.28048E+03	0.00000E+00	2.74545E+05	2.12902E+07	0.00000E+00
2050	5.54595E+02	4.67340E+01	5.52782E+02	1	9.62017E-03	1.31352E+03	0.00000E+00	2.81588E+05	2.18363E+07	0.00000E+00
2060	5.62913E+02	4.61476E+01	5.63462E+02	1	9.96791E-03	1.35716E+03	0.00000E+00	2.91766E+05	2.26256E+07	0.00000E+00
2070	5.71419E+02	4.55141E+01	5.74605E+02	1	1.04702E-02	1.41636E+03	0.00000E+00	3.06469E+05	2.37658E+07	0.00000E+00
2080	5.80197E+02	4.48224E+01	5.86357E+02	1	1.10852E-02	1.48836E+03	0.00000E+00	3.24470E+05	2.51617E+07	0.00000E+00
2090	5.89235E+02	4.40669E+01	5.98750E+02	1	1.16444E-02	1.55643E+03	0.00000E+00	3.40837E+05	2.64309E+07	0.00000E+00
2100	5.98258E+02	4.32604E+01	6.11465E+02	1	1.16782E-02	1.57121E+03	0.00000E+00	3.41828E+05	2.65077E+07	0.00000E+00
2110	6.06478E+02	4.24781E+01	6.23372E+02	1	1.01607E-02	1.42842E+03	0.00000E+00	2.97410E+05	2.30632E+07	0.00000E+00
2120	6.12288E+02	4.18914E+01	6.32008E+02	1	5.67958E-03	1.03087E+03	0.00000E+00	1.66244E+05	1.28918E+07	0.00000E+00
CHANNEL 3										
3010	5.24795E+02	4.86207E+01	5.15970E+02	1	3.24671E-03	7.45818E+02	0.00000E+00	9.50331E+04	9.82605E+06	0.00000E+00
3020	5.28984E+02	4.83729E+01	5.21024E+02	1	6.02329E-03	9.64993E+02	0.00000E+00	1.76305E+05	1.82292E+07	0.00000E+00
3030	5.34906E+02	4.80137E+01	5.28231E+02	1	7.19506E-03	1.07038E+03	0.00000E+00	2.10603E+05	2.17756E+07	0.00000E+00
3040	5.41474E+02	4.76028E+01	5.36314E+02	1	7.63017E-03	1.11598E+03	0.00000E+00	2.23339E+05	2.30924E+07	0.00000E+00
3050	5.48262E+02	4.71608E+01	5.44781E+02	1	7.90016E-03	1.14749E+03	0.00000E+00	2.31242E+05	2.39095E+07	0.00000E+00
3060	5.55210E+02	4.66911E+01	5.53566E+02	1	8.21318E-03	1.18341E+03	0.00000E+00	2.40404E+05	2.48568E+07	0.00000E+00
3070	5.62354E+02	4.61860E+01	5.62745E+02	1	8.62212E-03	1.22903E+03	0.00000E+00	2.52374E+05	2.60945E+07	0.00000E+00

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3080	5.69744E+02	4.56392E+01	5.72400E+02	1	9.08609E-03	1.28102E+03	0.00000E+00	2.65955E+05	2.74987E+07	0.00000E+00
3090	5.77336E+02	4.50509E+01	5.82501E+02	1	9.44079E-03	1.32411E+03	0.00000E+00	2.76337E+05	2.85722E+07	0.00000E+00
3100	5.84853E+02	4.44364E+01	5.92710E+02	1	9.28483E-03	1.31828E+03	0.00000E+00	2.71772E+05	2.81002E+07	0.00000E+00
3110	5.91596E+02	4.38583E+01	6.02052E+02	1	7.84853E-03	1.19322E+03	0.00000E+00	2.29731E+05	2.37533E+07	0.00000E+00
3120	5.96265E+02	4.34391E+01	6.08639E+02	1	4.23375E-03	8.97441E+02	0.00000E+00	1.23924E+05	1.28133E+07	0.00000E+00
CHANNEL 4										
4010	5.25484E+02	4.85806E+01	5.16798E+02	1	4.76478E-03	8.61035E+02	0.00000E+00	1.39468E+05	2.25319E+07	0.00000E+00
4020	5.31107E+02	4.82460E+01	5.23598E+02	1	7.70733E-03	1.11045E+03	0.00000E+00	2.25598E+05	3.64468E+07	0.00000E+00
4030	5.38140E+02	4.78135E+01	5.32198E+02	1	8.06666E-03	1.15044E+03	0.00000E+00	2.36115E+05	3.81460E+07	0.00000E+00
4040	5.45261E+02	4.73592E+01	5.41020E+02	1	8.11501E-03	1.16301E+03	0.00000E+00	2.37531E+05	3.83746E+07	0.00000E+00
4050	5.52358E+02	4.68866E+01	5.49943E+02	1	8.25103E-03	1.18347E+03	0.00000E+00	2.41512E+05	3.90178E+07	0.00000E+00
4060	5.59541E+02	4.63887E+01	5.59109E+02	1	8.56084E-03	1.22006E+03	0.00000E+00	2.50580E+05	4.04829E+07	0.00000E+00
4070	5.66945E+02	4.58506E+01	5.68719E+02	1	9.06512E-03	1.27567E+03	0.00000E+00	2.65341E+05	4.28675E+07	0.00000E+00
4080	5.74701E+02	4.52589E+01	5.78971E+02	1	9.73848E-03	1.34929E+03	0.00000E+00	2.85051E+05	4.60518E+07	0.00000E+00
4090	5.82865E+02	4.46038E+01	5.89983E+02	1	1.04597E-02	1.42926E+03	0.00000E+00	3.06160E+05	4.94621E+07	0.00000E+00
4100	5.91267E+02	4.38879E+01	6.01589E+02	1	1.08264E-02	1.47587E+03	0.00000E+00	3.16893E+05	5.11962E+07	0.00000E+00
4110	5.99210E+02	4.31716E+01	6.12829E+02	1	9.78991E-03	1.38354E+03	0.00000E+00	2.86556E+05	4.62950E+07	0.00000E+00
4120	6.05036E+02	4.26158E+01	6.21270E+02	1	5.69149E-03	1.02383E+03	0.00000E+00	1.66593E+05	2.69142E+07	0.00000E+00
CHANNEL 5										
5010	5.24893E+02	4.86150E+01	5.16088E+02	1	3.46290E-03	7.61780E+02	0.00000E+00	1.01361E+05	3.27510E+07	0.00000E+00
5020	5.29135E+02	4.83640E+01	5.21206E+02	1	5.92440E-03	9.57075E+02	0.00000E+00	1.73410E+05	5.60311E+07	0.00000E+00
5030	5.34712E+02	4.80257E+01	5.27993E+02	1	6.52473E-03	1.01296E+03	0.00000E+00	1.90982E+05	6.17089E+07	0.00000E+00
5040	5.40570E+02	4.76601E+01	5.35196E+02	1	6.68636E-03	1.03337E+03	0.00000E+00	1.95713E+05	6.32375E+07	0.00000E+00
5050	5.46502E+02	4.72766E+01	5.42576E+02	1	6.84851E-03	1.05411E+03	0.00000E+00	2.00460E+05	6.47711E+07	0.00000E+00
5060	5.52550E+02	4.68730E+01	5.50189E+02	1	7.11457E-03	1.08418E+03	0.00000E+00	2.08247E+05	6.72874E+07	0.00000E+00
5070	5.58798E+02	4.64393E+01	5.58161E+02	1	7.50839E-03	1.12535E+03	0.00000E+00	2.19775E+05	7.10120E+07	0.00000E+00
5080	5.65330E+02	4.59678E+01	5.66616E+02	1	7.99919E-03	1.17609E+03	0.00000E+00	2.34141E+05	7.56539E+07	0.00000E+00
5090	5.72157E+02	4.54549E+01	5.75592E+02	1	8.46322E-03	1.22607E+03	0.00000E+00	2.47723E+05	8.00425E+07	0.00000E+00
5100	5.79089E+02	4.49088E+01	5.84869E+02	1	8.55231E-03	1.24250E+03	0.00000E+00	2.50331E+05	8.08851E+07	0.00000E+00
5110	5.85511E+02	4.43805E+01	5.93616E+02	1	7.49243E-03	1.15465E+03	0.00000E+00	2.19308E+05	7.08611E+07	0.00000E+00
5120	5.90114E+02	4.39851E+01	5.99992E+02	1	4.20052E-03	8.88175E+02	0.00000E+00	1.22952E+05	3.97272E+07	0.00000E+00
CHANNEL 6										
6010	5.24896E+02	4.86149E+01	5.16091E+02	1	3.46826E-03	7.62178E+02	0.00000E+00	1.01518E+05	3.28017E+07	0.00000E+00
6020	5.29145E+02	4.83634E+01	5.21218E+02	1	5.93596E-03	9.58030E+02	0.00000E+00	1.73749E+05	5.61404E+07	0.00000E+00
6030	5.34734E+02	4.80243E+01	5.28021E+02	1	6.54205E-03	1.01444E+03	0.00000E+00	1.91489E+05	6.18726E+07	0.00000E+00
6040	5.40609E+02	4.76577E+01	5.35245E+02	1	6.70625E-03	1.03510E+03	0.00000E+00	1.96296E+05	6.34257E+07	0.00000E+00
6050	5.46558E+02	4.72729E+01	5.42646E+02	1	6.86957E-03	1.05598E+03	0.00000E+00	2.01076E+05	6.49703E+07	0.00000E+00
6060	5.52624E+02	4.68679E+01	5.50283E+02	1	7.13668E-03	1.08617E+03	0.00000E+00	2.08895E+05	6.74965E+07	0.00000E+00
6070	5.58891E+02	4.64327E+01	5.58280E+02	1	7.53165E-03	1.12748E+03	0.00000E+00	2.20456E+05	7.12320E+07	0.00000E+00
6080	5.65441E+02	4.59596E+01	5.66761E+02	1	8.02367E-03	1.17840E+03	0.00000E+00	2.34857E+05	7.58854E+07	0.00000E+00
6090	5.72287E+02	4.54450E+01	5.75764E+02	1	8.48865E-03	1.22856E+03	0.00000E+00	2.48468E+05	8.02830E+07	0.00000E+00
6100	5.79237E+02	4.48969E+01	5.85068E+02	1	8.57747E-03	1.24499E+03	0.00000E+00	2.51067E+05	8.11231E+07	0.00000E+00
6110	5.85675E+02	4.43667E+01	5.93842E+02	1	7.51416E-03	1.15675E+03	0.00000E+00	2.19944E+05	7.10666E+07	0.00000E+00
6120	5.90289E+02	4.39699E+01	6.00235E+02	1	4.21262E-03	8.89299E+02	0.00000E+00	1.23306E+05	3.98417E+07	0.00000E+00
CHANNEL 7										
7010	5.24043E+02	4.86644E+01	5.15068E+02	1	1.59192E-03	6.28011E+02	0.00000E+00	4.65963E+04	1.08402E+07	0.00000E+00
7020	5.26118E+02	4.85421E+01	5.17564E+02	1	2.98664E-03	7.28278E+02	0.00000E+00	8.74207E+04	2.03377E+07	0.00000E+00
7030	5.29088E+02	4.83654E+01	5.21153E+02	1	3.59605E-03	7.76192E+02	0.00000E+00	1.05258E+05	2.44874E+07	0.00000E+00
7040	5.32440E+02	4.81636E+01	5.25223E+02	1	3.86926E-03	8.00340E+02	0.00000E+00	1.13255E+05	2.63479E+07	0.00000E+00
7050	5.35968E+02	4.79463E+01	5.29538E+02	1	4.04365E-03	8.17482E+02	0.00000E+00	1.18360E+05	2.75354E+07	0.00000E+00
7060	5.39635E+02	4.77171E+01	5.34047E+02	1	4.22811E-03	8.35443E+02	0.00000E+00	1.23759E+05	2.87915E+07	0.00000E+00
7070	5.43453E+02	4.74724E+01	5.38781E+02	1	4.45422E-03	8.56817E+02	0.00000E+00	1.30377E+05	3.03312E+07	0.00000E+00
7080	5.47447E+02	4.72107E+01	5.43771E+02	1	4.69819E-03	8.80001E+02	0.00000E+00	1.37519E+05	3.19925E+07	0.00000E+00
7090	5.51588E+02	4.69340E+01	5.48985E+02	1	4.86483E-03	8.97557E+02	0.00000E+00	1.42396E+05	3.31272E+07	0.00000E+00
7100	5.55706E+02	4.66509E+01	5.54218E+02	1	4.73386E-03	8.91862E+02	0.00000E+00	1.38563E+05	3.22354E+07	0.00000E+00
7110	5.59390E+02	4.63926E+01	5.58938E+02	1	3.92246E-03	8.33716E+02	0.00000E+00	1.14812E+05	2.67101E+07	0.00000E+00
7120	5.61915E+02	4.62107E+01	5.62199E+02	1	2.05986E-03	7.00019E+02	0.00000E+00	6.02933E+04	1.40267E+07	0.00000E+00

APPROXIMATE POINT KINETICS REACTIVITY DATA

	K-INFINITY	TOTAL REACTIVITY	CONTROL REACTIVITY	MODERATOR REACTIVITY	DENSITY REACTIVITY	DOPPLER REACTIVITY	RESIDUAL REACTIVITY
ADJOINT FLUX WTS	1.001935E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	-3.846243E-02

0 CONTROL ROD POSITION

0	1	2	3	4	5	6	7	8	9	10
1	8.0160E+01	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02	8.0160E+01	4.2672E+02	4.2672E+02	4.2672E+02
2	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02
3	4.2672E+02	4.2672E+02	8.0160E+01	4.2672E+02	4.2672E+02	4.2672E+02	8.0160E+01	4.2672E+02	4.2672E+02	4.2672E+02
4	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02
5	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02	8.0160E+01	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02
6	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02
7	8.0160E+01	4.2672E+02	8.0160E+01	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02
8	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02
9	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02
10	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02	4.2672E+02

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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   50
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:59:12
 REA FOR PWR - RETRAN3D SAMPLE PROBLEM - 1/4 CORE, 7 TH CHAN/ 1 BYP, NO ADFS                                    CPU TIME =     9.422
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *
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SYSTEM ELAPSED TIME (SEC)	SYSTEM ELAPSED TIME (SEC)	TIME STP ACTUAL	SYSTEM NORM. POWER	CBLK -1 OUTPUT	CORE-PHY ADJ TOT REAC (K-1)/K	CORE-PHY ADJ CTR REAC (K-1)/K	CORE-PHY ADJ DOP REAC (K-1)/K	CORE 6 AVG. TEMP. (DEG F)
0.00000E+00	0.00000E+00	0.00000E+00	1.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1.28795E+03
1.00000E-02	1.00000E-02	2.00000E+01	1.00000E+00	0.00000E+00	-1.86953E-11	0.00000E+00	-1.86953E-11	1.28795E+03
2.00000E-02	2.00000E-02	4.00000E+01	1.00000E+00	0.00000E+00	-1.86953E-11	0.00000E+00	-1.86953E-11	1.28795E+03
3.00000E-02	3.00000E-02	6.00000E+01	1.00000E+00	0.00000E+00	2.90049E-12	0.00000E+00	2.90049E-12	1.28795E+03
4.00000E-02	4.00000E-02	8.00000E+01	1.00000E+00	0.00000E+00	-4.87010E-11	0.00000E+00	-4.87010E-11	1.28795E+03
5.00000E-02	5.00000E-02	1.00000E+02	1.00000E+00	0.00000E+00	-2.50562E-10	0.00000E+00	-2.50562E-10	1.28795E+03
6.00000E-02	6.00000E-02	1.20000E+02	1.00000E+00	0.00000E+00	-3.17104E-10	0.00000E+00	-3.17104E-10	1.28795E+03
7.00000E-02	7.00000E-02	1.40000E+02	1.00000E+00	0.00000E+00	-8.69435E-11	0.00000E+00	-8.69435E-11	1.28795E+03
8.00000E-02	8.00000E-02	1.60000E+02	1.00000E+00	0.00000E+00	-1.85574E-10	0.00000E+00	-3.84500E-10	1.28795E+03
9.00000E-02	9.00000E-02	1.80000E+02	1.00000E+00	0.00000E+00	9.95933E-11	0.00000E+00	-3.84500E-10	1.28795E+03
1.00000E-01	1.00000E-01	2.00000E+02	1.00000E+00	1.50000E-01	8.15595E-10	0.00000E+00	-3.84500E-10	1.28795E+03
1.10000E-01	1.10000E-01	2.20000E+02	1.02435E+00	6.15000E+00	1.72922E-04	1.64643E-04	-2.05246E-07	1.28797E+03
1.20000E-01	1.20000E-01	2.40000E+02	1.06654E+00	1.21500E+01	4.01776E-04	3.82525E-04	-1.22943E-06	1.28805E+03
1.30000E-01	1.30000E-01	2.60000E+02	1.10801E+00	1.81500E+01	6.01521E-04	5.52644E-04	-3.36735E-06	1.28821E+03
1.40000E-01	1.40000E-01	2.80000E+02	1.15888E+00	2.41500E+01	8.46093E-04	7.61516E-04	-6.77994E-06	1.28847E+03
1.50000E-01	1.50000E-01	3.00000E+02	1.22846E+00	3.01500E+01	1.15473E-03	1.02609E-03	-1.19920E-05	1.28885E+03
1.60000E-01	1.60000E-01	3.20000E+02	1.32935E+00	3.61500E+01	1.55653E-03	1.37181E-03	-1.99550E-05	1.28941E+03
1.70000E-01	1.70000E-01	3.40000E+02	1.48768E+00	4.21500E+01	2.09996E-03	1.84119E-03	-3.24744E-05	1.29023E+03
1.80000E-01	1.80000E-01	3.60000E+02	1.64283E+00	4.81500E+01	2.43520E-03	2.13729E-03	-5.02378E-05	1.29141E+03
1.90000E-01	1.90000E-01	3.80000E+02	1.80416E+00	5.41500E+01	2.79979E-03	2.46095E-03	-7.32005E-05	1.29294E+03
2.00000E-01	2.00000E-01	4.00000E+02	2.03298E+00	6.01500E+01	3.24501E-03	2.85795E-03	-1.03503E-04	1.29491E+03
2.10000E-01	2.10000E-01	4.20000E+02	2.39132E+00	6.61500E+01	3.80053E-03	3.35653E-03	-1.45260E-04	1.29755E+03
2.20000E-01	2.20000E-01	4.44000E+02	3.05478E+00	7.21321E+01	4.54095E-03	4.02868E-03	-2.10161E-04	1.30131E+03
2.30000E-01	2.30000E-01	4.67000E+02	3.84259E+00	7.81500E+01	4.88336E-03	4.38239E-03	-2.95672E-04	1.30688E+03
2.40000E-01	2.40000E-01	4.87000E+02	4.61136E+00	8.41500E+01	5.15423E-03	4.69375E-03	-4.05610E-04	1.31437E+03
2.50000E-01	2.50000E-01	5.07000E+02	5.58283E+00	9.01500E+01	5.44175E-03	5.04244E-03	-5.46795E-04	1.32403E+03
2.60000E-01	2.60000E-01	5.30000E+02	7.07182E+00	9.61360E+01	5.77228E-03	5.46509E-03	-7.37880E-04	1.33669E+03
2.70000E-01	2.70000E-01	5.57000E+02	9.35057E+00	1.02150E+02	6.11276E-03	5.93656E-03	-9.80804E-04	1.35403E+03
2.80000E-01	2.80000E-01	5.82000E+02	1.20575E+01	1.08106E+02	6.07280E-03	6.15473E-03	-1.30625E-03	1.37839E+03
2.90000E-01	2.90000E-01	6.02000E+02	1.32304E+01	1.14150E+02	5.91273E-03	6.29194E-03	-1.65996E-03	1.40801E+03
3.00000E-01	3.00000E-01	6.22000E+02	1.31648E+01	1.20000E+02	5.77713E-03	6.45347E-03	-2.02707E-03	1.43906E+03
3.10000E-01	3.10000E-01	6.42000E+02	1.15886E+01	1.20000E+02	5.40567E-03	6.38335E-03	-2.36107E-03	1.46799E+03
3.20000E-01	3.20000E-01	6.64000E+02	9.22868E+00	1.20000E+02	5.11238E-03	6.30805E-03	-2.61715E-03	1.49089E+03
3.30000E-01	3.30000E-01	6.86000E+02	7.39373E+00	1.20000E+02	4.90555E-03	6.23861E-03	-2.80565E-03	1.50799E+03
3.40000E-01	3.40000E-01	7.06000E+02	6.35739E+00	1.20000E+02	4.77627E-03	6.18843E-03	-2.94578E-03	1.52131E+03
3.50000E-01	3.50000E-01	7.26000E+02	5.80223E+00	1.20000E+02	4.68879E-03	6.15472E-03	-3.06786E-03	1.53257E+03
3.60000E-01	3.60000E-01	7.46000E+02	5.50974E+00	1.20000E+02	4.62643E-03	6.13241E-03	-3.17993E-03	1.54276E+03
3.70000E-01	3.70000E-01	7.66000E+02	5.35080E+00	1.20000E+02	4.58108E-03	6.11730E-03	-3.28704E-03	1.55238E+03
3.80000E-01	3.80000E-01	7.86000E+02	5.25914E+00	1.20000E+02	4.54533E-03	6.10599E-03	-3.39118E-03	1.56168E+03
3.90000E-01	3.90000E-01	8.06000E+02	5.20096E+00	1.20000E+02	4.51528E-03	6.09620E-03	-3.49311E-03	1.57079E+03
4.00000E-01	4.00000E-01	8.26000E+02	5.16105E+00	1.20000E+02	4.48904E-03	6.08714E-03	-3.59329E-03	1.57976E+03
4.10000E-01	4.10000E-01	8.46000E+02	5.13152E+00	1.20000E+02	4.46528E-03	6.07805E-03	-3.69187E-03	1.58864E+03
4.20000E-01	4.20000E-01	8.66000E+02	5.10814E+00	1.20000E+02	4.44315E-03	6.06859E-03	-3.78892E-03	1.59744E+03
4.30000E-01	4.30000E-01	8.86000E+02	5.08848E+00	1.20000E+02	4.42212E-03	6.05853E-03	-3.88450E-03	1.60617E+03
4.40000E-01	4.40000E-01	9.06000E+02	5.07107E+00	1.20000E+02	4.40188E-03	6.04773E-03	-3.97859E-03	1.61484E+03
4.50000E-01	4.50000E-01	9.26000E+02	5.05517E+00	1.20000E+02	4.38231E-03	6.03609E-03	-4.07122E-03	1.62345E+03
4.60000E-01	4.60000E-01	9.46000E+02	5.04033E+00	1.20000E+02	4.36323E-03	6.02348E-03	-4.16232E-03	1.63201E+03
4.70000E-01	4.70000E-01	9.66000E+02	5.02613E+00	1.20000E+02	4.34450E-03	6.00984E-03	-4.25189E-03	1.64052E+03
4.80000E-01	4.80000E-01	9.86000E+02	5.01234E+00	1.20000E+02	4.32615E-03	5.99519E-03	-4.33994E-03	1.64898E+03
4.90000E-01	4.90000E-01	1.00600E+03	4.99952E+00	1.20000E+02	4.30866E-03	5.97975E-03	-4.42656E-03	1.65739E+03

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   51
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:59:12
 REA FOR PWR - RETRAN3D SAMPLE PROBLEM - 1/4 CORE, 7 TH CHAN/ 1 BYP, NO ADFS                                    CPU TIME =     9.422
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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SYSTEM ELAPSED TIME (SEC)	CORE 16 AVG. TEMP. (DEG F)	CORE 30 AVG. TEMP. (DEG F)	CORE 42 AVG. TEMP. (DEG F)	CORE 54 AVG. TEMP. (DEG F)	CORE 66 AVG. TEMP. (DEG F)
0.00000E+00	1.28048E+03	1.18341E+03	1.22006E+03	1.08418E+03	1.08617E+03
1.00000E-02	1.28048E+03	1.18341E+03	1.22006E+03	1.08418E+03	1.08617E+03
2.00000E-02	1.28048E+03	1.18341E+03	1.22006E+03	1.08418E+03	1.08617E+03
3.00000E-02	1.28048E+03	1.18341E+03	1.22006E+03	1.08418E+03	1.08617E+03
4.00000E-02	1.28048E+03	1.18341E+03	1.22006E+03	1.08418E+03	1.08617E+03
5.00000E-02	1.28048E+03	1.18341E+03	1.22006E+03	1.08418E+03	1.08617E+03
6.00000E-02	1.28048E+03	1.18341E+03	1.22006E+03	1.08418E+03	1.08617E+03
7.00000E-02	1.28048E+03	1.18341E+03	1.22006E+03	1.08418E+03	1.08617E+03
8.00000E-02	1.28048E+03	1.18341E+03	1.22006E+03	1.08418E+03	1.08617E+03
9.00000E-02	1.28048E+03	1.18341E+03	1.22006E+03	1.08418E+03	1.08617E+03
1.00000E-01	1.28048E+03	1.18341E+03	1.22006E+03	1.08418E+03	1.08617E+03
1.10000E-01	1.28052E+03	1.18342E+03	1.22007E+03	1.08419E+03	1.08618E+03
1.20000E-01	1.28071E+03	1.18349E+03	1.22015E+03	1.08425E+03	1.08625E+03
1.30000E-01	1.28107E+03	1.18364E+03	1.22031E+03	1.08439E+03	1.08638E+03
1.40000E-01	1.28163E+03	1.18387E+03	1.22056E+03	1.08459E+03	1.08658E+03
1.50000E-01	1.28246E+03	1.18421E+03	1.22093E+03	1.08490E+03	1.08689E+03
1.60000E-01	1.28366E+03	1.18471E+03	1.22148E+03	1.08535E+03	1.08734E+03
1.70000E-01	1.28542E+03	1.18543E+03	1.22228E+03	1.08601E+03	1.08800E+03
1.80000E-01	1.28793E+03	1.18649E+03	1.22344E+03	1.08696E+03	1.08896E+03
1.90000E-01	1.29110E+03	1.18785E+03	1.22495E+03	1.08820E+03	1.09020E+03
2.00000E-01	1.29513E+03	1.18960E+03	1.22690E+03	1.08980E+03	1.09180E+03
2.10000E-01	1.30048E+03	1.19195E+03	1.22953E+03	1.09196E+03	1.09397E+03
2.20000E-01	1.30805E+03	1.19531E+03	1.23328E+03	1.09505E+03	1.09706E+03
2.30000E-01	1.31907E+03	1.20028E+03	1.23890E+03	1.09966E+03	1.10168E+03
2.40000E-01	1.33343E+03	1.20699E+03	1.24654E+03	1.10593E+03	1.10796E+03
2.50000E-01	1.35149E+03	1.21566E+03	1.25652E+03	1.11411E+03	1.11616E+03
2.60000E-01	1.37459E+03	1.22706E+03	1.26979E+03	1.12499E+03	1.12705E+03
2.70000E-01	1.40545E+03	1.24273E+03	1.28823E+03	1.14011E+03	1.14219E+03
2.80000E-01	1.44760E+03	1.26482E+03	1.31462E+03	1.16171E+03	1.16382E+03
2.90000E-01	1.49727E+03	1.29179E+03	1.34748E+03	1.18850E+03	1.19064E+03
3.00000E-01	1.54762E+03	1.32021E+03	1.38290E+03	1.21724E+03	1.21940E+03
3.10000E-01	1.59347E+03	1.34676E+03	1.41641E+03	1.24439E+03	1.24657E+03
3.20000E-01	1.62958E+03	1.36780E+03	1.44296E+03	1.26594E+03	1.26812E+03
3.30000E-01	1.65651E+03	1.38353E+03	1.46287E+03	1.28209E+03	1.28429E+03
3.40000E-01	1.67753E+03	1.39581E+03	1.47847E+03	1.29475E+03	1.29695E+03
3.50000E-01	1.69532E+03	1.40619E+03	1.49172E+03	1.30549E+03	1.30769E+03
3.60000E-01	1.71143E+03	1.41559E+03	1.50375E+03	1.31523E+03	1.31744E+03
3.70000E-01	1.72663E+03	1.42447E+03	1.51513E+03	1.32445E+03	1.32666E+03
3.80000E-01	1.74132E+03	1.43306E+03	1.52615E+03	1.33338E+03	1.33559E+03
3.90000E-01	1.75566E+03	1.44147E+03	1.53696E+03	1.34212E+03	1.34434E+03
4.00000E-01	1.76977E+03	1.44977E+03	1.54762E+03	1.35074E+03	1.35296E+03
4.10000E-01	1.78368E+03	1.45797E+03	1.55817E+03	1.35927E+03	1.36149E+03
4.20000E-01	1.79742E+03	1.46610E+03	1.56864E+03	1.36772E+03	1.36995E+03
4.30000E-01	1.81102E+03	1.47417E+03	1.57903E+03	1.37612E+03	1.37835E+03
4.40000E-01	1.82446E+03	1.48218E+03	1.58936E+03	1.38446E+03	1.38669E+03
4.50000E-01	1.83777E+03	1.49015E+03	1.59964E+03	1.39275E+03	1.39498E+03
4.60000E-01	1.85094E+03	1.49806E+03	1.60986E+03	1.40099E+03	1.40322E+03
4.70000E-01	1.86397E+03	1.50593E+03	1.62003E+03	1.40918E+03	1.41142E+03
4.80000E-01	1.87686E+03	1.51376E+03	1.63014E+03	1.41733E+03	1.41957E+03
4.90000E-01	1.88961E+03	1.52154E+03	1.64021E+03	1.42543E+03	1.42768E+03

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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   55
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:59:13
 REA FOR PWR - RETRAN3D SAMPLE PROBLEM - 1/4 CORE, 7 TH CHAN/ 1 BYP, NO ADFS                                   CPU TIME =    9.547
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NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	ENERGY BALANCE (BTU)	TOTAL MASS BALANCE (LBM)	NCG MASS BALANCE (LBM)	AVERAGE TIME STEP (SEC)	CURRENT TIME STEP (SEC)	ELAPSED TIME (SEC)	TIME STEP NUM STANDRD/ACTUL
4.98802E+00	4.25379E+03	1.45182E+10	4.20811E+07	7.93758E+04	0.00000E+00	5.00000E-04	5.00000E-04	5.00000E-01	1000 1026

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	VOID FRAC.	POWR TO H2O (BTU/SEC)
8	2.25000E+03	5.46555E+04	5.43222E+02	4.72235E+01	5.46960E+02	0.00000E+00	0.00000E+00	0.00000E+00
37	2.29487E+03	1.83680E+03	5.14202E+02	4.87086E+01	5.23328E+02	0.00000E+00	0.00000E+00	0.00000E+00
38	2.29464E+03	1.83679E+03	5.14205E+02	4.87083E+01	5.23330E+02	0.00000E+00	0.00000E+00	0.00000E+00
39	2.29451E+03	1.83678E+03	5.14208E+02	4.87081E+01	5.23332E+02	0.00000E+00	0.00000E+00	0.00000E+00
192	2.29150E+03	1.02812E+03	5.14209E+02	4.87065E+01	5.23329E+02	0.00000E+00	0.00000E+00	0.00000E+00
193	2.28810E+03	1.02808E+03	5.14209E+02	4.87047E+01	5.23324E+02	0.00000E+00	0.00000E+00	0.00000E+00
194	2.28470E+03	1.02805E+03	5.14209E+02	4.87030E+01	5.23320E+02	0.00000E+00	0.00000E+00	0.00000E+00
195	2.28129E+03	1.02801E+03	5.14208E+02	4.87013E+01	5.23314E+02	0.00000E+00	0.00000E+00	0.00000E+00
196	2.27789E+03	1.02797E+03	5.14207E+02	4.86996E+01	5.23309E+02	0.00000E+00	0.00000E+00	0.00000E+00
197	2.27449E+03	1.02794E+03	5.14207E+02	4.86978E+01	5.23304E+02	0.00000E+00	0.00000E+00	0.00000E+00
198	2.27108E+03	1.02790E+03	5.14206E+02	4.86961E+01	5.23299E+02	0.00000E+00	0.00000E+00	0.00000E+00
199	2.26768E+03	1.02786E+03	5.14205E+02	4.86944E+01	5.23294E+02	0.00000E+00	0.00000E+00	0.00000E+00
200	2.26427E+03	1.02783E+03	5.14204E+02	4.86927E+01	5.23288E+02	0.00000E+00	0.00000E+00	0.00000E+00
201	2.26087E+03	1.02779E+03	5.14204E+02	4.86910E+01	5.23283E+02	0.00000E+00	0.00000E+00	0.00000E+00
202	2.25746E+03	1.02776E+03	5.14203E+02	4.86892E+01	5.23278E+02	0.00000E+00	0.00000E+00	0.00000E+00
203	2.25406E+03	1.02772E+03	5.14202E+02	4.86875E+01	5.23273E+02	0.00000E+00	0.00000E+00	0.00000E+00

JUNCTION NUMBER	CONNECTS VOLUMES	CHOK/ PATH	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E VEL. PSI	ELEV. PSI	D I F F E R E N T I A L S FRIC. PSI	ACCL. PSI	PUMP PSI
37	37 TO 38		1.73949E+04	5.14202E+02	2.05303E-02	6.89055E-05	-1.66420E-01	-6.12643E-02	4.13009E-05	0.00000E+00
38	38 TO 39		1.73947E+04	5.14205E+02	2.05304E-02	9.81675E-02	-1.66420E-01	-6.12636E-02	8.27311E-05	0.00000E+00
192	39 TO 192		8.39996E+03	5.14208E+02	2.05305E-02	-1.22456E+00	-2.52330E-01	-1.53007E+00	5.48033E-03	0.00000E+00
193	192 TO 193		8.39990E+03	5.14209E+02	2.05311E-02	-4.92887E-05	-3.38234E-01	-3.05400E+00	1.04623E-02	0.00000E+00
194	193 TO 194		8.39985E+03	5.14209E+02	2.05319E-02	-5.54029E-05	-3.38221E-01	-3.05403E+00	1.07627E-02	0.00000E+00
195	194 TO 195		8.39980E+03	5.14209E+02	2.05326E-02	-5.57245E-05	-3.38209E-01	-3.05407E+00	1.10574E-02	0.00000E+00
196	195 TO 196		8.39975E+03	5.14208E+02	2.05333E-02	-5.60526E-05	-3.38197E-01	-3.05410E+00	1.13345E-02	0.00000E+00
197	196 TO 197		8.39971E+03	5.14207E+02	2.05341E-02	-5.69326E-05	-3.38185E-01	-3.05413E+00	1.15812E-02	0.00000E+00
198	197 TO 198		8.39966E+03	5.14207E+02	2.05348E-02	-5.87369E-05	-3.38173E-01	-3.05417E+00	1.17868E-02	0.00000E+00
199	198 TO 199		8.39962E+03	5.14206E+02	2.05355E-02	-6.16709E-05	-3.38162E-01	-3.05420E+00	1.19456E-02	0.00000E+00
200	199 TO 200		8.39958E+03	5.14205E+02	2.05362E-02	-6.57972E-05	-3.38150E-01	-3.05424E+00	1.20576E-02	0.00000E+00
201	200 TO 201		8.39955E+03	5.14204E+02	2.05370E-02	-7.10540E-05	-3.38138E-01	-3.05429E+00	1.21288E-02	0.00000E+00
202	201 TO 202		8.39953E+03	5.14204E+02	2.05377E-02	-7.72738E-05	-3.38126E-01	-3.05434E+00	1.21686E-02	0.00000E+00
203	202 TO 203		8.39952E+03	5.14203E+02	2.05384E-02	-8.42046E-05	-3.38114E-01	-3.05440E+00	1.21872E-02	0.00000E+00
204	203 TO 8		8.39952E+03	5.14202E+02	2.05391E-02	1.27183E+00	-1.08729E+00	-4.23116E+00	7.93019E-03	0.00000E+00
CHANNEL JUNCTIONS										
1010	39 TO 1010	CHI	1.85137E+02	5.14208E+02	2.05305E-02	-1.09601E+00	-2.51508E-01	-2.20827E-01	-4.12879E-03	
1130	1120 TO 8	CHX	2.02593E+02	6.28637E+02	2.37397E-02	1.54452E+00	-1.06488E+00	-2.26778E+01	6.63513E-03	
2010	39 TO 2010	CHI	5.46095E+02	5.14208E+02	2.05305E-02	-1.06103E+00	-2.51311E-01	-2.14186E-01	-1.00294E-02	
2130	2120 TO 8	CHX	6.10217E+02	6.41145E+02	2.42367E-02	1.58443E+00	-1.06199E+00	-2.27800E+01	7.79082E-03	
3010	39 TO 3010	CHI	7.46847E+02	5.14208E+02	2.05305E-02	-1.11427E+00	-2.51586E-01	-2.24284E-01	-2.83442E-03	
3130	3120 TO 8	CHX	8.08891E+02	6.15545E+02	2.32586E-02	1.51091E+00	-1.06785E+00	-2.26839E+01	6.80982E-03	
4010	39 TO 4010	CHI	1.12857E+03	5.14208E+02	2.05305E-02	-1.04556E+00	-2.51158E-01	-2.11146E-01	-1.07412E-02	
4130	4120 TO 8	CHX	1.27204E+03	6.29928E+02	2.37891E-02	1.55919E+00	-1.06471E+00	-2.28941E+01	4.83666E-03	
5010	39 TO 5010	CHI	2.32387E+03	5.14208E+02	2.05305E-02	-1.10577E+00	-2.51489E-01	-2.22812E-01	-3.65062E-03	
5130	5120 TO 8	CHX	2.52912E+03	6.06515E+02	2.29482E-02	1.49348E+00	-1.06988E+00	-2.27698E+01	8.16438E-03	
6010	39 TO 6010	CHI	2.32371E+03	5.14208E+02	2.05305E-02	-1.10562E+00	-2.51489E-01	-2.22784E-01	-3.66119E-03	
6130	6120 TO 8	CHX	2.52916E+03	6.06778E+02	2.29570E-02	1.49404E+00	-1.06982E+00	-2.27689E+01	7.97802E-03	
7010	39 TO 7010	CHI	1.74043E+03	5.14208E+02	2.05305E-02	-1.19232E+00	-2.51964E-01	-2.39166E-01	1.97896E-03	
7130	7120 TO 8	CHX	1.80642E+03	5.65529E+02	2.17269E-02	1.39969E+00	-1.07818E+00	-2.26462E+01	6.52711E-03	
36	0 TO 37		1.73950E+04	5.14200E+02	2.05400E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

RETRAN CHANNEL EDIT - (VOLUMES AND CONDUCTORS ARE IDENTICALLY NUMBERED)

VOLUME NUMBER	MODERATOR TEMPERATURE (DEG. F)	MODERATOR DENSITY (LBM/FT**3)	MODERATOR ENTHALPY (BTU/LBM)	HEAT TRANSFER MODE	POWER DENSITY	FUEL TEMPERATURE (DEG. F)	FUEL ENTHALPY (CAL/GM)	HEAT FLUX (BTU/HR/FT**2)	CONDUCTOR HEATING RATE (BTU/HR)	DIR. MOD HEATING RATE (BTU/HR)
CHANNEL 1										
1010	5.27402E+02	4.84697E+01	5.19104E+02	1	5.04945E-03	1.02782E+03	0.00000E+00	2.53855E+05	1.90567E+07	0.00000E+00
1020	5.38356E+02	4.78035E+01	5.32453E+02	1	9.48325E-03	1.49690E+03	0.00000E+00	4.58567E+05	3.57899E+07	0.00000E+00
1030	5.52150E+02	4.69052E+01	5.49666E+02	1	1.13286E-02	1.70554E+03	0.00000E+00	5.33159E+05	4.27543E+07	0.00000E+00
1040	5.64385E+02	4.60459E+01	5.65355E+02	1	1.15134E-02	1.74853E+03	0.00000E+00	5.33702E+05	4.34516E+07	0.00000E+00
1050	5.73438E+02	4.53647E+01	5.77263E+02	1	1.06657E-02	1.71765E+03	0.00000E+00	5.01271E+05	4.02524E+07	0.00000E+00
1060	5.79768E+02	4.48645E+01	5.85750E+02	1	9.23782E-03	1.66575E+03	0.00000E+00	4.59432E+05	3.48637E+07	0.00000E+00
1070	5.84581E+02	4.44677E+01	5.92308E+02	1	7.74784E-03	1.62855E+03	0.00000E+00	4.25244E+05	2.92404E+07	0.00000E+00
1080	5.89122E+02	4.40805E+01	5.98579E+02	1	6.57494E-03	1.61871E+03	0.00000E+00	4.05856E+05	2.48139E+07	0.00000E+00
1090	5.94210E+02	4.36334E+01	6.05701E+02	1	5.75501E-03	1.62004E+03	0.00000E+00	3.95566E+05	2.17195E+07	0.00000E+00
1100	5.99914E+02	4.31100E+01	6.13826E+02	1	5.04450E-03	1.57826E+03	0.00000E+00	3.75509E+05	1.90380E+07	0.00000E+00
1110	6.05406E+02	4.25859E+01	6.21791E+02	1	3.99321E-03	1.39648E+03	0.00000E+00	3.11696E+05	1.50704E+07	0.00000E+00
1120	6.08961E+02	4.22318E+01	6.27037E+02	1	2.10342E-03	1.00350E+03	0.00000E+00	1.66217E+05	7.93834E+06	0.00000E+00
CHANNEL 2										
2010	5.28361E+02	4.84131E+01	5.20262E+02	1	6.24641E-03	1.14532E+03	0.00000E+00	3.08743E+05	7.07221E+07	0.00000E+00
2020	5.41479E+02	4.76066E+01	5.36308E+02	1	1.13254E-02	1.67960E+03	0.00000E+00	5.35517E+05	1.28226E+08	0.00000E+00
2030	5.57298E+02	4.65519E+01	5.56213E+02	1	1.32155E-02	1.87953E+03	0.00000E+00	6.03840E+05	1.49626E+08	0.00000E+00
2040	5.70701E+02	4.55765E+01	5.73629E+02	1	1.32674E-02	1.90222E+03	0.00000E+00	5.94519E+05	1.50214E+08	0.00000E+00
2050	5.80198E+02	4.48308E+01	5.86329E+02	2	1.21530E-02	1.85062E+03	0.00000E+00	5.67385E+05	1.37597E+08	0.00000E+00
2060	5.86433E+02	4.43151E+01	5.94842E+02	1	1.03371E-02	1.77940E+03	0.00000E+00	4.98623E+05	1.17037E+08	0.00000E+00
2070	5.90981E+02	4.39224E+01	6.01157E+02	1	8.51498E-03	1.73237E+03	0.00000E+00	4.57697E+05	9.64070E+07	0.00000E+00
2080	5.95339E+02	4.35334E+01	6.07291E+02	1	7.18162E-03	1.72748E+03	0.00000E+00	4.38060E+05	8.13106E+07	0.00000E+00
2090	6.00522E+02	4.30565E+01	6.14689E+02	1	6.32653E-03	1.74576E+03	0.00000E+00	4.32186E+05	7.16293E+07	0.00000E+00
2100	6.06788E+02	4.24521E+01	6.23814E+02	2	5.64405E-03	1.72630E+03	0.00000E+00	4.32867E+05	6.39022E+07	0.00000E+00
2110	6.12943E+02	4.18307E+01	6.32971E+02	2	4.60091E-03	1.54887E+03	0.00000E+00	3.66537E+05	5.20917E+07	0.00000E+00
2120	6.16999E+02	4.14008E+01	6.39133E+02	1	2.50455E-03	1.09590E+03	0.00000E+00	1.98484E+05	2.83566E+07	0.00000E+00
CHANNEL 3										
3010	5.27019E+02	4.84923E+01	5.18641E+02	1	4.62969E-03	9.79570E+02	0.00000E+00	2.31838E+05	6.98901E+07	0.00000E+00
3020	5.36959E+02	4.78904E+01	5.30736E+02	1	8.74479E-03	1.39856E+03	0.00000E+00	4.19164E+05	1.32012E+08	0.00000E+00
3030	5.49510E+02	4.70823E+01	5.46336E+02	1	1.04978E-02	1.58166E+03	0.00000E+00	4.87625E+05	1.58475E+08	0.00000E+00
3040	5.60646E+02	4.63151E+01	5.60516E+02	1	1.07009E-02	1.61853E+03	0.00000E+00	4.87991E+05	1.61541E+08	0.00000E+00
3050	5.68802E+02	4.57174E+01	5.71136E+02	1	9.87611E-03	1.58526E+03	0.00000E+00	4.55765E+05	1.49090E+08	0.00000E+00
3060	5.74323E+02	4.52953E+01	5.78444E+02	1	8.43004E-03	1.52928E+03	0.00000E+00	4.12979E+05	1.27260E+08	0.00000E+00
3070	5.78360E+02	4.49751E+01	5.83859E+02	1	6.96135E-03	1.48902E+03	0.00000E+00	3.79019E+05	1.05089E+08	0.00000E+00

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3080	5.82191E+02	4.46627E+01	5.89054E+02	1	5.87117E-03	1.47815E+03	0.00000E+00	3.61367E+05	8.86314E+07	0.00000E+00
3090	5.86662E+02	4.42894E+01	5.95180E+02	1	5.13499E-03	1.47937E+03	0.00000E+00	3.52718E+05	7.75181E+07	0.00000E+00
3100	5.91819E+02	4.38422E+01	6.02351E+02	1	4.50191E-03	1.44348E+03	0.00000E+00	3.34920E+05	6.79610E+07	0.00000E+00
3110	5.96845E+02	4.33918E+01	6.09444E+02	1	3.56628E-03	1.28768E+03	0.00000E+00	2.77817E+05	5.38368E+07	0.00000E+00
3120	6.00109E+02	4.30875E+01	6.14121E+02	1	1.87182E-03	9.46461E+02	0.00000E+00	1.47739E+05	2.82572E+07	0.00000E+00
CHANNEL 4										
4010	5.29106E+02	4.83689E+01	5.21162E+02	1	7.29959E-03	1.23381E+03	0.00000E+00	3.51892E+05	1.72180E+08	0.00000E+00
4020	5.43625E+02	4.74694E+01	5.38969E+02	1	1.28318E-02	1.76076E+03	0.00000E+00	5.79818E+05	3.02670E+08	0.00000E+00
4030	5.60239E+02	4.63450E+01	5.59988E+02	1	1.48315E-02	1.89371E+03	0.00000E+00	6.29935E+05	3.49838E+08	0.00000E+00
4040	5.73606E+02	4.53541E+01	5.77479E+02	2	1.48013E-02	1.87534E+03	0.00000E+00	6.35137E+05	3.49127E+08	0.00000E+00
4050	5.81816E+02	4.46994E+01	5.88523E+02	2	1.33037E-02	1.78106E+03	0.00000E+00	5.62682E+05	3.13801E+08	0.00000E+00
4060	5.85940E+02	4.43567E+01	5.94164E+02	1	1.04679E-02	1.65024E+03	0.00000E+00	4.59512E+05	2.46912E+08	0.00000E+00
4070	5.87875E+02	4.41903E+01	5.96841E+02	1	7.91465E-03	1.57135E+03	0.00000E+00	4.03417E+05	1.86687E+08	0.00000E+00
4080	5.89891E+02	4.40144E+01	5.99647E+02	1	6.50890E-03	1.56675E+03	0.00000E+00	3.86654E+05	1.53529E+08	0.00000E+00
4090	5.93561E+02	4.36916E+01	6.04785E+02	1	5.76324E-03	1.60179E+03	0.00000E+00	3.89500E+05	1.35941E+08	0.00000E+00
4100	5.98994E+02	4.31957E+01	6.12507E+02	1	5.26512E-03	1.62034E+03	0.00000E+00	3.89618E+05	1.24191E+08	0.00000E+00
4110	6.05042E+02	4.26215E+01	6.21258E+02	1	4.44745E-03	1.49961E+03	0.00000E+00	3.46846E+05	1.04905E+08	0.00000E+00
4120	6.09434E+02	4.21846E+01	6.27738E+02	1	2.51493E-03	1.08891E+03	0.00000E+00	1.99520E+05	5.93212E+07	0.00000E+00
CHANNEL 5										
5010	5.27491E+02	4.84645E+01	5.19211E+02	1	5.34147E-03	1.03495E+03	0.00000E+00	2.60565E+05	2.51985E+08	0.00000E+00
5020	5.38360E+02	4.78032E+01	5.32458E+02	1	9.80568E-03	1.45342E+03	0.00000E+00	4.50781E+05	4.62585E+08	0.00000E+00
5030	5.51457E+02	4.69520E+01	5.48789E+02	1	1.15968E-02	1.59310E+03	0.00000E+00	5.05489E+05	5.47083E+08	0.00000E+00
5040	5.62389E+02	4.61904E+01	5.62767E+02	1	1.17039E-02	1.59666E+03	0.00000E+00	4.93061E+05	5.52133E+08	0.00000E+00
5050	5.69624E+02	4.56557E+01	5.72218E+02	1	1.05610E-02	1.53038E+03	0.00000E+00	4.45153E+05	4.98219E+08	0.00000E+00
5060	5.73558E+02	4.53547E+01	5.77425E+02	1	8.43032E-03	1.43349E+03	0.00000E+00	3.81029E+05	3.97702E+08	0.00000E+00
5070	5.75631E+02	4.51910E+01	5.80197E+02	1	6.47674E-03	1.36943E+03	0.00000E+00	3.35966E+05	3.05541E+08	0.00000E+00
5080	5.77690E+02	4.50261E+01	5.82966E+02	1	5.31567E-03	1.35569E+03	0.00000E+00	3.19186E+05	2.50767E+08	0.00000E+00
5090	5.80954E+02	4.47628E+01	5.87377E+02	1	4.65602E-03	1.36734E+03	0.00000E+00	3.16516E+05	2.19649E+08	0.00000E+00
5100	5.85481E+02	4.43863E+01	5.93564E+02	1	4.16425E-03	1.35844E+03	0.00000E+00	3.08830E+05	1.96449E+08	0.00000E+00
5110	5.90323E+02	4.39720E+01	6.00265E+02	1	3.41111E-03	1.24490E+03	0.00000E+00	2.65839E+05	1.60919E+08	0.00000E+00
5120	5.93689E+02	4.36731E+01	6.04989E+02	1	1.85922E-03	9.36779E+02	0.00000E+00	1.47064E+05	8.77091E+07	0.00000E+00
CHANNEL 6										
6010	5.27494E+02	4.84643E+01	5.19215E+02	1	5.34285E-03	1.03537E+03	0.00000E+00	2.60725E+05	2.52050E+08	0.00000E+00
6020	5.38370E+02	4.78026E+01	5.32471E+02	1	9.80776E-03	1.45437E+03	0.00000E+00	4.51087E+05	4.62683E+08	0.00000E+00
6030	5.51479E+02	4.69505E+01	5.48818E+02	1	1.15990E-02	1.59451E+03	0.00000E+00	5.05913E+05	5.47184E+08	0.00000E+00
6040	5.62426E+02	4.61877E+01	5.62815E+02	1	1.17064E-02	1.59834E+03	0.00000E+00	4.93568E+05	5.52254E+08	0.00000E+00
6050	5.69678E+02	4.56516E+01	5.72289E+02	1	1.05653E-02	1.53231E+03	0.00000E+00	4.45767E+05	4.98418E+08	0.00000E+00
6060	5.73633E+02	4.53489E+01	5.77525E+02	1	8.43853E-03	1.43574E+03	0.00000E+00	3.81804E+05	3.98089E+08	0.00000E+00
6070	5.75731E+02	4.51832E+01	5.80331E+02	1	6.48930E-03	1.37198E+03	0.00000E+00	3.36865E+05	3.06134E+08	0.00000E+00
6080	5.77814E+02	4.50163E+01	5.83132E+02	1	5.32886E-03	1.35840E+03	0.00000E+00	3.20115E+05	2.51390E+08	0.00000E+00
6090	5.81099E+02	4.47510E+01	5.87573E+02	1	4.66857E-03	1.37018E+03	0.00000E+00	3.17444E+05	2.20241E+08	0.00000E+00
6100	5.85643E+02	4.43727E+01	5.93787E+02	1	4.17582E-03	1.36124E+03	0.00000E+00	3.09725E+05	1.96995E+08	0.00000E+00
6110	5.90498E+02	4.39568E+01	6.00510E+02	1	3.42062E-03	1.24723E+03	0.00000E+00	2.66591E+05	1.61368E+08	0.00000E+00
6120	5.93873E+02	4.36567E+01	6.05248E+02	1	1.86442E-03	9.38035E+02	0.00000E+00	1.47481E+05	8.79545E+07	0.00000E+00
CHANNEL 7										
7010	5.25155E+02	4.86013E+01	5.16399E+02	1	2.33648E-03	7.47840E+02	0.00000E+00	1.18722E+05	7.93613E+07	0.00000E+00
7020	5.30209E+02	4.83015E+01	5.22503E+02	1	4.56206E-03	9.58274E+02	0.00000E+00	2.21274E+05	1.54956E+08	0.00000E+00
7030	5.36838E+02	4.78963E+01	5.30593E+02	1	5.64970E-03	1.05600E+03	0.00000E+00	2.63327E+05	1.91899E+08	0.00000E+00
7040	5.42921E+02	4.75121E+01	5.38103E+02	1	5.85125E-03	1.07978E+03	0.00000E+00	2.66594E+05	1.98744E+08	0.00000E+00
7050	5.47416E+02	4.72184E+01	5.43714E+02	1	5.40745E-03	1.06067E+03	0.00000E+00	2.47928E+05	1.83670E+08	0.00000E+00
7060	5.50345E+02	4.70234E+01	5.47397E+02	1	4.53771E-03	1.02414E+03	0.00000E+00	2.20941E+05	1.54128E+08	0.00000E+00
7070	5.52351E+02	4.68865E+01	5.49936E+02	1	3.67299E-03	9.96100E+02	0.00000E+00	2.00051E+05	1.24757E+08	0.00000E+00
7080	5.54269E+02	4.67539E+01	5.52376E+02	1	3.07022E-03	9.84915E+02	0.00000E+00	1.89600E+05	1.04283E+08	0.00000E+00
7090	5.56646E+02	4.65892E+01	5.55407E+02	1	2.66839E-03	9.79875E+02	0.00000E+00	1.83845E+05	9.06349E+07	0.00000E+00
7100	5.59477E+02	4.63886E+01	5.59042E+02	1	2.31135E-03	9.57525E+02	0.00000E+00	1.72354E+05	7.85078E+07	0.00000E+00
7110	5.62236E+02	4.61910E+01	5.62603E+02	1	1.79279E-03	8.82138E+02	0.00000E+00	1.39993E+05	6.08943E+07	0.00000E+00
7120	5.63978E+02	4.60628E+01	5.64869E+02	1	9.14524E-04	7.24407E+02	0.00000E+00	7.20297E+04	3.10628E+07	0.00000E+00

APPROXIMATE POINT KINETICS REACTIVITY DATA

	K-INFINITY	TOTAL REACTIVITY	CONTROL REACTIVITY	MODERATOR REACTIVITY	DENSITY REACTIVITY	DOPPLER REACTIVITY	RESIDUAL REACTIVITY
ADJOINT FLUX WTS	1.006484E+00	4.291931E-03	5.963395E-03	0.000000E+00	1.721001E-03	-4.511748E-03	-4.948917E-06

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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   56
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:59:13
 REA FOR PWR - RETRAN3D SAMPLE PROBLEM - 1/4 CORE, 7 TH CHAN/ 1 BYP, NO ADFS                                    CPU TIME =    9.547
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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SYSTEM ELAPSED TIME (SEC)	SYSTEM ELAPSED TIME (SEC)	TIME STP ACTUAL	SYSTEM NORM. POWER	CBLK -1 OUTPUT	CORE-PHY ADJ TOT REAC (K-1)/K	CORE-PHY ADJ CTR REAC (K-1)/K	CORE-PHY ADJ DOP REAC (K-1)/K	CORE 6 AVG. TEMP. (DEG F)
5.00000E-01	5.00000E-01	1.02600E+03	4.98802E+00	1.20000E+02	4.29193E-03	5.96340E-03	-4.51175E-03	1.66575E+03

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PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   57
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:59:13
 REA FOR PWR - RETRAN3D SAMPLE PROBLEM - 1/4 CORE, 7 TH CHAN/ 1 BYP, NO ADFS                                    CPU TIME =    9.547
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *



     SYSTEM       CORE  16      CORE  30      CORE  42      CORE  54      CORE  66
  ELAPSED TIME   AVG. TEMP.    AVG. TEMP.    AVG. TEMP.    AVG. TEMP.    AVG. TEMP.
     (SEC)        (DEG F)       (DEG F)       (DEG F)       (DEG F)       (DEG F)
  5.00000E-01   1.90222E+03   1.52928E+03   1.65024E+03   1.43349E+03   1.43574E+03
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15.0 PWR STEAMLINE BREAK

The steamline break transient analysis is required for licensing and is one of the final Safety Analysis Report Chapter 15 events. The transient is initiated by a rupture in a main steamlinecausing a sudden cooling of the water in the primary side of the affected loop. This causes a significant asymmetric cooling of the core coupled with flow variations. The cold water inserted into the core is a positive reactivity effect that must be mitigated by the immediate insertion of control rods. Additional asymmetries are introduced into the event by postulating that the highest worth rod is stuck out of the core as an analysis conservatism. The power rise is ultimately affected by the introduction of soluble boron into the core from the emergency core cooling system.

The RETRAN-3D model is a plenum-to-plenum model which represents the core and enough of the core inlet and outlet to supply the boundary conditions simulating the broken and intact loop temperatures, pressures, and mass fluxes. The upper plenum regions are time-dependent volumes using pressure versus time data. The RETRAN-3D boundary conditions were specified so that the mass flux was specified independently for each channel by a fill junction.

The neutronics core is a half-core model. There are 14 axial planes of height 30.48 cm and 19 rows and 10 columns of assemblies 21.402 cm^2 cross-sectional area (Column 1 is half-assemblies). Of the 180.5 assemblies only 96.5 are powered. Ten assembly types and 11 composition types are modeled.

The half-core model simulates a 1/8 core 'cold' (broken loop) side with an inlet temperature versus time table and a 3/8 core 'hot' (three intact loops) side with a second temperature versus time table. There are 30 control rods modeled in 10 rod groups; Rod Groups 5, 6, and 7 drop at time 0.0 and Rod Group 10 (one rod) remains stuck out. In the RETRAN model the rod groups are specified using RETRAN control systems and boron injection can be simulated using the generalized transport option.

The neutronics model encompasses the cross-section data, the layout of the fuel assemblies, and the axial composition of the fuel assemblies, the control rod descriptions, and the neutronics calculation options and boundary conditions.

The RETRAN-3D core model is a half-core, plenum-to-plenum model based on the configuration from the neutronics model described above. The thermal-hydraulics to neutronics overlay is shown in Figure VII.15-1, where the squares represent the assembly locations and the shades of grey and texture represent assemblies that are combined into a single thermal-hydraulic channel. In the overlay, the 180.5 assemblies in the neutronics model were grouped into 19 thermal-hydraulic channels. This overlay was developed on the assumption that the position of the stuck rod (Row 12, Column 1) is the most significant location and number of assemblies per channel should become more coarse as one moves further from the stuck rod location. It was postulated (based on the rod ejection study experience and preliminary CORETRAN studies) that more detail in regions near the withdrawn rod would allow a better representation of the neutronic feedback

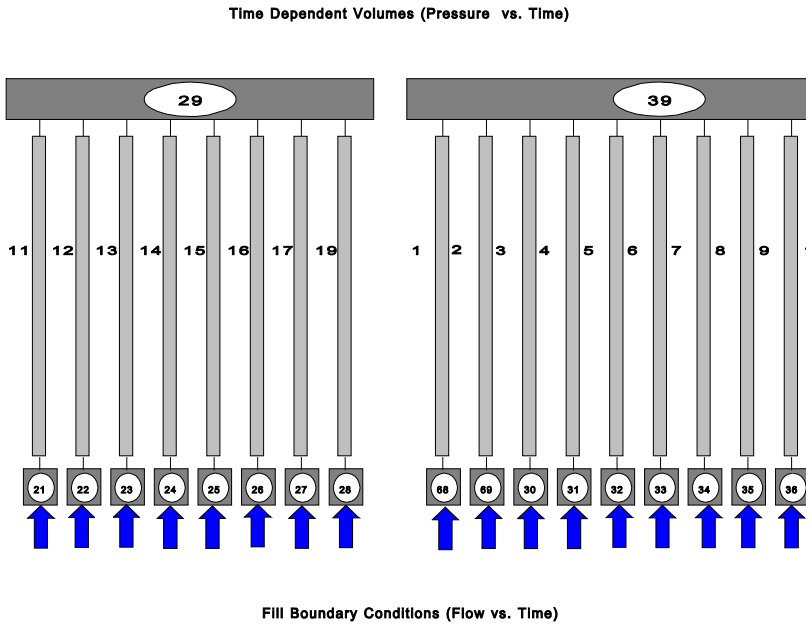


Figure VII.15-1. 19-Channel, Fill Boundary, Steamline Break Model

mechanisms.The upper plenum regions are time-dependent volumes using pressure versus time data. Initial flow splits for the channels were defined so that each channel has the same mass flux as the original reference calculation (see the steamline break discussion in Volume 4). The RETRAN-3D boundary conditions were specified so that the mass flux was specified independently for each RETRAN channel by a fill junction to exactly match these fluxes.

Figure VII.15-2 indicates the fill structure for the RETRAN model. The steamline break sample problem is terminated after 1.0 second.

The input listing and selected output are given below.

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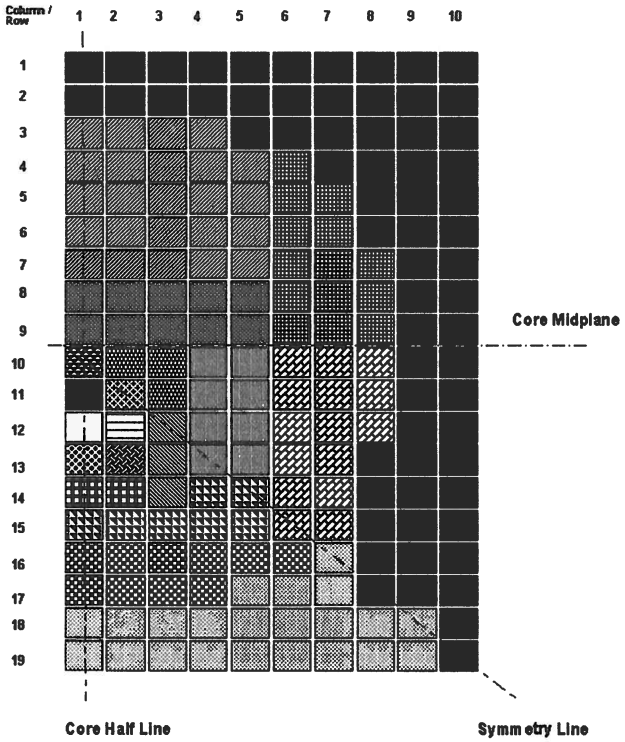


Figure VII.15-2. Steamline Break 19 Thermal-Hydraulic Channels Overlay

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```
LISTING OF INPUT DATA FOR CASE  1

    1    =STEAMLINE BREAK - RETRAN-3D SAMPLE PROBLEM - 1/2 CORE, 17 CHAN/ 2 BYP, FILL BC
    2    *
    3    ********************************************************************************
    4    *
    5    *  PROBLEM DIMENSIONS
    6    *
    7    *        1     2     3     4     5     6     7     8     9    10    11    12
    8    *      TAPE PRNPLT  POW    SS  NVOID GENTRN HTMAP SLIP  5EQ  NCOND  NSOL  PNMTH
    9    010001   0     0     3     0     0    -1     0     0     0     0     2     0
   10    *
   11    *
   12    *       INITIAL POWER (MEGAWATTS)
   13    010005        0.01              *  10kW
   14    *
   15    *
   16    020000  'TIMX'  0 'NTTS'  0 'POWR'  0 'RHOA'  0
   17    020001  'CTRA'  0 'DOPA'  0 'MODA'  0 'DENA'  0
   18    *
   19    *
   20    * FORMAT FOR TAPE60
   21    *
   22    025000 1
   23    025001 '(5(1X,1P,E15.7))'
   24    *
   25    *
   26    *30010  TRTG  TMIN  TRST  TMAJ  TDMP  NCHK  DELTM  TLAST
   27    030010  0.    0.01  0.0   50.0  50.0    0   0.01   50.0
   28    030020  0.    1.0   0.0   10.0  10.0    0   0.25  120.0
   29    030030  0.    4.0   0.0   40.0  40.0    0   0.25  250.0
   30    *
   31    *
   32    040010    1     1    0    0    1.0   0.0  ' PROBLEM END TIME'
   33    040020    2     1    0    0    0.0   0.0  ' POWER TABLE '
   34    *
   35    *
   36    * A LOWER PLENUM VOLUME FOR EACH CHANNEL
   37    *
   38    *      IBUB IREAD   PRES     TEMP   X       DESCRIPTION
   39    050211  0    0  2277.5000     0.0  0.0    * CHAN 11
   40    050221  0    0     0.0000     0.0  0.0    * CHAN 12
   41    050231  0    0     0.0000     0.0  0.0    * CHAN 13
   42    050241  0    0     0.0000     0.0  0.0    * CHAN 14
   43    050251  0    0     0.0000     0.0  0.0    * CHAN 15
   44    050261  0    0     0.0000     0.0  0.0    * CHAN 16
   45    050271  0    0     0.0000     0.0  0.0    * CHAN 17
   46    050281  0    0     0.0000     0.0  0.0    * CHAN 19
   47    050681  0    0  2277.5000     0.0  0.0    * CHAN  1
   48    050691  0    0     0.0000     0.0  0.0    * CHAN  2
   49    050301  0    0     0.0000     0.0  0.0    * CHAN  3
   50    050311  0    0     0.0000     0.0  0.0    * CHAN  4
   51    050321  0    0     0.0000     0.0  0.0    * CHAN  5
   52    050331  0    0     0.0000     0.0  0.0    * CHAN  6
   53    050341  0    0     0.0000     0.0  0.0    * CHAN  7
   54    050351  0    0     0.0000     0.0  0.0    * CHAN  8
   55    050361  0    0     0.0000     0.0  0.0    * CHAN  9
   56    050371  0    0     0.0000     0.0  0.0    * CHAN 10
   57    050381  0    0     0.0000     0.0  0.0    * CHAN 18
   58    *
   59    *        VOL     ZVOL     FLOWL     DESCRIPTION
   60    050212   .26420   1.0        1.0    * CHAN 11
   61    050222   .79260   1.0        1.0    * CHAN 12
   62    050232  2.11360   1.0        1.0    * CHAN 13
   63    050242  4.22720   1.0        1.0    * CHAN 14
   64    050252  2.37780   1.0        1.0    * CHAN 15
   65    050262  5.68030   1.0        1.0    * CHAN 16
   66    050272  3.69880   1.0        1.0    * CHAN 17
   67    050282 16.64460   1.0        1.0    * CHAN 19
   68    050682   .13210   1.0        1.0    * CHAN  1
   69    050692   .13210   1.0        1.0    * CHAN  2
   70    050302   .13210   1.0        1.0    * CHAN  3
   71    050312   .26420   1.0        1.0    * CHAN  4
   72    050322   .13210   1.0        1.0    * CHAN  5
   73    050332   .26420   1.0        1.0    * CHAN  6
   74    050342   .39630   1.0        1.0    * CHAN  7
   75    050352   .79260   1.0        1.0    * CHAN  8
   76    050362  1.71730   1.0        1.0    * CHAN  9
   77    050372  2.37780   1.0        1.0    * CHAN 10
   78    050382  5.54820   1.0        1.0    * CHAN 18
   79    *
   80    *        FLOWA   DIAMV    ELEV      DESCRIPTION
   81    050213   .26420  1.2230 -18.1930   * CHAN 11
   82    050223   .79260  1.2230 -18.1930   * CHAN 12
   83    050233  2.11360  1.2230 -18.1930   * CHAN 13
   84    050243  4.22720  1.2230 -18.1930   * CHAN 14
   85    050253  2.37780  1.2230 -18.1930   * CHAN 15
   86    050263  5.68030  1.2230 -18.1930   * CHAN 16
   87    050273  3.69880  1.2230 -18.1930   * CHAN 17
   88    050283 16.64460  1.2230 -18.1930   * CHAN 19
   89    050683   .13210  1.2230 -18.1930   * CHAN  1
   90    050693   .13210  1.2230 -18.1930   * CHAN  2
   91    050303   .13210  1.2230 -18.1930   * CHAN  3
   92    050313   .26420  1.2230 -18.1930   * CHAN  4
   93    050323   .13210  1.2230 -18.1930   * CHAN  5
   94    050333   .26420  1.2230 -18.1930   * CHAN  6
   95    050343   .39630  1.2230 -18.1930   * CHAN  7
   96    050353   .79260  1.2230 -18.1930   * CHAN  8
   97    050363  1.71730  1.2230 -18.1930   * CHAN  9
   98    050373  2.37780  1.2230 -18.1930   * CHAN 10
   99    050383  5.54820  1.2230 -18.1930   * CHAN 18
  100    *
```

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101   *
102   *05XXX1 VOLUME DATA CARDS - SET1 (CORE BOUNDARIES)
103   *
104   *       IBUB IREAD   PRES      TEMP           X         DESCRIPTION
105   050291    0     1  2.26500E+3  0.00000E+0  0.00000E+0  * 3LP UPPER PLENUM
106   050391    0     2  2.26500E+3  0.00000E+0  0.00000E+0  * 1LP UPPER PLENUM
107   *
108   *05XXX2 VOLUME DATA CARDS - SET2
109   *
110   *               VOL        ZVOL                 FLOWL   DESCRIPTION
111   050292 6.24720E+2  9.26800E+0              8.40100E+0  * 3LP UPPER PLENUM
112   050392 2.08240E+2  9.26800E+0              8.40100E+0  * 1LP UPPER PLENUM
113   *
114   *05XXX3 VOLUME DATA CARDS - SET3
115   *
116   *             FLOWA         DIAMV          ELEV          DESCRIPTION
117   050293  7.43800E+1    2.23200E+0    -5.21800E+0        * 3LP UPPER PLENUM
118   050393  2.47900E+1    2.23200E+0    -5.21800E+0        * 1LP UPPER PLENUM
119   *
120   *
121   *  BOUNDRY CONDITIONS
122   *
123   *        IRIN                                          DESCRIPTION
124   070100     16                                        * 3LG UPPER PLENUM
125   *
126   *     TIMTBL   PTABL   TTABL  XTABL   ZTABL
127   070101  0.0 2.2653+3 5.578+2 0.0 9.268
128   070102  1.0 2.2346+3 5.578+2 0.0 9.268
129   +       2.0 2.2330+3 5.578+2 0.0 9.268
130   070103  6.0 2.0989+3 5.578+2 0.0 9.268
131   +      10.0 1.9374+3 5.578+2 0.0 9.268
132   070104 16.0 1.7908+3 5.578+2 0.0 9.268
133   +      17.0 1.7980+3 5.578+2 0.0 9.268
134   070105 18.0 1.7396+3 5.578+2 0.0 9.268
135   +      19.0 1.7107+3 5.578+2 0.0 9.268
136   070106 20.0 1.6960+3 5.578+2 0.0 9.268
137   +      27.0 1.4060+3 5.578+2 0.0 9.268
138   070107 32.0 1.2523+3 4.578+2 0.0 9.268
139   +      39.0 1.0963+3 4.578+2 0.0 9.268
140   070108 48.0 9.8378+2 4.578+2 0.0 9.268
141   +     200.0 8.7917+2 4.578+2 0.0 9.268
142   070109 1.+9 8.7917+2 4.578+2 0.0 9.268
143   *
144   *
145   *        IRIN                                          DESCRIPTION
146   070200     16                                        * 1LG UPPER PLENUM
147   *
148   *
149   *     TIMTBL   PTABL   TTABL  XTABL   ZTABL
150   070201  0.0 2.2653+3 5.578+2 0.0 9.268
151   070202  1.0 2.2346+3 5.578+2 0.0 9.268
152   +       2.0 2.2330+3 5.578+2 0.0 9.268
153   070203  6.0 2.0989+3 5.578+2 0.0 9.268
154   +      10.0 1.9374+3 5.578+2 0.0 9.268
155   070204 16.0 1.7908+3 5.578+2 0.0 9.268
156   +      17.0 1.7980+3 5.578+2 0.0 9.268
157   070205 18.0 1.7396+3 5.578+2 0.0 9.268
158   +      19.0 1.7107+3 5.578+2 0.0 9.268
159   070206 20.0 1.6960+3 5.578+2 0.0 9.268
160   +      27.0 1.4060+3 5.578+2 0.0 9.268
161   070207 32.0 1.2523+3 4.578+2 0.0 9.268
162   +      39.0 1.0963+3 4.578+2 0.0 9.268
163   070208 48.0 9.8378+2 4.578+2 0.0 9.268
164   +     200.0 8.7917+2 4.578+2 0.0 9.268
165   070209 1.+9 8.7917+2 4.578+2 0.0 9.268
166   *
167   *
168   *
169   * FILL JUNCTIONS INTO LOWER PLENUM VOLUMES
170   *
171   *      IN OUT IPM IVL    FLOW          AJUN     DESCRIPTION
172   080211  0 21   1   0     0.0000        .26420   * CHAN 11
173   080221  0 22   1   0     0.0000        .79260   * CHAN 12
174   080231  0 23   1   0     0.0000       2.11360   * CHAN 13
175   080241  0 24   1   0     0.0000       4.22720   * CHAN 14
176   080251  0 25   1   0     0.0000       2.37780   * CHAN 15
177   080261  0 26   1   0     0.0000       5.68030   * CHAN 16
178   080271  0 27   1   0     0.0000       3.69880   * CHAN 17
179   080281  0 28   1   0     0.0000      16.64460   * CHAN 19
180   080681  0 68   2   0     0.0000        .13210   * CHAN  1
181   080691  0 69   2   0     0.0000        .13210   * CHAN  2
182   080701  0 30   2   0     0.0000        .13210   * CHAN  3
183   080711  0 31   2   0     0.0000        .26420   * CHAN  4
184   080721  0 32   2   0     0.0000        .13210   * CHAN  5
185   080731  0 33   2   0     0.0000        .26420   * CHAN  6
186   080741  0 34   2   0     0.0000        .39630   * CHAN  7
187   080751  0 35   2   0     0.0000        .79260   * CHAN  8
188   080761  0 36   2   0     0.0000       1.71730   * CHAN  9
189   080771  0 37   2   0     0.0000       2.37780   * CHAN 10
190   080781  0 38   2   0     0.0000       5.54820   * CHAN 18
191   *
192   *
193   *           ZJUN      INERTA       FJUNF       FJUNR   DESCRIPTION
194   080212 -1.81930E+1 5.25000E-1  1.90330E+0  0.00000E+0   *
195   080222 -1.81930E+1 5.25000E-1  1.90330E+0  0.00000E+0   *
196   080232 -1.81930E+1 5.25000E-1  1.90330E+0  0.00000E+0   *
197   080242 -1.81930E+1 5.25000E-1  1.90330E+0  0.00000E+0   *
198   080252 -1.81930E+1 5.25000E-1  1.90330E+0  0.00000E+0   *
199   080262 -1.81930E+1 5.25000E-1  1.90330E+0  0.00000E+0   *
200   080272 -1.81930E+1 5.25000E-1  1.90330E+0  0.00000E+0   *
201   080282 -1.81930E+1 5.25000E-1  1.90330E+0  0.00000E+0   *
202   080682 -1.81930E+1 1.57500E+0  1.90330E+0  0.00000E+0   *
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080692 -1.81930E+1 1.57500E+0  1.90330E+0  0.00000E+0   *
080702 -1.81930E+1 1.57500E+0  1.90330E+0  0.00000E+0   *
080712 -1.81930E+1 1.57500E+0  1.90330E+0  0.00000E+0   *
080722 -1.81930E+1 1.57500E+0  1.90330E+0  0.00000E+0   *
080732 -1.81930E+1 1.57500E+0  1.90330E+0  0.00000E+0   *
080742 -1.81930E+1 1.57500E+0  1.90330E+0  0.00000E+0   *
080752 -1.81930E+1 1.57500E+0  1.90330E+0  0.00000E+0   *
080762 -1.81930E+1 1.57500E+0  1.90330E+0  0.00000E+0   *
080772 -1.81930E+1 1.57500E+0  1.90330E+0  0.00000E+0   *
080782 -1.81930E+1 1.57500E+0  1.90330E+0  0.00000E+0   *
*
*        JVT  JCH  JCA  MVM     DIAMV       CONCO      DESCRIPTION
080213    0    1    0    0  1.48500E+0  1.00000E+0     *
080223    0    1    0    0  1.48500E+0  1.00000E+0     *
080233    0    1    0    0  1.48500E+0  1.00000E+0     *
080243    0    1    0    0  1.48500E+0  1.00000E+0     *
080253    0    1    0    0  1.48500E+0  1.00000E+0     *
080263    0    1    0    0  1.48500E+0  1.00000E+0     *
080273    0    1    0    0  1.48500E+0  1.00000E+0     *
080283    0    1    0    0  1.48500E+0  1.00000E+0     *
080683    0    1    0    0  1.48500E+0  1.00000E+0     *
080693    0    1    0    0  1.48500E+0  1.00000E+0     *
080703    0    1    0    0  1.48500E+0  1.00000E+0     *
080713    0    1    0    0  1.48500E+0  1.00000E+0     *
080723    0    1    0    0  1.48500E+0  1.00000E+0     *
080733    0    1    0    0  1.48500E+0  1.00000E+0     *
080743    0    1    0    0  1.48500E+0  1.00000E+0     *
080753    0    1    0    0  1.48500E+0  1.00000E+0     *
080763    0    1    0    0  1.48500E+0  1.00000E+0     *
080773    0    1    0    0  1.48500E+0  1.00000E+0     *
080783    0    1    0    0  1.48500E+0  1.00000E+0     *
*
*        IFR JTP IHQ ISP ANGL1 ANGL2
080214    0   0   0  0
080224    0   0   0  0
080234    0   0   0  0
080244    0   0   0  0
080254    0   0   0  0
080264    0   0   0  0
080274    0   0   0  0
080284    0   0   0  0
080684    0   0   0  0
080694    0   0   0  0
080704    0   0   0  0
080714    0   0   0  0
080724    0   0   0  0
080734    0   0   0  0
080744    0   0   0  0
080754    0   0   0  0
080764    0   0   0  0
080774    0   0   0  0
080784    0   0   0  0
*
*
* INLET FLOW AND TEMPERATURE
*
*
130100 102 2 0 0                          .0 7.41140+2 5.569553+2 2.26530+3
130101  1.0 7.39465+2 5.565412+2 2.23460+3 3.0 7.37180+2 5.556452+2 2.19947+3
130102  5.0 6.29830+2 5.524609+2 2.13243+3 7.0 5.50190+2 5.452798+2 2.05853+3
130103  9.0 4.88980+2 5.365245+2 1.97778+3 11.0 4.40360+2 5.278286+2 1.91297+3
130104 13.0 4.01370+2 5.191951+2 1.86410+3 15.0 3.68270+2 5.106483+2 1.81523+3
130105 17.0 3.36590+2 5.043985+2 1.79840+3 19.0 3.11471+2 4.997988+2 1.71070+3
130106 21.0 2.89234+2 4.966800+2 1.65457+3 23.0 2.66997+2 4.946644+2 1.57171+3
130107 25.0 2.44760+2 4.937108+2 1.48886+3 27.0 2.26910+2 4.927551+2 1.40600+3
130108 29.0 2.12175+2 4.921990+2 1.34452+3 31.0 1.98465+2 4.920683+2 1.28304+3
130109 33.0 1.86193+2 4.919277+2 1.23001+3 35.0 1.75360+2 4.917772+2 1.18544+3
130110 37.0 1.66948+2 4.916253+2 1.14087+3 39.0 1.58536+2 4.914743+2 1.09630+3
130111 41.0 1.51364+2 4.913011+2 1.07130+3 43.0 1.45431+2 4.911276+2 1.04629+3
130112 45.0 1.39498+2 4.909541+2 1.02129+3 47.0 1.33565+2 4.907791+2 9.96282+2
130113 49.0 1.27633+2 4.905921+2 9.83092+2 51.0 1.21700+2 4.903920+2 9.81715+2
130114 53.0 1.17256+2 4.901918+2 9.80339+2 55.0 1.12812+2 4.899906+2 9.78962+2
130115 57.0 1.09062+2 4.897905+2 9.77586+2 59.0 1.06008+2 4.895905+2 9.76210+2
130116 61.0 1.02953+2 4.893905+2 9.74833+2 63.0 9.98975+1 4.891894+2 9.73457+2
130117 65.0 9.68425+1 4.889895+2 9.72080+2 67.0 9.37875+1 4.887896+2 9.70704+2
130118 69.0 9.12184+1 4.881802+2 9.69327+2 71.0 8.91352+1 4.875700+2 9.67951+2
130119 73.0 8.70521+1 4.869614+2 9.66574+2 75.0 8.49689+1 4.863533+2 9.65198+2
130120 77.0 8.28857+1 4.857455+2 9.63822+2 79.0 8.08025+1 4.851369+2 9.62445+2
130121 81.0 7.87194+1 4.845300+2 9.61069+2 83.0 7.66362+1 4.839234+2 9.59692+2
130122 85.0 7.45530+1 4.833161+2 9.58316+2 87.0 7.31919+1 4.827104+2 9.56939+2
130123 89.0 7.18308+1 4.821050+2 9.55563+2 91.0 7.04697+1 4.815001+2 9.54186+2
130124 93.0 6.91086+1 4.808943+2 9.52810+2 95.0 6.77475+1 4.802902+2 9.51433+2
130125 97.0 6.63864+1 4.796864+2 9.50057+2 99.0 6.50253+1 4.790819+2 9.48681+2
130126 101.0 6.36642+1 4.784789+2 9.47304+2 103.0 6.23031+1 4.778763+2 9.45928+2
130127 105.0 6.09420+1 4.772741+2 9.44551+2 107.0 6.01011+1 4.766711+2 9.43175+2
130128 109.0 5.92602+1 4.760697+2 9.41798+2 111.0 5.84193+1 4.754686+2 9.40422+2
130129 113.0 5.75784+1 4.748679+2 9.39045+2 115.0 5.67375+1 4.742664+2 9.37669+2
130130 117.0 5.58966+1 4.736665+2 9.36293+2 119.0 5.50557+1 4.730670+2 9.34916+2
130131 121.0 5.42148+1 4.724666+2 9.33540+2 123.0 5.33739+1 4.718678+2 9.32163+2
130132 125.0 5.25330+1 4.712694+2 9.30787+2 127.0 5.16921+1 4.706713+2 9.29410+2
130133 129.0 5.08512+1 4.700724+2 9.28034+2 131.0 5.00103+1 4.694751+2 9.26657+2
130134 133.0 4.91694+1 4.688781+2 9.25281+2 135.0 4.84734+1 4.682803+2 9.23905+2
130135 137.0 4.79223+1 4.676841+2 9.22528+2 139.0 4.73712+1 4.670882+2 9.21152+2
130136 141.0 4.68201+1 4.664926+2 9.19775+2 143.0 4.62690+1 4.658963+2 9.18399+2
130137 145.0 4.57179+1 4.653014+2 9.17022+2 147.0 4.51668+1 4.647069+2 9.15646+2
130138 149.0 4.46156+1 4.641117+2 9.14269+2 151.0 4.40645+1 4.635179+2 9.12893+2
130139 153.0 4.35134+1 4.629244+2 9.11517+2 155.0 4.29623+1 4.623314+2 9.10140+2
130140 157.0 4.24112+1 4.617375+2 9.08764+2 159.0 4.18601+1 4.611451+2 9.07387+2
130141 161.0 4.13089+1 4.605530+2 9.06011+2 163.0 4.07578+1 4.599601+2 9.04634+2
130142 165.0 4.02067+1 4.593688+2 9.03258+2 167.0 3.96556+1 4.587777+2 9.01881+2
130143 169.0 3.91045+1 4.581870+2 9.00505+2 171.0 3.85534+1 4.575955+2 8.99128+2
130144 173.0 3.80023+1 4.570055+2 8.97752+2 175.0 3.74511+1 4.564157+2 8.96376+2
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130145 177.0 3.69000+1 4.558252+2 8.94999+2 179.0 3.63489+1 4.552362+2 8.93623+2
130146 181.0 3.57978+1 4.546475+2 8.92246+2 183.0 3.52467+1 4.540591+2 8.90870+2
130147 185.0 3.46956+1 4.534699+2 8.89493+2 187.0 3.41899+1 4.528821+2 8.88117+2
130148 189.0 3.37296+1 4.522947+2 8.86740+2 191.0 3.32693+1 4.517065+2 8.85364+2
130149 193.0 3.28090+1 4.511197+2 8.83988+2 195.0 3.23487+1 4.505332+2 8.82611+2
130150 197.0 3.18884+1 4.499471+2 8.81235+2 199.0 3.14281+1 4.492939+2 8.79858+2
130151 200.0 3.11980+1 4.489343+2 8.79170+2
*
130200 102 2 0 0                           .0 7.41140+2 5.569553+2 2.26530+3
130201  1.0 7.39465+2 5.567744+2 2.23460+3 3.0 7.37180+2 5.563433+2 2.19947+3
130202  5.0 6.29830+2 5.526521+2 2.13243+3 7.0 5.50190+2 5.431578+2 2.05853+3
130203  9.0 4.88980+2 5.337939+2 1.97778+3 11.0 4.40360+2 5.245037+2 1.91297+3
130204 13.0 4.01370+2 5.152880+2 1.86410+3 15.0 3.68270+2 5.061714+2 1.81523+3
130205 17.0 3.36590+2 4.986566+2 1.79840+3 19.0 3.11471+2 4.912882+2 1.71070+3
130206 21.0 2.89234+2 4.839287+2 1.65457+3 23.0 2.66997+2 4.778394+2 1.57171+3
130207 25.0 2.44760+2 4.729695+2 1.48886+3 27.0 2.26910+2 4.681094+2 1.40600+3
130208 29.0 2.12175+2 4.632477+2 1.34452+3 31.0 1.98465+2 4.595866+2 1.28304+3
130209 33.0 1.86193+2 4.559285+2 1.23001+3 35.0 1.75360+2 4.522727+2 1.18544+3
130210 37.0 1.66948+2 4.486250+2 1.14087+3 39.0 1.58536+2 4.449828+2 1.09630+3
130211 41.0 1.51364+2 4.413471+2 1.07130+3 43.0 1.45431+2 4.377193+2 1.04629+3
130212 45.0 1.39498+2 4.348312+2 1.02129+3 47.0 1.33565+2 4.319480+2 9.96282+2
130213 49.0 1.27633+2 4.290706+2 9.83092+2 51.0 1.21700+2 4.262034+2 9.81715+2
130214 53.0 1.17256+2 4.233433+2 9.80339+2 55.0 1.12812+2 4.204903+2 9.78962+2
130215 57.0 1.09062+2 4.176431+2 9.77586+2 59.0 1.06008+2 4.148038+2 9.76210+2
130216 61.0 1.02953+2 4.122741+2 9.74833+2 63.0 9.98975+1 4.100509+2 9.73457+2
130217 65.0 9.68425+1 4.078316+2 9.72080+2 67.0 9.37875+1 4.056162+2 9.70704+2
130218 69.0 9.12184+1 4.034036+2 9.69327+2 71.0 8.91352+1 4.011968+2 9.67951+2
130219 73.0 8.70521+1 3.989927+2 9.66574+2 75.0 8.49689+1 3.967923+2 9.65198+2
130220 77.0 8.28857+1 3.945954+2 9.63822+2 79.0 8.08025+1 3.924020+2 9.62445+2
130221 81.0 7.87194+1 3.904569+2 9.61069+2 83.0 7.66362+1 3.887612+2 9.59692+2
130222 85.0 7.45530+1 3.870686+2 9.58316+2 87.0 7.31919+1 3.853769+2 9.56939+2
130223 89.0 7.18308+1 3.836872+2 9.55563+2 91.0 7.04697+1 3.819994+2 9.54186+2
130224 93.0 6.91086+1 3.803135+2 9.52810+2 95.0 6.77475+1 3.786295+2 9.51433+2
130225 97.0 6.63864+1 3.769474+2 9.50057+2 99.0 6.50253+1 3.752671+2 9.48681+2
130226 101.0 6.36642+1 3.735887+2 9.47304+2 103.0 6.23031+1 3.719120+2 9.45928+2
130227 105.0 6.09420+1 3.702371+2 9.44551+2 107.0 6.01011+1 3.685640+2 9.43175+2
130228 109.0 5.92602+1 3.668926+2 9.41798+2 111.0 5.84193+1 3.652229+2 9.40422+2
130229 113.0 5.75784+1 3.637358+2 9.39045+2 115.0 5.67375+1 3.624318+2 9.37669+2
130230 117.0 5.58966+1 3.611278+2 9.36293+2 119.0 5.50557+1 3.598259+2 9.34916+2
130231 121.0 5.42148+1 3.585249+2 9.33540+2 123.0 5.33739+1 3.572249+2 9.32163+2
130232 125.0 5.25330+1 3.559248+2 9.30787+2 127.0 5.16921+1 3.546266+2 9.29410+2
130233 129.0 5.08512+1 3.533295+2 9.28034+2 131.0 5.00103+1 3.520332+2 9.26657+2
130234 133.0 4.91694+1 3.507369+2 9.25281+2 135.0 4.84734+1 3.494425+2 9.23905+2
130235 137.0 4.79223+1 3.481490+2 9.22528+2 139.0 4.73712+1 3.468563+2 9.21152+2
130236 141.0 4.68201+1 3.455636+2 9.19775+2 143.0 4.62690+1 3.442727+2 9.18399+2
130237 145.0 4.57179+1 3.429827+2 9.17022+2 147.0 4.51668+1 3.420373+2 9.15646+2
130238 149.0 4.46156+1 3.410923+2 9.14269+2 151.0 4.40645+1 3.401478+2 9.12893+2
130239 153.0 4.35134+1 3.392037+2 9.11517+2 155.0 4.29623+1 3.382600+2 9.10140+2
130240 157.0 4.24112+1 3.373168+2 9.08764+2 159.0 4.18601+1 3.363751+2 9.07387+2
130241 161.0 4.13089+1 3.354327+2 9.06011+2 163.0 4.07578+1 3.344908+2 9.04634+2
130242 165.0 4.02067+1 3.335493+2 9.03258+2 167.0 3.96556+1 3.326082+2 9.01881+2
130243 169.0 3.91045+1 3.316675+2 9.00505+2 171.0 3.85534+1 3.307272+2 8.99128+2
130244 173.0 3.80023+1 3.297873+2 8.97752+2 175.0 3.74511+1 3.288479+2 8.96376+2
130245 177.0 3.69000+1 3.279088+2 8.94999+2 179.0 3.63489+1 3.269701+2 8.93623+2
130246 181.0 3.57978+1 3.260319+2 8.92246+2 183.0 3.52467+1 3.250940+2 8.90870+2
130247 185.0 3.46956+1 3.242482+2 8.89493+2 187.0 3.41899+1 3.234923+2 8.88117+2
130248 189.0 3.37296+1 3.227377+2 8.86740+2 191.0 3.32693+1 3.219823+2 8.85364+2
130249 193.0 3.28090+1 3.212282+2 8.83988+2 195.0 3.23487+1 3.204733+2 8.82611+2
130250 197.0 3.18884+1 3.197196+2 8.81235+2 199.0 3.14281+1 3.189652+2 8.79858+2
130251 200.0 3.11980+1 3.185886+2 8.79170+2
*
**************************************************************************
*
*18XXYY THERMAL CONDUCTIVITY DATA CARDS
*        NKP        TEMP    T COND      TEMP    T COND    DESCRIPTION
180101  -15   3.200E+1  4.960E+0  2.120E+2  4.090E+0   * FUEL UO2
180102        3.920E+2  3.480E+0  7.520E+2  2.680E+0
180103        1.112E+3  2.190E+0  1.472E+3  1.850E+0
180104        1.832E+3  1.620E+0  2.192E+3  1.460E+0
180105        2.500E+3  1.350E+0  3.000E+3  1.250E+0
180106        3.500E+3  1.350E+0  4.000E+3  1.530E+0
180107        4.500E+3  1.810E+0  4.800E+3  2.080E+0
180108        5.100E+3  2.440E+0
*
*        NKP        TEMP    T COND      TEMP    T COND    DESCRIPTION
180201   -2   6.245E+2  1.385E-1  6.845E+2  1.446E-1   * EFF GAP COND/FRAP2
*
*        NKP        TEMP    T COND      TEMP    T COND    DESCRIPTION
180301  -12   3.200E+1  7.103E+0  4.000E+2  8.679E+0   * FUEL CLAD ZR-4
180302        8.000E+2  1.021E+1  1.100E+3  1.140E+1
180303        1.400E+3  1.276E+1  1.700E+3  1.442E+1
180304        2.000E+3  1.651E+1  2.300E+3  1.913E+1
180305        2.600E+3  2.242E+1  2.900E+3  2.651E+1
180306        3.200E+3  3.151E+1  3.500E+3  3.754E+1
*
*
*19XXYY VOLUMETRIC HEAT CAPACITY DATA CARDS
*
*        NCP        TEMP    HT CAP      TEMP    HT CAP    DESCRIPTION
190101  -14   7.700E+1  3.657E+1  2.000E+2  4.005E+1   * VOL HT CAP UO2
190102        6.000E+2  4.523E+1  1.000E+3  4.748E+1
190103        1.400E+3  4.894E+1  1.800E+3  5.014E+1
190104        2.200E+3  5.144E+1  2.600E+3  5.336E+1
190105        3.000E+3  5.662E+1  3.400E+3  6.197E+1
190106        3.800E+3  6.998E+1  4.200E+3  8.092E+1
190107        4.600E+3  9.476E+1  5.000E+3  1.112E+2
*
*        NCP        TEMP    HT CAP      TEMP    HT CAP    DESCRIPTION
190201   -2   3.200E+1  1.490E-2  3.400E+3  1.490E-2   * VOL HT CAP HELIUM
*
*        NCP        TEMP    HT CAP      TEMP    HT CAP    DESCRIPTION
190301  -15   3.200E+1  2.875E+1  9.320E+2  3.256E+1   * VOL HT CAP ZR-2
```

```
190302        1.112E+3  3.440E+1  1.184E+3  3.522E+1
190303        1.490E+3  3.522E+1  1.508E+3  4.914E+1
190304        1.544E+3  5.774E+1  1.580E+3  6.020E+1
190305        1.616E+3  7.043E+1  1.652E+3  7.985E+1
190306        1.688E+3  7.535E+1  1.724E+3  5.938E+1
190307        1.760E+3  4.586E+1  1.787E+3  3.481E+1
190308        3.300E+3  3.481E+1
*
*
*      LCOUNT  ACEPSI  HEPSI  EPSIM  VEPSI  EPSIMG
230000   25    5.0-5   5.0-6  5.0-3  5.0-5  5.0-5
*
*
************************************************************************
*
* CONTROL RODS
*
*
040030    3      1     0    0    1.0+9  0.  ' FIXED RODS'
040040    4      1     0    0    0.000  0.  ' TRIP ROD GP 2'
*
*
*      IDC  VAR   REG  GAIN      CIC
702001  1   TRIP   3    1.0      1.0
702002  2   TRIP   4    1.0      1.0
702003  3   CONS   0    0.0      0.0
702004  4   CONS   0  213.36   213.36
702005  5   CONS   0  320.04   320.04
702006  6   CONS   0  426.72   426.72
*
*      IDC  TYPE  INC1 INC2  GAIN  CP1  CP2   CIC
703001 -1   SUM    3    3    1.0   1.0  1.0   0.0  *  position for
*                                                  *  rod groups
*                                                  *  1,2,3,4,8,9
*
*
*      IDC  TYPE  INC1 INC2  GAIN  CP1  CP2   CIC Ymin
703010 -10   INT    2    0    1.0  0.0  0.0   0.0      *  -11 : position
703011 -11   FNG  -10   01    1.0  0.0  0.0   0.0      *  change for rod
703012 -12   SUM  -11    4    1.0  1.0  1.0 213.36 0.0 *  groups 5, 6
*
*
*      IDC  TYPE  INC1 INC2  GAIN  CP1  CP2   CIC
703020 -20   INT    2    0    1.0  0.0  0.0   0.0      *  -21 : position
703021 -21   FNG  -20   01    1.0  0.0  0.0   0.0      *  cahnge for rod
703022 -22   SUM  -21    5    1.0  1.0  1.0 320.04 0.0 *  group 7
*
*
*      IDC  TYPE  INC1 INC2  GAIN  CP1  CP2   CIC
703030 -30   SUM    3    6    1.0  1.0  1.0 426.72 0.0 *  position for
*                                                  *  rod groups
*                                                  *  10
*
*       TABLE 1 -  rod position vs time
120100 -3  0.0        0.0
120101     0.0005  -500.0
120102     1.+6    -500.0
*
*
************************************************************************
*
* BORON
*
*
*       TABLE 2 -  boron vs time
120200 -3
120201    0.0 0.0  90.0 0.0  200.0 30.0
*
*
*      IDC  VAR   REG  GAIN      CIC
702007  7   TRIP   2    1.0      1.0
*      IDC  TYPE  INC1 INC2  GAIN  CP1  CP2   CIC Ymin
703031 -31   INT    7    0    1.0  0.0  0.0   0.0      * integrate time
703032 -32   FNG  -31   02    1.0  0.0  0.0   0.0      *  boron conc.
*
*      fll jun cout conc. cout eff.
*
453001  21 -32   0
453002  22 -32   0
453003  23 -32   0
453004  24 -32   0
453005  25 -32   0
453006  26 -32   0
453007  27 -32   0
453008  28 -32   0
453009  68 -32   0
453010  69 -32   0
453011  70 -32   0
453012  71 -32   0
453013  72 -32   0
453014  73 -32   0
453015  74 -32   0
453016  75 -32   0
453017  76 -32   0
453018  77 -32   0
453019  78 -32   0
*
************************************************************************
*
*STEAMLINE BREAK - RETRAN-3D SAMPLE PROBLEM -HALF CORE, 19 CHANNEL
*
************************************************************************
```

```
*
*   CORE CHANNELS ON FAULTED SIDE  = 1, 2, 3, 4, 5, 6, 7, 8, 9, 10
*   CORE CHANNELS ON INTACT SIDE   = 11, 12, 13, 14. 15, 16, 17
*   BYPASS CHANNEL ON FAULTED SIDE = 18
*   BYPASS CHANNEL ON INTACT SIDE  = 19
*
*   RETRAN CHANNEL    NUMBER OF KINETICS      FLOW
*      NUMBER             ASSEMBLIES        FRACTION
*        1                    .500         0.0051813472
*        2                    .500         0.0051813472
*        3                    .500         0.0051813472
*        4                   1.000         0.0103626943
*        5                    .500         0.0051813472
*        6                   1.000         0.0103626943
*        7                   1.500         0.0155440414
*        8                   3.000         0.0310880829
*        9                   6.500         0.0673575129
*       10                   9.000         0.0932642487
*       11                   1.000         0.0103626943
*       12                   3.000         0.0310880829
*       13                   8.000         0.0829015544
*       14                  16.000         0.1658031088
*       15                   9.000         0.0932642487
*       16                  21.500         0.2227979274
*       17                  14.000         0.1450777202
*
*               TOTAL   =    96.500
*
*   BYPASS CHANNEL
*       18                  21.000             .0
*       19                  63.000             .0
*
*************************************************************************
*
* 3-Dimensional Kinetics:
*
*
*670001 NCHANL NBYPSS NCROSS JENTH JTPM IMC QPMD  QDMD QBMD EW WCORE   IHTGL
670001    17     2      0      1    0   10  0.026 0.0  0.0  0  18895.5878  0
*
*670010 NED1 NED2 NED3 NED4 NED5 NED8 NED9 NED11 NED14
670010    1    1    1    0    0    0    0     0     0
*
*670020 NOTERS MAXOUT MAXRIT NCNCRS NCNCRT IPURDU
670020     5    200     50      4      2      0
*
*670021 NSERCH NBORON NFREEZ NADJNT ISPECK IEXPAN IFXISP
670021     0      0      0      1      0     -1      2
*
*
* assembly -to- channel mapping
*
671011 -2 -2 -2 -2 -2 -2 -2 -2 -2 -2
671021 -2 -2 -2 -2 -2 -2 -2 -2 -2 -2
671031 16 16 16 16 -2 -2 -2 -2 -2 -2
671041 16 16 16 16 16 17 -2 -2 -2 -2
671051 16 16 16 16 16 17 17 -2 -2 -2
671061 16 16 16 16 16 17 17 -2 -2 -2
671071 16 16 16 16 16 17 17 17 -2 -2
671081 15 15 15 15 15 17 17 17 -2 -2
671091 15 15 15 15 15 17 17 17 -2 -2
671101  1 12 12 13 13 14 14 14 -2 -2
671111  2 11 12 13 13 14 14 14 -2 -2
671121  3  4  8 13 13 14 14 14 -2 -2
671131  5  6  8 13 13 14 14 14 -2 -2
671141  7  7  8  9  9 14 14 -2 -2 -2
671151  9  9  9  9  9 14 14 -2 -2 -2
671161 10 10 10 10 10 10 -1 -2 -2 -2
671171 10 10 10 10 -1 -1 -1 -2 -2 -2
671181 -1 -1 -1 -1 -1 -1 -1 -1 -1 -2
671191 -1 -1 -1 -1 -1 -1 -1 -1 -1 -2
*
*
*670030    CONEIG    CONDEG    CONSRS    CONSRT   CONPOW
670030    1.E-005   5.E-005   5.E-005   5.E-005  1.E-003
*
*
*672XXX INLET OUTLET KFLAG  WNORM
672001    68    39      2  0.0051813472
672002    69    39      0  0.0051813472
672003    30    39      0  0.0051813472
672004    31    39      0  0.0103626943
672005    32    39      0  0.0051813472
672006    33    39      0  0.0103626943
672007    34    39      0  0.0155440414
672008    35    39      0  0.0310880829
672009    36    39      0  0.0673575129
672010    37    39      0  0.0932642487
672011    21    29      2  0.0103626943
672012    22    29      0  0.0310880829
672013    23    29      0  0.0829015544
672014    24    29      0  0.1658031088
672015    25    29      0  0.0932642487
672016    26    29      0  0.2227979274
672017    27    29      0  0.1450777202
*
*
*     ROD GROUP POSITIONS CONTROL BLOCKS
*
*6740YY NGSP COUT ...
674001    5  -11
674002    6  -11
```

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


```
674003    7  -21
*
*
*   BYPASS CHANNEL DESCRIPTION
*
*    BYPASS 1 - FAULTED SIDE
*    BYPASS 2 - INTACT SIDE
*
*675XXY  VOL NODE ...
675011   38  1 322  2 323  3 324  4 325  5 326  6 327  7 328  8 329  9
675012  330 10 331 11 332 12 333 13  39 14
675021   28  1 335  2 336  3 337  4 338  5 339  6 340  7 341  8 342  9
675022  343 10 344 11 345 12 346 13  29 14
*
*BYPASS CHANNEL 1 (FAULTED SIDE)
*     IBUB IREAD PRESSURE   ENTHALPY   QLTY      VOLUME
053221  0   0      0.0         0.0      0.0       5.54820  * BYP   1
053231  0   0      0.0         0.0      0.0       5.54820  * BYP   2
053241  0   0      0.0         0.0      0.0       5.54820  * BYP   3
053251  0   0      0.0         0.0      0.0       5.54820  * BYP   4
053261  0   0      0.0         0.0      0.0       5.54820  * BYP   5
053271  0   0      0.0         0.0      0.0       5.54820  * BYP   6
053281  0   0      0.0         0.0      0.0       5.54820  * BYP   7
053291  0   0      0.0         0.0      0.0       5.54820  * BYP   8
053301  0   0      0.0         0.0      0.0       5.54820  * BYP   9
053311  0   0      0.0         0.0      0.0       5.54820  * BYP  10
053321  0   0      0.0         0.0      0.0       5.54820  * BYP  11
053331  0   0      0.0         0.0      0.0       5.54820  * BYP  12
*
*        HEIGHT      FLOWL      FLOWAREA     HYDIAM       VOLELEV
053222      1.00000     1.00000     5.54820    .0371000   -17.19300 * BYP   1
053232      1.00000     1.00000     5.54820    .0371000   -16.19300 * BYP   2
053242      1.00000     1.00000     5.54820    .0371000   -15.19300 * BYP   3
053252      1.00000     1.00000     5.54820    .0371000   -14.19300 * BYP   4
053262      1.00000     1.00000     5.54820    .0371000   -13.19300 * BYP   5
053272      1.00000     1.00000     5.54820    .0371000   -12.19300 * BYP   6
053282      1.00000     1.00000     5.54820    .0371000   -11.19300 * BYP   7
053292      1.00000     1.00000     5.54820    .0371000   -10.19300 * BYP   8
053302      1.00000     1.00000     5.54820    .0371000    -9.19300 * BYP   9
053312      1.00000     1.00000     5.54820    .0371000    -8.19300 * BYP  10
053322      1.00000     1.00000     5.54820    .0371000    -7.19300 * BYP  11
053332      1.00000     1.00000     5.54820    .0371000    -6.19300 * BYP  12
*
*BYPASS CHANNEL 2 (INTACT SIDE)
*     IBUB IREAD PRESSURE   ENTHALPY   QLTY      VOLUME
053351  0   0      0.0         0.0      0.0       16.64460 * BYP   1
053361  0   0      0.0         0.0      0.0       16.64460 * BYP   2
053371  0   0      0.0         0.0      0.0       16.64460 * BYP   3
053381  0   0      0.0         0.0      0.0       16.64460 * BYP   4
053391  0   0      0.0         0.0      0.0       16.64460 * BYP   5
053401  0   0      0.0         0.0      0.0       16.64460 * BYP   6
053411  0   0      0.0         0.0      0.0       16.64460 * BYP   7
053421  0   0      0.0         0.0      0.0       16.64460 * BYP   8
053431  0   0      0.0         0.0      0.0       16.64460 * BYP   9
053441  0   0      0.0         0.0      0.0       16.64460 * BYP  10
053451  0   0      0.0         0.0      0.0       16.64460 * BYP  11
053461  0   0      0.0         0.0      0.0       16.64460 * BYP  12
*
*        HEIGHT      FLOWL      FLOWAREA     HYDIAM       VOLELEV
053352      1.00000     1.00000    16.64460    .0371000   -17.19300 * BYP   1
053362      1.00000     1.00000    16.64460    .0371000   -16.19300 * BYP   2
053372      1.00000     1.00000    16.64460    .0371000   -15.19300 * BYP   3
053382      1.00000     1.00000    16.64460    .0371000   -14.19300 * BYP   4
053392      1.00000     1.00000    16.64460    .0371000   -13.19300 * BYP   5
053402      1.00000     1.00000    16.64460    .0371000   -12.19300 * BYP   6
053412      1.00000     1.00000    16.64460    .0371000   -11.19300 * BYP   7
053422      1.00000     1.00000    16.64460    .0371000   -10.19300 * BYP   8
053432      1.00000     1.00000    16.64460    .0371000    -9.19300 * BYP   9
053442      1.00000     1.00000    16.64460    .0371000    -8.19300 * BYP  10
053452      1.00000     1.00000    16.64460    .0371000    -7.19300 * BYP  11
053462      1.00000     1.00000    16.64460    .0371000    -6.19300 * BYP  12
*
* BYPASS CHANNEL 1
*     FROM TO  PUMP VLV  FLOWRATE     JUNAREA    JUNELEV    INERT
083221  38 322   0   0  4111.99316     5.54820   -17.19300  0.0 * BYP  0 TO  1
083231 322 323   0   0      .00000     5.54820   -16.19300  0.0 * BYP  1 TO  2
083241 323 324   0   0      .00000     5.54820   -15.19300  0.0 * BYP  2 TO  3
083251 324 325   0   0      .00000     5.54820   -14.19300  0.0 * BYP  3 TO  4
083261 325 326   0   0      .00000     5.54820   -13.19300  0.0 * BYP  4 TO  5
083271 326 327   0   0      .00000     5.54820   -12.19300  0.0 * BYP  5 TO  6
083281 327 328   0   0      .00000     5.54820   -11.19300  0.0 * BYP  6 TO  7
083291 328 329   0   0      .00000     5.54820   -10.19300  0.0 * BYP  7 TO  8
083301 329 330   0   0      .00000     5.54820    -9.19300  0.0 * BYP  8 TO  9
083311 330 331   0   0      .00000     5.54820    -8.19300  0.0 * BYP  9 TO 10
083321 331 332   0   0      .00000     5.54820    -7.19300  0.0 * BYP 10 TO 11
083331 332 333   0   0      .00000     5.54820    -6.19300  0.0 * BYP 11 TO 12
083341 333  39   0   0      .00000     5.54820    -5.19300  0.0 * BYP 12 TO 13
*
*       FJUNF    FJUNR  JVT JCK JCL MVMX  HYDIAM   CNC  IFR JTP
083222   .0000    .0000   0 -1  2  0     .0371000 1.0     0  0 * BYP  0 TO  1
083232   .0000    .0000   0 -1  2  0     .0371000 1.0     0  0 * BYP  1 TO  2
083242   .0000    .0000   0 -1  2  0     .0371000 1.0     0  0 * BYP  2 TO  3
083252   .0000    .0000   0 -1  2  0     .0371000 1.0     0  0 * BYP  3 TO  4
083262   .0000    .0000   0 -1  2  0     .0371000 1.0     0  0 * BYP  4 TO  5
083272   .0000    .0000   0 -1  2  0     .0371000 1.0     0  0 * BYP  5 TO  6
083282   .0000    .0000   0 -1  2  0     .0371000 1.0     0  0 * BYP  6 TO  7
083292   .0000    .0000   0 -1  2  0     .0371000 1.0     0  0 * BYP  7 TO  8
083302   .0000    .0000   0 -1  2  0     .0371000 1.0     0  0 * BYP  8 TO  9
083312   .0000    .0000   0 -1  2  0     .0371000 1.0     0  0 * BYP  9 TO 10
083322   .0000    .0000   0 -1  2  0     .0371000 1.0     0  0 * BYP 10 TO 11
083332   .0000    .0000   0 -1  2  0     .0371000 1.0     0  0 * BYP 11 TO 12
083342  1.0000  -1.0000   0 -1  2  0     .0371000 1.0     0  0 * BYP 12 TO 13
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PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


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713    *
714    * BYPASS CHANNEL 2
715    *     FROM TO  PUMP VLV  FLOWRATE     JUNAREA    JUNELEV    INERT
716    083351  28 335   0   0 12335.97852    16.64460   -17.19300  0.0 * BYP  0 TO  1
717    083361 335 336   0   0       .00000    16.64460   -16.19300  0.0 * BYP  1 TO  2
718    083371 336 337   0   0       .00000    16.64460   -15.19300  0.0 * BYP  2 TO  3
719    083381 337 338   0   0       .00000    16.64460   -14.19300  0.0 * BYP  3 TO  4
720    083391 338 339   0   0       .00000    16.64460   -13.19300  0.0 * BYP  4 TO  5
721    083401 339 340   0   0       .00000    16.64460   -12.19300  0.0 * BYP  5 TO  6
722    083411 340 341   0   0       .00000    16.64460   -11.19300  0.0 * BYP  6 TO  7
723    083421 341 342   0   0       .00000    16.64460   -10.19300  0.0 * BYP  7 TO  8
724    083431 342 343   0   0       .00000    16.64460    -9.19300  0.0 * BYP  8 TO  9
725    083441 343 344   0   0       .00000    16.64460    -8.19300  0.0 * BYP  9 TO 10
726    083451 344 345   0   0       .00000    16.64460    -7.19300  0.0 * BYP 10 TO 11
727    083461 345 346   0   0       .00000    16.64460    -6.19300  0.0 * BYP 11 TO 12
728    083471 346  29   0   0       .00000    16.64460    -5.19300  0.0 * BYP 12 TO 13
729    *
730    *       FJUNF    FJUNR  JVT JCK JCL MVMX  HYDIAM   CNC  IFR JTP
731    083352   .0000    .0000   0 -1  2  0     .0371000 1.0     0  0 * BYP  0 TO  1
732    083362   .0000    .0000   0 -1  2  0     .0371000 1.0     0  0 * BYP  1 TO  2
733    083372   .0000    .0000   0 -1  2  0     .0371000 1.0     0  0 * BYP  2 TO  3
734    083382   .0000    .0000   0 -1  2  0     .0371000 1.0     0  0 * BYP  3 TO  4
735    083392   .0000    .0000   0 -1  2  0     .0371000 1.0     0  0 * BYP  4 TO  5
736    083402   .0000    .0000   0 -1  2  0     .0371000 1.0     0  0 * BYP  5 TO  6
737    083412   .0000    .0000   0 -1  2  0     .0371000 1.0     0  0 * BYP  6 TO  7
738    083422   .0000    .0000   0 -1  2  0     .0371000 1.0     0  0 * BYP  7 TO  8
739    083432   .0000    .0000   0 -1  2  0     .0371000 1.0     0  0 * BYP  8 TO  9
740    083442   .0000    .0000   0 -1  2  0     .0371000 1.0     0  0 * BYP  9 TO 10
741    083452   .0000    .0000   0 -1  2  0     .0371000 1.0     0  0 * BYP 10 TO 11
742    083462   .0000    .0000   0 -1  2  0     .0371000 1.0     0  0 * BYP 11 TO 12
743    083472  1.0000  -1.0000   0 -1  2  0     .0371000 1.0     0  0 * BYP 12 TO 13
744    *
745    ********************************************************************************
746    *
747    *670020 NOTERS MAXOUT MAXRIT NCNCRS NCNCRT IPURDU
748    670020     5    200     50      4      2      1
+                                                                                *** THIS CARD IS A REPLACEMENT CARD. ***
749    *
750    *  PNM Neutronics Numerics Option - Iteration control variables
751    *
752    *670040 IFUPD  NODOPT NEMCY  IFSACC ICHEB0 IRAGGED
753    670040  0      2      5      0      3      0
754    *
755    *670041 EPSNEM EPSXEC EPSL2  EPSINF EPSR2  EPSERF  ESHIFT CETAK
756    670041  0.001  0.001   .00001 .0001  .001   .005    .04    1.0
757    *
758    *
759    ********************************************************************************
760    * CHANGES MADE TO FIX ERROR IN INPUT, FJUNR CAN NOT BE CALCULATED WHEN FLOW IS P
761    **
762    * HJK - 6/1/2011
763    *       FJUNF    FJUNR  JVT JCK JCL MVMX  HYDIAM   CNC  IFR JTP
764    083342  1.0000   0.0000   0 -1  2  0     .0371000 1.0     0  0 * BYP 12 TO 13
+                                                                                *** THIS CARD IS A REPLACEMENT CARD. ***
765    083472  1.0000   0.0000   0 -1  2  0     .0371000 1.0     0  0 * BYP 12 TO 13
+                                                                                *** THIS CARD IS A REPLACEMENT CARD. ***
766    . END
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PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    -- NRC APPROVED VERSION       29/08/14  Page    1
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:59:23
 STEAMLINE BREAK - RETRAN-3D SAMPLE PROBLEM - 1/2 CORE, 17 CHAN/ 2 BYP, FILL BC                                 CPU TIME =     0.031
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *

RETRAN PROBLEM CONTROL AND DESCRIPTION DATA.

    WORD  DESCRIPTION
    ====  ===================================================================
      1   RESTART FILE OPTION (SAVE=-1 / NO SAVE=0) .................... =    0
      2   PRINTER PLOT OPTION (YES=1 / NO=0) ........................... =    0
      3   POWER OPTION (TAPE OPTNS<0 / NO/TBL=0 / PT KIN=1 / 1D=2 / 3D=3) =    3
      4   USE STEADY-STATE SOLUTION (YES=0 / NO=1) ..................... =    0
      5   USE NEUTRON VOID MODEL (YES=1 / NO=0) ........................ =    0
      6   USE GENERALIZED TRANSPORT MODEL (NO=0 / VAP=1 / LIQ=-1) ...... =   -1
      7   HEAT TRANSFER MAP OPTION (FORCED=0 / NAT CONV=1) ............. =    0
      8   SLIP OPTION (DYN=1 / Z-L=2 / C-L=3 / Z-L TAUGL=4 / C-L TAUGL=5) =    0
      9   FIVE-EQUATION OPTION (NO= 0 / YES=1) ......................... =    0
     10   NONCONDENSABLE GAS FLOW OPTION (NO=0 / YES=1) ................ =    0
     11   TH MATRIX DIRECT SOLVER OPTION (4-EQ=2 / 6-EQ=3) ............. =    2
     12   TH MATRIX ITERATIVE SOLVER OPTION (NO<=1 / YES=2) ............ =    0

    (DIMENSIONS AND OPTIONS AUTOMATICALLY DETERMINED BY CONTENT OF INPUT DATA)

          NUMBER OF MINOR EDIT SETS (0200XX DATA )...................... =    8
          NUMBER OF TIME-STEP CONTROL SETS (03XXX0 DATA )............... =    3
          NUMBER OF TRIP CONTROL SETS (04XXX0 DATA ).................... =    4
          NUMBER OF CONTROL VOLUME DESCRIPTIONS (05XXXY DATA ).......... =   45
          NUMBER OF BUBBLE RISE DESCRIPTIONS (060XXY DATA) ............. =    0
          NUMBER OF TIME DEPENDENT VOLUMES FORM CARDS (07XXYY DATA) .... =    2
          NUMBER OF JUNCTION DESCRIPTIONS (08XXXY DATA) ................ =   45
          NUMBER OF CENTRIFUGAL PUMP DESCRIPTIONS (090XXY DATA )........ =    0
          NUMBER OF VALVE DESCRIPTIONS (11XXXY DATA) ................... =    0
          NUMBER OF GENERAL DATA TABLE DESCRIPTIONS (12XXYY DATA) ...... =    2
          NUMBER OF FILL DESCRIPTIONS (13XXYY DATA )...................... =    2
          NUMBER OF HEAT CONDUCTOR DESCRIPTIONS (15XXXY DATA) .......... =    0
          NUMBER OF HEAT CONDUCTOR GEOMETRY DESCRIPTIONS (17XXYY DATA) .. =    0
          NUMBER OF HEAT CONDUCTOR MATERIAL DESCRIPTIONS (18XXYY DATA) .. =    3
          NUMBER OF CORE SECTION DESCRIPTIONS (16XXXY DATA) ............ =    0
          NUMBER OF NON-CONDUCTNG HEAT EXCHNGR DESCRIPTIONS (21XXYY DATA) =    0
          NUMBER OF TIME DEP BCS FROM TAPE (IREAD<0 ON 05XXXY DATA) ..... =    0
          NUMBER OF SPECIFIED HEAT TRAN COEF DESCRIPTIONS (015XXX DATA) . =    0
          TWO-REGION NONEQ VOL DESCRIPTIONS (610XXX OR 611XXX DATA) ..... =    0
          TEMP. TRANSPORT DELAY OPTION (MESH>0 ON 05XXXY DATA) .......... =    0
          AUXILIARY DNB MODEL (8001XX DATA INCLUDED) ................... =    0
          CONTROL SYSTEM MODEL (702XXX OR 702XXXX DATA) ................ =    1
          ACCUMULATOR MODEL DESCRIPTIONS (620XXX OR 621XXX DATA)......... =    0
          DYNAMIC GAP CONDUCTANCE MODEL DESCRIPTIONS (225XX0 DATA) ...... =    0
          NUMBER OF HT CONDUCTOR STACK DESCRIPTIONS (2200XY DATA) ....... =    0
          NUMBER OF TURBINE SHAFT DESCRIPTIONS (500XXY DATA) ........... =    0
          NUMBER OF PROFILE FIT DESCRIPTIONS (061XX1 DATA) ............. =    0
          NUMBER OF STEAM-WATER SEPARATOR DESCRIPTIONS (60XXX0 DATA) .... =    0


                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * *                                                * * *
                   * * *          STEADY-STATE OPTION    =   0          * * *
                   * * *                                                * * *
                   * * *          SLIP OPTION            =   0          * * *
                   * * *                                                * * *
                   * * *          NUMERICS OPTION        =   2          * * *
                   * * *                                                * * *
                   * * *          HEAT TRANSFER OPTION   =   0          * * *
                   * * *                                                * * *
                   * * *          NEW EQUATIONS OPTION   =   0          * * *
                   * * *                                                * * *
                   * * *         USING THE 4-EQ SOLVER - SOLVE3         * * *
                   * * *                                                * * *
                   * * *     USING STANDARD STEADY-STATE SOLUTION       * * *
                   * * *                                                * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *


INITIAL THERMAL POWER (MEGAWATTS) =  1.00000E-02


AIR IS THE DEFAULT NONCONDENSABLE GAS.
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PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE -- NRC APPROVED VERSION 29/08/14 Page 78
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis 11:59:24
STEAMLINE BREAK - RETRAN-3D SAMPLE PROBLEM - 1/2 CORE, 17 CHAN/ 2 BYP, FILL BC CPU TIME = 0.718
* *

NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	ENERGY BALANCE (BTU)	TOTAL MASS BALANCE (LBM)	NCG MASS BALANCE (LBM)	AVERAGE TIME STEP (SEC)	CURRENT TIME STEP (SEC)	ELAPSED TIME (SEC)	TIME STEP NUM STANDRD/ACTUL
									0
1.00000E+00	1.00000E-02	3.41300E+04	3.70162E+07	6.75592E+04	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	VOID FRAC.	POWR TO H2O (BTU/SEC)
21	2.27750E+03	1.22864E+01	5.56955E+02	4.65042E+01	5.57855E+02	0.00000E+00	0.00000E+00	0.00000E+00
22	2.27634E+03	3.68586E+01	5.56955E+02	4.65035E+01	5.57852E+02	0.00000E+00	0.00000E+00	0.00000E+00
23	2.27634E+03	9.82897E+01	5.56955E+02	4.65035E+01	5.57852E+02	0.00000E+00	0.00000E+00	0.00000E+00
24	2.27634E+03	1.96579E+02	5.56955E+02	4.65035E+01	5.57852E+02	0.00000E+00	0.00000E+00	0.00000E+00
25	2.27634E+03	1.10576E+02	5.56955E+02	4.65035E+01	5.57852E+02	0.00000E+00	0.00000E+00	0.00000E+00
26	2.27634E+03	2.64154E+02	5.56955E+02	4.65035E+01	5.57852E+02	0.00000E+00	0.00000E+00	0.00000E+00
27	2.27634E+03	1.72007E+02	5.56955E+02	4.65035E+01	5.57852E+02	0.00000E+00	0.00000E+00	0.00000E+00
28	2.27634E+03	7.74032E+02	5.56955E+02	4.65035E+01	5.57852E+02	0.00000E+00	0.00000E+00	0.00000E+00
29	2.26530E+03	2.90485E+04	5.56917E+02	4.64985E+01	5.57800E+02	0.00000E+00	0.00000E+00	0.00000E+00
30	2.27635E+03	6.14311E+00	5.56955E+02	4.65035E+01	5.57852E+02	0.00000E+00	0.00000E+00	0.00000E+00
31	2.27635E+03	1.22862E+01	5.56955E+02	4.65035E+01	5.57852E+02	0.00000E+00	0.00000E+00	0.00000E+00
32	2.27635E+03	6.14311E+00	5.56955E+02	4.65035E+01	5.57852E+02	0.00000E+00	0.00000E+00	0.00000E+00
33	2.27635E+03	1.22862E+01	5.56955E+02	4.65035E+01	5.57852E+02	0.00000E+00	0.00000E+00	0.00000E+00
34	2.27635E+03	1.84293E+01	5.56955E+02	4.65035E+01	5.57852E+02	0.00000E+00	0.00000E+00	0.00000E+00
35	2.27635E+03	3.68587E+01	5.56955E+02	4.65035E+01	5.57852E+02	0.00000E+00	0.00000E+00	0.00000E+00
36	2.27635E+03	7.98604E+01	5.56955E+02	4.65035E+01	5.57852E+02	0.00000E+00	0.00000E+00	0.00000E+00
37	2.27635E+03	1.10576E+02	5.56955E+02	4.65035E+01	5.57852E+02	0.00000E+00	0.00000E+00	0.00000E+00
38	2.27635E+03	2.58011E+02	5.56955E+02	4.65035E+01	5.57852E+02	0.00000E+00	0.00000E+00	0.00000E+00
39	2.26530E+03	9.68285E+03	5.56917E+02	4.64985E+01	5.57800E+02	0.00000E+00	0.00000E+00	0.00000E+00
68	2.27750E+03	6.14321E+00	5.56955E+02	4.65042E+01	5.57855E+02	0.00000E+00	0.00000E+00	0.00000E+00
69	2.27635E+03	6.14311E+00	5.56955E+02	4.65035E+01	5.57852E+02	0.00000E+00	0.00000E+00	0.00000E+00
322	2.27579E+03	2.58009E+02	5.56955E+02	4.65031E+01	5.57851E+02	0.00000E+00	0.00000E+00	0.00000E+00
323	2.27499E+03	2.58006E+02	5.56955E+02	4.65026E+01	5.57850E+02	0.00000E+00	0.00000E+00	0.00000E+00
324	2.27420E+03	2.58003E+02	5.56955E+02	4.65021E+01	5.57848E+02	0.00000E+00	0.00000E+00	0.00000E+00
325	2.27341E+03	2.58000E+02	5.56955E+02	4.65016E+01	5.57846E+02	0.00000E+00	0.00000E+00	0.00000E+00
326	2.27261E+03	2.57997E+02	5.56955E+02	4.65011E+01	5.57845E+02	0.00000E+00	0.00000E+00	0.00000E+00
327	2.27182E+03	2.57994E+02	5.56955E+02	4.65006E+01	5.57843E+02	0.00000E+00	0.00000E+00	0.00000E+00
328	2.27103E+03	2.57992E+02	5.56955E+02	4.65001E+01	5.57842E+02	0.00000E+00	0.00000E+00	0.00000E+00
329	2.27023E+03	2.57989E+02	5.56955E+02	4.64996E+01	5.57840E+02	0.00000E+00	0.00000E+00	0.00000E+00
330	2.26944E+03	2.57986E+02	5.56955E+02	4.64991E+01	5.57838E+02	0.00000E+00	0.00000E+00	0.00000E+00
331	2.26865E+03	2.57983E+02	5.56955E+02	4.64985E+01	5.57837E+02	0.00000E+00	0.00000E+00	0.00000E+00
332	2.26785E+03	2.57980E+02	5.56955E+02	4.64980E+01	5.57835E+02	0.00000E+00	0.00000E+00	0.00000E+00
333	2.26706E+03	2.57978E+02	5.56955E+02	4.64975E+01	5.57834E+02	0.00000E+00	0.00000E+00	0.00000E+00
335	2.27578E+03	7.74026E+02	5.56955E+02	4.65031E+01	5.57851E+02	0.00000E+00	0.00000E+00	0.00000E+00
336	2.27499E+03	7.74017E+02	5.56955E+02	4.65026E+01	5.57850E+02	0.00000E+00	0.00000E+00	0.00000E+00
337	2.27419E+03	7.74009E+02	5.56955E+02	4.65021E+01	5.57848E+02	0.00000E+00	0.00000E+00	0.00000E+00
338	2.27340E+03	7.74000E+02	5.56955E+02	4.65016E+01	5.57846E+02	0.00000E+00	0.00000E+00	0.00000E+00
339	2.27261E+03	7.73992E+02	5.56955E+02	4.65011E+01	5.57845E+02	0.00000E+00	0.00000E+00	0.00000E+00
340	2.27181E+03	7.73983E+02	5.56955E+02	4.65006E+01	5.57843E+02	0.00000E+00	0.00000E+00	0.00000E+00
341	2.27102E+03	7.73975E+02	5.56955E+02	4.65001E+01	5.57842E+02	0.00000E+00	0.00000E+00	0.00000E+00
342	2.27023E+03	7.73966E+02	5.56955E+02	4.64996E+01	5.57840E+02	0.00000E+00	0.00000E+00	0.00000E+00
343	2.26943E+03	7.73958E+02	5.56955E+02	4.64990E+01	5.57838E+02	0.00000E+00	0.00000E+00	0.00000E+00
344	2.26864E+03	7.73950E+02	5.56955E+02	4.64985E+01	5.57837E+02	0.00000E+00	0.00000E+00	0.00000E+00
345	2.26785E+03	7.73941E+02	5.56955E+02	4.64980E+01	5.57835E+02	0.00000E+00	0.00000E+00	0.00000E+00
346	2.26705E+03	7.73933E+02	5.56955E+02	4.64975E+01	5.57834E+02	0.00000E+00	0.00000E+00	0.00000E+00

JUNCTION NUMBER	CONNECTS VOLUMES	CHOK/ PATH	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E VEL. PSI	D I F F E R E N T I A L S ELEV. PSI	FRIC. PSI	ACCL. PSI	PUMP PSI
322	38 TO 322		4.11199E+03	5.56955E+02	2.15038E-02	1.83879E-04	-3.22940E-01	-2.39220E-01	-1.21014E-14	0.00000E+00
323	322 TO 323		4.11199E+03	5.56955E+02	2.15039E-02	-2.37629E-05	-3.22937E-01	-4.70297E-01	-1.30285E-13	0.00000E+00
324	323 TO 324		4.11199E+03	5.56955E+02	2.15042E-02	-2.78203E-05	-3.22933E-01	-4.70301E-01	-2.41474E-13	0.00000E+00
325	324 TO 325		4.11199E+03	5.56955E+02	2.15044E-02	-2.78228E-05	-3.22929E-01	-4.70304E-01	2.84106E-13	0.00000E+00
326	325 TO 326		4.11199E+03	5.56955E+02	2.15046E-02	-2.78251E-05	-3.22926E-01	-4.70308E-01	9.32032E-14	0.00000E+00
327	326 TO 327		4.11199E+03	5.56955E+02	2.15049E-02	-2.78275E-05	-3.22922E-01	-4.70312E-01	-3.78253E-13	0.00000E+00
328	327 TO 328		4.11199E+03	5.56955E+02	2.15051E-02	-2.78299E-05	-3.22919E-01	-4.70315E-01	2.13607E-13	0.00000E+00
329	328 TO 329		4.11199E+03	5.56955E+02	2.15053E-02	-2.78323E-05	-3.22915E-01	-4.70319E-01	2.94209E-14	0.00000E+00
330	329 TO 330		4.11199E+03	5.56955E+02	2.15056E-02	-2.78347E-05	-3.22912E-01	-4.70323E-01	-4.11338E-14	0.00000E+00
331	330 TO 331		4.11199E+03	5.56955E+02	2.15058E-02	-2.78371E-05	-3.22908E-01	-4.70326E-01	-1.86517E-14	0.00000E+00
332	331 TO 332		4.11199E+03	5.56955E+02	2.15060E-02	-2.78394E-05	-3.22905E-01	-4.70330E-01	7.74936E-14	0.00000E+00
333	332 TO 333		4.11199E+03	5.56955E+02	2.15063E-02	-2.78418E-05	-3.22901E-01	-4.70334E-01	-2.28373E-13	0.00000E+00
334	333 TO 39		4.11199E+03	5.56955E+02	2.15065E-02	1.40057E+00	-1.64972E+00	-1.51113E+00	1.74749E-13	0.00000E+00
335	28 TO 335		1.23360E+04	5.56955E+02	2.15038E-02	1.83880E-04	-3.22939E-01	-2.39220E-01	1.07359E-13	0.00000E+00
336	335 TO 336		1.23360E+04	5.56955E+02	2.15039E-02	-2.37629E-05	-3.22936E-01	-4.70297E-01	9.04832E-15	0.00000E+00
337	336 TO 337		1.23360E+04	5.56955E+02	2.15042E-02	-2.78203E-05	-3.22933E-01	-4.70301E-01	-8.88178E-14	0.00000E+00
338	337 TO 338		1.23360E+04	5.56955E+02	2.15044E-02	-2.78228E-05	-3.22929E-01	-4.70304E-01	-5.16254E-15	0.00000E+00
339	338 TO 339		1.23360E+04	5.56955E+02	2.15046E-02	-2.78252E-05	-3.22926E-01	-4.70308E-01	-1.82965E-13	0.00000E+00
340	339 TO 340		1.23360E+04	5.56955E+02	2.15049E-02	-2.78275E-05	-3.22922E-01	-4.70312E-01	2.67841E-13	0.00000E+00
341	340 TO 341		1.23360E+04	5.56955E+02	2.15051E-02	-2.78299E-05	-3.22919E-01	-4.70315E-01	-3.77476E-14	0.00000E+00
342	341 TO 342		1.23360E+04	5.56955E+02	2.15053E-02	-2.78323E-05	-3.22915E-01	-4.70319E-01	-2.09832E-13	0.00000E+00
343	342 TO 343		1.23360E+04	5.56955E+02	2.15056E-02	-2.78347E-05	-3.22912E-01	-4.70323E-01	1.86351E-13	0.00000E+00
344	343 TO 344		1.23360E+04	5.56955E+02	2.15058E-02	-2.78371E-05	-3.22908E-01	-4.70326E-01	-2.34146E-13	0.00000E+00
345	344 TO 345		1.23360E+04	5.56955E+02	2.15061E-02	-2.78395E-05	-3.22905E-01	-4.70330E-01	3.28404E-13	0.00000E+00
346	345 TO 346		1.23360E+04	5.56955E+02	2.15063E-02	-2.78418E-05	-3.22901E-01	-4.70334E-01	3.41394E-14	0.00000E+00
347	346 TO 29		1.23360E+04	5.56955E+02	2.15065E-02	1.40812E+00	-1.64972E+00	-1.51113E+00	-2.02061E-13	0.00000E+00
CHANNEL JUNCTIONS										
1010	68 TO 1010	CHI	9.79046E+01	5.56955E+02	2.15034E-02	2.04018E-04	-3.22945E-01	-2.39217E-01	-1.01141E-13	
1130	1120 TO 39	CHX	9.79046E+01	5.56956E+02	2.15062E-02	1.40054E+00	-1.64973E+00	-2.66298E+00	-8.32823E-12	
2010	69 TO 2010	CHI	9.79046E+01	5.56955E+02	2.15038E-02	1.83772E-04	-3.22940E-01	-2.39220E-01	1.88405E-13	
2130	2120 TO 39	CHX	9.79046E+01	5.56956E+02	2.15065E-02	1.40057E+00	-1.64972E+00	-1.51006E+00	-1.54481E-11	
3010	30 TO 3010	CHI	9.79046E+01	5.56955E+02	2.15038E-02	1.83739E-04	-3.22940E-01	-2.39220E-01	-2.83440E-13	
3130	3120 TO 39	CHX	9.79046E+01	5.56957E+02	2.15066E-02	1.40057E+00	-1.64972E+00	-1.51006E+00	-2.95737E-11	
4010	31 TO 4010	CHI	1.95809E+02	5.56955E+02	2.15038E-02	1.83778E-04	-3.22940E-01	-2.39220E-01	-1.94289E-14	
4130	4120 TO 39	CHX	1.95809E+02	5.56956E+02	2.15065E-02	1.40057E+00	-1.64972E+00	-1.51007E+00	-2.10607E-11	
5010	32 TO 5010	CHI	9.79046E+01	5.56955E+02	2.15038E-02	1.83749E-04	-3.22940E-01	-2.39220E-01	-4.53915E-13	
5130	5120 TO 39	CHX	9.79046E+01	5.56956E+02	2.15065E-02	1.40057E+00	-1.64972E+00	-1.51006E+00	-2.87874E-11	
6010	33 TO 6010	CHI	1.95809E+02	5.56955E+02	2.15038E-02	1.83756E-04	-3.22940E-01	-2.39220E-01	-6.14009E-13	
6130	6120 TO 39	CHX	1.95809E+02	5.56957E+02	2.15066E-02	1.40057E+00	-1.64972E+00	-1.51007E+00	-2.88181E-11	
7010	34 TO 7010	CHI	2.93714E+02	5.56955E+02	2.15038E-02	1.83791E-04	-3.22940E-01	-2.39220E-01	-1.78468E-13	
7130	7120 TO 39	CHX	2.93714E+02	5.56956E+02	2.15065E-02	1.40057E+00	-1.64972E+00	-1.51007E+00	-1.96370E-11	
8010	35 TO 8010	CHI	5.87428E+02	5.56955E+02	2.15038E-02	1.83780E-04	-3.22940E-01	-2.39220E-01	3.24629E-13	

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8130	8120 TO 39	CHX	5.87428E+02	5.56956E+02	2.15065E-02	1.40057E+00	-1.64972E+00	-1.51009E+00	-1.96763E-11	
9010	36 TO 9010	CHI	1.27276E+03	5.56955E+02	2.15038E-02	1.83807E-04	-3.22940E-01	-2.39220E-01	3.09641E-13	
9130	9120 TO 39	CHX	1.27276E+03	5.56956E+02	2.15065E-02	1.40057E+00	-1.64972E+00	-1.51018E+00	-1.09390E-11	
10010	37 TO 10010	CHI	1.76228E+03	5.56955E+02	2.15038E-02	1.83828E-04	-3.22940E-01	-2.39220E-01	2.17049E-13	
10130	10120 TO 39	CHX	1.76228E+03	5.56956E+02	2.15065E-02	1.40057E+00	-1.64972E+00	-1.51028E+00	-3.61267E-12	
11010	21 TO 11010	CHI	1.95809E+02	5.56955E+02	2.15034E-02	2.03998E-04	-3.22945E-01	-2.39217E-01	-1.75859E-13	
11130	11120 TO 29	CHX	1.95809E+02	5.56956E+02	2.15062E-02	1.40810E+00	-1.64973E+00	-2.67053E+00	-2.91467E-11	
12010	22 TO 12010	CHI	5.87428E+02	5.56955E+02	2.15038E-02	1.83677E-04	-3.22939E-01	-2.39220E-01	1.70253E-13	
12130	12120 TO 29	CHX	5.87428E+02	5.56956E+02	2.15065E-02	1.40812E+00	-1.64972E+00	-1.51007E+00	-4.83569E-12	
13010	23 TO 13010	CHI	1.56647E+03	5.56955E+02	2.15038E-02	1.83646E-04	-3.22939E-01	-2.39220E-01	2.22711E-13	
13130	13120 TO 29	CHX	1.56647E+03	5.56956E+02	2.15065E-02	1.40812E+00	-1.64972E+00	-1.51009E+00	-1.19245E-11	
14010	24 TO 14010	CHI	3.13295E+03	5.56955E+02	2.15038E-02	1.83672E-04	-3.22939E-01	-2.39220E-01	3.20410E-13	
14130	14120 TO 29	CHX	3.13295E+03	5.56956E+02	2.15065E-02	1.40812E+00	-1.64972E+00	-1.51015E+00	-3.24141E-12	
15010	25 TO 15010	CHI	1.76228E+03	5.56955E+02	2.15038E-02	1.83672E-04	-3.22939E-01	-2.39220E-01	-2.32092E-13	
15130	15120 TO 29	CHX	1.76228E+03	5.56956E+02	2.15065E-02	1.40812E+00	-1.64972E+00	-1.51009E+00	8.27960E-12	
16010	26 TO 16010	CHI	4.20990E+03	5.56955E+02	2.15038E-02	1.83691E-04	-3.22939E-01	-2.39220E-01	5.16032E-13	
16130	16120 TO 29	CHX	4.20990E+03	5.56956E+02	2.15065E-02	1.40812E+00	-1.64972E+00	-1.51021E+00	9.87899E-12	
17010	27 TO 17010	CHI	2.74133E+03	5.56955E+02	2.15038E-02	1.83682E-04	-3.22939E-01	-2.39220E-01	4.67515E-13	
17130	17120 TO 29	CHX	2.74133E+03	5.56956E+02	2.15065E-02	1.40812E+00	-1.64972E+00	-1.51013E+00	1.21860E-11	
78	0 TO 38		4.11199E+03	5.56955E+02	2.15070E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
77	0 TO 37		1.76228E+03	5.56955E+02	2.15070E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
76	0 TO 36		1.27276E+03	5.56955E+02	2.15070E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
75	0 TO 35		5.87428E+02	5.56955E+02	2.15070E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
74	0 TO 34		2.93714E+02	5.56955E+02	2.15070E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
73	0 TO 33		1.95809E+02	5.56955E+02	2.15070E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
72	0 TO 32		9.79046E+01	5.56955E+02	2.15070E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
71	0 TO 31		1.95809E+02	5.56955E+02	2.15070E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
70	0 TO 30		9.79046E+01	5.56955E+02	2.15070E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
69	0 TO 69		9.79046E+01	5.56955E+02	2.15070E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
68	0 TO 68		9.79046E+01	5.56955E+02	2.15070E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
28	0 TO 28		1.23360E+04	5.56955E+02	2.15070E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
27	0 TO 27		2.74133E+03	5.56955E+02	2.15070E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
26	0 TO 26		4.20990E+03	5.56955E+02	2.15070E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
25	0 TO 25		1.76228E+03	5.56955E+02	2.15070E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
24	0 TO 24		3.13295E+03	5.56955E+02	2.15070E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
23	0 TO 23		1.56647E+03	5.56955E+02	2.15070E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
22	0 TO 22		5.87428E+02	5.56955E+02	2.15070E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
21	0 TO 21		1.95809E+02	5.56955E+02	2.15070E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

RETRAN CHANNEL EDIT - (VOLUMES AND CONDUCTORS ARE IDENTICALLY NUMBERED)

VOLUME NUMBER	MODERATOR TEMPERATURE (DEG. F)	MODERATOR DENSITY (LBM/FT**3)	MODERATOR ENTHALPY (BTU/LBM)	HEAT TRANSFER MODE	POWER DENSITY	FUEL TEMPERATURE (DEG. F)	FUEL ENTHALPY (CAL/GM)	HEAT FLUX (BTU/HR/FT**2)	CONDUCTOR HEATING RATE (BTU/HR)	DIR. MOD HEATING RATE (BTU/HR)
CHANNEL 1										
1010	5.57853E+02	4.65038E+01	5.56955E+02	1	1.22369E-03	5.57855E+02	0.00000E+00	4.00308E-01	5.37367E+00	1.43445E-01
1020	5.57852E+02	4.65033E+01	5.56955E+02	1	2.60292E-03	5.57855E+02	0.00000E+00	8.51496E-01	1.14303E+01	3.05122E-01
1030	5.57850E+02	4.65028E+01	5.56955E+02	1	3.63875E-03	5.57855E+02	0.00000E+00	1.19035E+00	1.59790E+01	4.26545E-01
1040	5.57849E+02	4.65023E+01	5.56955E+02	1	4.18598E-03	5.57854E+02	0.00000E+00	1.36936E+00	1.83821E+01	4.90693E-01
1050	5.57847E+02	4.65018E+01	5.56955E+02	1	4.21386E-03	5.57853E+02	0.00000E+00	1.37848E+00	1.85045E+01	4.93961E-01
1060	5.57846E+02	4.65013E+01	5.56955E+02	1	3.80077E-03	5.57851E+02	0.00000E+00	1.24335E+00	1.66905E+01	4.45537E-01
1070	5.57844E+02	4.65008E+01	5.56956E+02	1	3.12193E-03	5.57848E+02	0.00000E+00	1.02128E+00	1.37095E+01	3.65962E-01
1080	5.57842E+02	4.65003E+01	5.56956E+02	1	2.37505E-03	5.57846E+02	0.00000E+00	7.76953E-01	1.04297E+01	2.78411E-01
1090	5.57841E+02	4.64998E+01	5.56956E+02	1	1.69358E-03	5.57843E+02	0.00000E+00	5.54022E-01	7.43711E+00	1.98527E-01
1100	5.57839E+02	4.64993E+01	5.56956E+02	1	1.12536E-03	5.57841E+02	0.00000E+00	3.68139E-01	4.94184E+00	1.31918E-01
1110	5.57838E+02	4.64988E+01	5.56956E+02	1	6.62815E-04	5.57839E+02	0.00000E+00	2.16827E-01	2.91065E+00	7.76971E-02
1120	5.57836E+02	4.64982E+01	5.56956E+02	1	2.78125E-04	5.57836E+02	0.00000E+00	9.09833E-02	1.22135E+00	3.26026E-02
CHANNEL 2										
2010	5.57851E+02	4.65031E+01	5.56955E+02	1	2.88811E-03	5.57855E+02	0.00000E+00	9.44789E-01	1.26827E+01	3.38553E-01
2020	5.57850E+02	4.65026E+01	5.56955E+02	1	6.19266E-03	5.57858E+02	0.00000E+00	2.02581E+00	2.71941E+01	7.25922E-01
2030	5.57848E+02	4.65021E+01	5.56955E+02	1	8.65117E-03	5.57859E+02	0.00000E+00	2.83006E+00	3.79903E+01	1.01411E+00
2040	5.57847E+02	4.65016E+01	5.56956E+02	1	9.95929E-03	5.57860E+02	0.00000E+00	3.25799E+00	4.37347E+01	1.16746E+00
2050	5.57845E+02	4.65011E+01	5.56956E+02	1	1.00297E-02	5.57858E+02	0.00000E+00	3.28103E+00	4.40440E+01	1.17571E+00
2060	5.57844E+02	4.65005E+01	5.56956E+02	1	9.04326E-03	5.57855E+02	0.00000E+00	2.95833E+00	3.97121E+01	1.06008E+00
2070	5.57842E+02	4.65000E+01	5.56956E+02	1	7.42145E-03	5.57852E+02	0.00000E+00	2.42778E+00	3.25902E+01	8.69964E-01
2080	5.57840E+02	4.64995E+01	5.56956E+02	1	5.64666E-03	5.57848E+02	0.00000E+00	1.84719E+00	2.47965E+01	6.61918E-01
2090	5.57839E+02	4.64990E+01	5.56956E+02	1	4.03427E-03	5.57844E+02	0.00000E+00	1.31973E+00	1.77159E+01	4.72909E-01
2100	5.57837E+02	4.64985E+01	5.56956E+02	1	2.68875E-03	5.57841E+02	0.00000E+00	8.79572E-01	1.18072E+01	3.15183E-01
2110	5.57836E+02	4.64980E+01	5.56956E+02	1	1.59002E-03	5.57838E+02	0.00000E+00	5.20143E-01	6.98231E+00	1.86386E-01
2120	5.57834E+02	4.64975E+01	5.56956E+02	1	6.64206E-04	5.57835E+02	0.00000E+00	2.17282E-01	2.91676E+00	7.78602E-02
CHANNEL 3										
3010	5.57851E+02	4.65031E+01	5.56955E+02	1	4.60662E-03	5.57857E+02	0.00000E+00	1.50697E+00	2.02293E+01	5.40001E-01
3020	5.57850E+02	4.65026E+01	5.56955E+02	1	9.93878E-03	5.57863E+02	0.00000E+00	3.25128E+00	4.36447E+01	1.16505E+00
3030	5.57848E+02	4.65021E+01	5.56956E+02	1	1.38694E-02	5.57866E+02	0.00000E+00	4.53711E+00	6.09055E+01	1.62581E+00
3040	5.57847E+02	4.65016E+01	5.56956E+02	1	1.59526E-02	5.57867E+02	0.00000E+00	5.21858E+00	7.00534E+01	1.87001E+00
3050	5.57845E+02	4.65010E+01	5.56956E+02	1	1.60169E-02	5.57866E+02	0.00000E+00	5.23961E+00	7.03357E+01	1.87754E+00
3060	5.57844E+02	4.65005E+01	5.56956E+02	1	1.43397E-02	5.57862E+02	0.00000E+00	4.69095E+00	6.29705E+01	1.68094E+00
3070	5.57842E+02	4.65000E+01	5.56956E+02	1	1.16417E-02	5.57857E+02	0.00000E+00	3.80835E+00	5.11227E+01	1.36467E+00
3080	5.57841E+02	4.64995E+01	5.56956E+02	1	8.77644E-03	5.57852E+02	0.00000E+00	2.87104E+00	3.85404E+01	1.02880E+00
3090	5.57839E+02	4.64990E+01	5.56957E+02	1	6.24162E-03	5.57847E+02	0.00000E+00	2.04182E+00	2.74091E+01	7.31660E-01
3100	5.57838E+02	4.64985E+01	5.56957E+02	1	4.15339E-03	5.57843E+02	0.00000E+00	1.35870E+00	1.82390E+01	4.86872E-01
3110	5.57836E+02	4.64980E+01	5.56957E+02	1	2.45699E-03	5.57839E+02	0.00000E+00	8.03757E-01	1.07895E+01	2.88016E-01
3120	5.57835E+02	4.64975E+01	5.56957E+02	1	1.02079E-03	5.57836E+02	0.00000E+00	3.33933E-01	4.48267E+00	1.19660E-01
CHANNEL 4										
4010	5.57851E+02	4.65031E+01	5.56955E+02	1	3.46144E-03	5.57856E+02	0.00000E+00	1.13234E+00	3.04008E+01	8.11520E-01
4020	5.57850E+02	4.65026E+01	5.56955E+02	1	7.42121E-03	5.57859E+02	0.00000E+00	2.42770E+00	6.51782E+01	1.73987E+00
4030	5.57848E+02	4.65021E+01	5.56955E+02	1	1.03604E-02	5.57862E+02	0.00000E+00	3.38920E+00	9.09922E+01	2.42895E+00
4040	5.57847E+02	4.65016E+01	5.56956E+02	1	1.19027E-02	5.57862E+02	0.00000E+00	3.89373E+00	1.04538E+02	2.79054E+00
4050	5.57845E+02	4.65011E+01	5.56956E+02	1	1.19258E-02	5.57861E+02	0.00000E+00	3.90128E+00	1.04740E+02	2.79595E+00
4060	5.57844E+02	4.65005E+01	5.56956E+02	1	1.06360E-02	5.57857E+02	0.00000E+00	3.47935E+00	9.34125E+01	2.49356E+00
4070	5.57842E+02	4.65000E+01	5.56956E+02	1	8.58506E-03	5.57853E+02	0.00000E+00	2.80844E+00	7.54000E+01	2.01273E+00
4080	5.57841E+02	4.64995E+01	5.56956E+02	1	6.43525E-03	5.57849E+02	0.00000E+00	2.10517E+00	5.65189E+01	1.50872E+00
4090	5.57839E+02	4.64990E+01	5.56956E+02	1	4.55387E-03	5.57845E+02	0.00000E+00	1.48971E+00	3.99953E+01	1.06764E+00
4100	5.57837E+02	4.64985E+01	5.56956E+02	1	3.01790E-03	5.57841E+02	0.00000E+00	9.87246E-01	2.65053E+01	7.07533E-01
4110	5.57836E+02	4.64980E+01	5.56956E+02	1	1.77804E-03	5.57838E+02	0.00000E+00	5.81651E-01	1.56160E+01	4.16854E-01
4120	5.57834E+02	4.64975E+01	5.56956E+02	1	7.41043E-04	5.57835E+02	0.00000E+00	2.42418E-01	6.50836E+00	1.73734E-01
CHANNEL 5										
5010	5.57851E+02	4.65031E+01	5.56955E+02	1	4.09220E-03	5.57856E+02	0.00000E+00	1.33868E+00	1.79703E+01	4.79699E-01
5020	5.57850E+02	4.65026E+01	5.56955E+02	1	8.78750E-03	5.57861E+02	0.00000E+00	2.87466E+00	3.85890E+01	1.03010E+00
5030	5.57848E+02	4.65021E+01	5.56956E+02	1	1.22627E-02	5.57864E+02	0.00000E+00	4.01151E+00	5.38499E+01	1.43747E+00
5040	5.57847E+02	4.65016E+01	5.56956E+02	1	1.40747E-02	5.57865E+02	0.00000E+00	4.60428E+00	6.18071E+01	1.64988E+00
5050	5.57845E+02	4.65011E+01	5.56956E+02	1	1.40445E-02	5.57863E+02	0.00000E+00	4.59439E+00	6.16744E+01	1.64634E+00

5060	5.57844E+02	4.65005E+01	5.56956E+02	1	1.23661E-02	5.57860E+02	0.00000E+00	4.04532E+00	5.43038E+01	1.44959E+00
5070	5.57842E+02	4.65000E+01	5.56956E+02	1	9.76468E-03	5.57855E+02	0.00000E+00	3.19433E+00	4.28801E+01	1.14464E+00
5080	5.57841E+02	4.64995E+01	5.56956E+02	1	7.20128E-03	5.57850E+02	0.00000E+00	2.35576E+00	3.16233E+01	8.44154E-01
5090	5.57839E+02	4.64990E+01	5.56956E+02	1	5.07230E-03	5.57846E+02	0.00000E+00	1.65930E+00	2.22742E+01	5.94589E-01
5100	5.57838E+02	4.64985E+01	5.56956E+02	1	3.36152E-03	5.57842E+02	0.00000E+00	1.09965E+00	1.47616E+01	3.94047E-01
5110	5.57836E+02	4.64980E+01	5.56956E+02	1	1.98304E-03	5.57839E+02	0.00000E+00	6.48712E-01	8.70821E+00	2.32457E-01
5120	5.57834E+02	4.64975E+01	5.56956E+02	1	8.26072E-04	5.57836E+02	0.00000E+00	2.70234E-01	3.62757E+00	9.68346E-02
CHANNEL 6										
6010	5.57851E+02	4.65031E+01	5.56955E+02	1	4.58122E-03	5.57857E+02	0.00000E+00	1.49866E+00	4.02355E+01	1.07405E+00
6020	5.57850E+02	4.65026E+01	5.56955E+02	1	9.87011E-03	5.57862E+02	0.00000E+00	3.22882E+00	8.66863E+01	2.31401E+00
6030	5.57848E+02	4.65021E+01	5.56956E+02	1	1.37589E-02	5.57866E+02	0.00000E+00	4.50096E+00	1.20840E+02	3.22572E+00
6040	5.57847E+02	4.65016E+01	5.56956E+02	1	1.57748E-02	5.57867E+02	0.00000E+00	5.16043E+00	1.38546E+02	3.69834E+00
6050	5.57845E+02	4.65010E+01	5.56956E+02	1	1.57033E-02	5.57866E+02	0.00000E+00	5.13705E+00	1.37918E+02	3.68158E+00
6060	5.57844E+02	4.65005E+01	5.56956E+02	1	1.37601E-02	5.57862E+02	0.00000E+00	4.50135E+00	1.20851E+02	3.22600E+00
6070	5.57842E+02	4.65000E+01	5.56956E+02	1	1.07749E-02	5.57856E+02	0.00000E+00	3.52481E+00	9.46329E+01	2.52614E+00
6080	5.57841E+02	4.64995E+01	5.56956E+02	1	7.88555E-03	5.57851E+02	0.00000E+00	2.57961E+00	6.92564E+01	1.84873E+00
6090	5.57839E+02	4.64990E+01	5.56956E+02	1	5.52154E-03	5.57846E+02	0.00000E+00	1.80626E+00	4.84940E+01	1.29450E+00
6100	5.57838E+02	4.64985E+01	5.56957E+02	1	3.63994E-03	5.57842E+02	0.00000E+00	1.19073E+00	3.19685E+01	8.53368E-01
6110	5.57836E+02	4.64980E+01	5.56957E+02	1	2.13942E-03	5.57839E+02	0.00000E+00	6.99871E-01	1.87899E+01	5.01579E-01
6120	5.57835E+02	4.64975E+01	5.56957E+02	1	8.86409E-04	5.57836E+02	0.00000E+00	2.89971E-01	7.78506E+00	2.07815E-01
CHANNEL 7										
7010	5.57851E+02	4.65031E+01	5.56955E+02	1	3.06660E-03	5.57855E+02	0.00000E+00	1.00318E+00	4.03995E+01	1.07843E+00
7020	5.57850E+02	4.65026E+01	5.56955E+02	1	6.57057E-03	5.57858E+02	0.00000E+00	2.14943E+00	8.65610E+01	2.31066E+00
7030	5.57848E+02	4.65021E+01	5.56955E+02	1	9.15702E-03	5.57860E+02	0.00000E+00	2.99554E+00	1.20635E+02	3.22024E+00
7040	5.57847E+02	4.65016E+01	5.56956E+02	1	1.04648E-02	5.57860E+02	0.00000E+00	3.42336E+00	1.37864E+02	3.68015E+00
7050	5.57845E+02	4.65011E+01	5.56956E+02	1	1.03120E-02	5.57858E+02	0.00000E+00	3.37336E+00	1.35850E+02	3.62639E+00
7060	5.57844E+02	4.65005E+01	5.56956E+02	1	8.63901E-03	5.57855E+02	0.00000E+00	2.82609E+00	1.13811E+02	3.03807E+00
7070	5.57842E+02	4.65000E+01	5.56956E+02	1	6.01214E-03	5.57850E+02	0.00000E+00	1.96676E+00	7.92043E+01	2.11428E+00
7080	5.57840E+02	4.64995E+01	5.56956E+02	1	4.15209E-03	5.57846E+02	0.00000E+00	1.35828E+00	5.46998E+01	1.46016E+00
7090	5.57839E+02	4.64990E+01	5.56956E+02	1	2.86508E-03	5.57843E+02	0.00000E+00	9.37256E-01	3.77447E+01	1.00756E+00
7100	5.57837E+02	4.64985E+01	5.56956E+02	1	1.87706E-03	5.57840E+02	0.00000E+00	6.14045E-01	2.47285E+01	6.60105E-01
7110	5.57836E+02	4.64980E+01	5.56956E+02	1	1.09953E-03	5.57837E+02	0.00000E+00	3.59691E-01	1.44853E+01	3.86672E-01
7120	5.57834E+02	4.64975E+01	5.56956E+02	1	4.57591E-04	5.57835E+02	0.00000E+00	1.49692E-01	6.02832E+00	1.60920E-01
CHANNEL 8										
8010	5.57851E+02	4.65031E+01	5.56955E+02	1	3.35220E-03	5.57855E+02	0.00000E+00	1.09661E+00	8.83240E+01	2.35773E+00
8020	5.57850E+02	4.65026E+01	5.56955E+02	1	7.19387E-03	5.57859E+02	0.00000E+00	2.35334E+00	1.89545E+02	5.05972E+00
8030	5.57848E+02	4.65021E+01	5.56955E+02	1	1.00167E-02	5.57861E+02	0.00000E+00	3.27677E+00	2.63921E+02	7.04511E+00
8040	5.57847E+02	4.65016E+01	5.56956E+02	1	1.14445E-02	5.57861E+02	0.00000E+00	3.74384E+00	3.01540E+02	8.04932E+00
8050	5.57845E+02	4.65011E+01	5.56956E+02	1	1.13120E-02	5.57860E+02	0.00000E+00	3.70050E+00	2.98050E+02	7.95616E+00
8060	5.57844E+02	4.65005E+01	5.56956E+02	1	9.75277E-03	5.57856E+02	0.00000E+00	3.19043E+00	2.56967E+02	6.85949E+00
8070	5.57842E+02	4.65000E+01	5.56956E+02	1	7.42026E-03	5.57852E+02	0.00000E+00	2.42739E+00	1.95510E+02	5.21895E+00
8080	5.57841E+02	4.64995E+01	5.56956E+02	1	5.29622E-03	5.57847E+02	0.00000E+00	1.73256E+00	1.39545E+02	3.72503E+00
8090	5.57839E+02	4.64990E+01	5.56956E+02	1	3.63615E-03	5.57844E+02	0.00000E+00	1.18950E+00	9.58057E+01	2.55744E+00
8100	5.57837E+02	4.64985E+01	5.56956E+02	1	2.35490E-03	5.57840E+02	0.00000E+00	7.70359E-01	6.20471E+01	1.65629E+00
8110	5.57836E+02	4.64980E+01	5.56956E+02	1	1.36329E-03	5.57838E+02	0.00000E+00	4.45972E-01	3.59200E+01	9.58850E-01
8120	5.57834E+02	4.64975E+01	5.56956E+02	1	5.61785E-04	5.57835E+02	0.00000E+00	1.83777E-01	1.48020E+01	3.95124E-01
CHANNEL 9										
9010	5.57851E+02	4.65031E+01	5.56955E+02	1	2.11441E-03	5.57854E+02	0.00000E+00	6.91687E-01	1.20706E+02	3.22214E+00
9020	5.57850E+02	4.65026E+01	5.56955E+02	1	4.51699E-03	5.57855E+02	0.00000E+00	1.47765E+00	2.57864E+02	6.88343E+00
9030	5.57848E+02	4.65021E+01	5.56955E+02	1	6.27648E-03	5.57856E+02	0.00000E+00	2.05323E+00	3.58309E+02	9.56471E+00
9040	5.57846E+02	4.65016E+01	5.56955E+02	1	7.12744E-03	5.57856E+02	0.00000E+00	2.33160E+00	4.06888E+02	1.08615E+01
9050	5.57845E+02	4.65011E+01	5.56956E+02	1	6.92734E-03	5.57854E+02	0.00000E+00	2.26615E+00	3.95465E+02	1.05566E+01
9060	5.57843E+02	4.65006E+01	5.56956E+02	1	5.58427E-03	5.57851E+02	0.00000E+00	1.82679E+00	3.18792E+02	8.50986E+00
9070	5.57842E+02	4.65000E+01	5.56956E+02	1	3.38451E-03	5.57846E+02	0.00000E+00	1.10718E+00	1.93213E+02	5.15765E+00
9080	5.57840E+02	4.64995E+01	5.56956E+02	1	2.18653E-03	5.57843E+02	0.00000E+00	7.15280E-01	1.24823E+02	3.33204E+00
9090	5.57839E+02	4.64990E+01	5.56956E+02	1	1.43186E-03	5.57841E+02	0.00000E+00	4.68406E-01	8.17416E+01	2.18201E+00
9100	5.57837E+02	4.64985E+01	5.56956E+02	1	8.90678E-04	5.57838E+02	0.00000E+00	2.91368E-01	5.08466E+01	1.35730E+00
9110	5.57836E+02	4.64980E+01	5.56956E+02	1	4.99123E-04	5.57836E+02	0.00000E+00	1.63278E-01	2.84937E+01	7.60613E-01
9120	5.57834E+02	4.64975E+01	5.56956E+02	1	2.03473E-04	5.57834E+02	0.00000E+00	6.65624E-02	1.16158E+01	3.10073E-01
CHANNEL 10										
10010	5.57851E+02	4.65031E+01	5.56955E+02	1	1.05245E-03	5.57852E+02	0.00000E+00	3.44289E-01	8.31902E+01	2.22068E+00
10020	5.57850E+02	4.65026E+01	5.56955E+02	1	2.24616E-03	5.57852E+02	0.00000E+00	7.34787E-01	1.77546E+02	4.73942E+00
10030	5.57848E+02	4.65021E+01	5.56955E+02	1	3.11072E-03	5.57852E+02	0.00000E+00	1.01761E+00	2.45885E+02	6.56366E+00
10040	5.57846E+02	4.65016E+01	5.56955E+02	1	3.51325E-03	5.57851E+02	0.00000E+00	1.14929E+00	2.77702E+02	7.41299E+00
10050	5.57845E+02	4.65011E+01	5.56955E+02	1	3.35993E-03	5.57849E+02	0.00000E+00	1.09914E+00	2.65584E+02	7.08950E+00
10060	5.57843E+02	4.65006E+01	5.56955E+02	1	2.58170E-03	5.57847E+02	0.00000E+00	8.44552E-01	2.04068E+02	5.44741E+00
10070	5.57842E+02	4.65001E+01	5.56955E+02	1	1.41255E-03	5.57844E+02	0.00000E+00	4.62088E-01	1.11654E+02	2.98049E+00
10080	5.57840E+02	4.64995E+01	5.56955E+02	1	8.06004E-04	5.57841E+02	0.00000E+00	2.63669E-01	6.37100E+01	1.70068E+00
10090	5.57838E+02	4.64990E+01	5.56956E+02	1	4.98513E-04	5.57839E+02	0.00000E+00	1.63079E-01	3.94046E+01	1.05187E+00
10100	5.57837E+02	4.64985E+01	5.56956E+02	1	3.06314E-04	5.57837E+02	0.00000E+00	1.00205E-01	2.42124E+01	6.46327E-01
10110	5.57835E+02	4.64980E+01	5.56956E+02	1	1.72407E-04	5.57836E+02	0.00000E+00	5.63995E-02	1.36278E+01	3.63780E-01
10120	5.57834E+02	4.64975E+01	5.56956E+02	1	7.05813E-05	5.57834E+02	0.00000E+00	2.30893E-02	5.57905E+00	1.48927E-01
CHANNEL 11										
11010	5.57853E+02	4.65038E+01	5.56955E+02	1	3.14957E-03	5.57858E+02	0.00000E+00	1.03032E+00	2.76618E+01	7.38404E-01
11020	5.57852E+02	4.65033E+01	5.56955E+02	1	6.77122E-03	5.57861E+02	0.00000E+00	2.21507E+00	5.94696E+01	1.58748E+00
11030	5.57850E+02	4.65028E+01	5.56955E+02	1	9.45015E-03	5.57863E+02	0.00000E+00	3.09143E+00	8.29979E+01	2.21555E+00
11040	5.57849E+02	4.65023E+01	5.56956E+02	1	1.08679E-02	5.57863E+02	0.00000E+00	3.55523E+00	9.54496E+01	2.54794E+00
11050	5.57847E+02	4.65018E+01	5.56956E+02	1	1.09202E-02	5.57862E+02	0.00000E+00	3.57233E+00	9.59087E+01	2.56019E+00
11060	5.57846E+02	4.65013E+01	5.56956E+02	1	9.80823E-03	5.57859E+02	0.00000E+00	3.20857E+00	8.61427E+01	2.29950E+00
11070	5.57844E+02	4.65008E+01	5.56956E+02	1	8.00597E-03	5.57855E+02	0.00000E+00	2.61900E+00	7.03140E+01	1.87697E+00
11080	5.57843E+02	4.65003E+01	5.56956E+02	1	6.05711E-03	5.57851E+02	0.00000E+00	1.98147E+00	5.31978E+01	1.42006E+00
11090	5.57841E+02	4.64997E+01	5.56956E+02	1	4.30670E-03	5.57847E+02	0.00000E+00	1.40885E+00	3.78244E+01	1.00969E+00
11100	5.57840E+02	4.64992E+01	5.56956E+02	1	2.85842E-03	5.57843E+02	0.00000E+00	9.35078E-01	2.51047E+01	6.70145E-01
11110	5.57838E+02	4.64987E+01	5.56956E+02	1	1.68552E-03	5.57840E+02	0.00000E+00	5.51385E-01	1.48034E+01	3.95163E-01
11120	5.57837E+02	4.64982E+01	5.56956E+02	1	7.00637E-04	5.57837E+02	0.00000E+00	2.29200E-01	6.15348E+00	1.64261E-01
CHANNEL 12										
12010	5.57851E+02	4.65031E+01	5.56955E+02	1	1.82976E-03	5.57853E+02	0.00000E+00	5.98569E-01	4.82106E+01	1.28694E+00
12020	5.57850E+02	4.65026E+01	5.56955E+02	1	3.90206E-03	5.57855E+02	0.00000E+00	1.27648E+00	1.02812E+02	2.74447E+00
12030	5.57848E+02	4.65021E+01	5.56955E+02	1	5.44050E-03	5.57855E+02	0.00000E+00	1.77975E+00	1.43347E+02	3.82651E+00
12040	5.57846E+02	4.65016E+01	5.56955E+02	1	6.23128E-03	5.57855E+02	0.00000E+00	2.03844E+00	1.64182E+02	4.38269E+00
12050	5.57845E+02	4.65011E+01	5.56956E+02	1	6.21251E-03	5.57853E+02	0.00000E+00	2.03230E+00	1.63688E+02	4.36949E+00
12060	5.57843E+02	4.65006E+01	5.56956E+02	1	5.50021E-03	5.57851E+02	0.00000E+00	1.79929E+00	1.44920E+02	3.86850E+00
12070	5.57842E+02	4.65000E+01	5.56956E+02	1	4.39637E-03	5.57848E+02	0.00000E+00	1.43819E+00	1.15836E+02	3.09213E+00
12080	5.57840E+02	4.64995E+01	5.56956E+02	1	3.25691E-03	5.57844E+02	0.00000E+00	1.06543E+00	8.58133E+01	2.29070E+00
12090	5.57839E+02	4.64990E+01	5.56956E+02	1	2.27541E-03	5.57842E+02	0.00000E+00	7.44355E-01	5.99526E+01	1.60038E+00
12100	5.57837E+02	4.64985E+01	5.56956E+02	1	1.48838E-03	5.57839E+02	0.00000E+00	4.86895E-01	3.92160E+01	1.04683E+00
12110	5.57835E+02	4.64980E+01	5.56956E+02	1	8.66476E-04	5.57837E+02	0.00000E+00	2.83451E-01	2.28300E+01	6.09425E-01
12120	5.57834E+02	4.64975E+01	5.56956E+02	1	3.59832E-04	5.57834E+02	0.00000E+00	1.17712E-01	9.48089E+00	2.53083E-01
CHANNEL 13										
13010	5.57851E+02	4.65031E+01	5.56955E+02	1	3.43456E-03	5.57856E+02	0.00000E+00	1.12355E+00	2.41318E+02	6.44175E+00
13020	5.57850E+02	4.65026E+01	5.56955E+02	1	7.36476E-03	5.57859E+02	0.00000E+00	2.40924E+00	5.17460E+02	1.38131E+01
13030	5.57848E+02	4.65021E+01	5.56955E+02	1	1.02218E-02	5.57861E+02	0.00000E+00	3.34387E+00	7.18202E+02	1.91717E+01

13040	5.57847E+02	4.65016E+01	5.56956E+02	1	1.16106E-02	5.57862E+02	0.00000E+00	3.79817E+00	8.15776E+02	2.17764E+01
13050	5.57845E+02	4.65011E+01	5.56956E+02	1	1.13430E-02	5.57860E+02	0.00000E+00	3.71064E+00	7.96977E+02	2.12745E+01
13060	5.57844E+02	4.65005E+01	5.56956E+02	1	9.53946E-03	5.57856E+02	0.00000E+00	3.12065E+00	6.70258E+02	1.78919E+01
13070	5.57842E+02	4.65000E+01	5.56956E+02	1	6.93647E-03	5.57851E+02	0.00000E+00	2.26913E+00	4.87367E+02	1.30098E+01
13080	5.57841E+02	4.64995E+01	5.56956E+02	1	4.74688E-03	5.57847E+02	0.00000E+00	1.55285E+00	3.33523E+02	8.90308E+00
13090	5.57839E+02	4.64990E+01	5.56956E+02	1	3.13196E-03	5.57843E+02	0.00000E+00	1.02456E+00	2.20057E+02	5.87420E+00
13100	5.57837E+02	4.64985E+01	5.56956E+02	1	1.92510E-03	5.57840E+02	0.00000E+00	6.29759E-01	1.35261E+02	3.61065E+00
13110	5.57836E+02	4.64980E+01	5.56956E+02	1	1.06335E-03	5.57837E+02	0.00000E+00	3.47855E-01	7.47128E+01	1.99439E+00
13120	5.57834E+02	4.64975E+01	5.56956E+02	1	4.27233E-04	5.57835E+02	0.00000E+00	1.39761E-01	3.00180E+01	8.01303E-01
CHANNEL 14										
14010	5.57851E+02	4.65031E+01	5.56955E+02	1	2.11648E-03	5.57854E+02	0.00000E+00	6.92365E-01	2.97415E+02	7.93920E+00
14020	5.57850E+02	4.65026E+01	5.56955E+02	1	4.52638E-03	5.57855E+02	0.00000E+00	1.48072E+00	6.36062E+02	1.69791E+01
14030	5.57848E+02	4.65021E+01	5.56955E+02	1	6.25581E-03	5.57856E+02	0.00000E+00	2.04647E+00	8.79086E+02	2.34664E+01
14040	5.57846E+02	4.65016E+01	5.56955E+02	1	7.04523E-03	5.57856E+02	0.00000E+00	2.30471E+00	9.90018E+02	2.64276E+01
14050	5.57845E+02	4.65011E+01	5.56956E+02	1	6.73289E-03	5.57854E+02	0.00000E+00	2.20253E+00	9.46127E+02	2.52560E+01
14060	5.57843E+02	4.65005E+01	5.56956E+02	1	5.21834E-03	5.57850E+02	0.00000E+00	1.70708E+00	7.33298E+02	1.95747E+01
14070	5.57842E+02	4.65000E+01	5.56956E+02	1	2.91958E-03	5.57846E+02	0.00000E+00	9.55085E-01	4.10269E+02	1.09517E+01
14080	5.57840E+02	4.64995E+01	5.56956E+02	1	1.70443E-03	5.57842E+02	0.00000E+00	5.57572E-01	2.39512E+02	6.39356E+00
14090	5.57839E+02	4.64990E+01	5.56956E+02	1	1.01071E-03	5.57840E+02	0.00000E+00	3.30636E-01	1.42029E+02	3.79132E+00
14100	5.57837E+02	4.64985E+01	5.56956E+02	1	5.16072E-04	5.57838E+02	0.00000E+00	1.68823E-01	7.25201E+01	1.93585E+00
14110	5.57835E+02	4.64980E+01	5.56956E+02	1	2.41438E-04	5.57836E+02	0.00000E+00	7.89817E-02	3.39276E+01	9.05666E-01
14120	5.57834E+02	4.64975E+01	5.56956E+02	1	9.04707E-05	5.57834E+02	0.00000E+00	2.95957E-02	1.27132E+01	3.39368E-01
CHANNEL 15										
15010	5.57851E+02	4.65031E+01	5.56955E+02	1	2.07016E-03	5.57854E+02	0.00000E+00	6.77212E-01	1.63634E+02	4.36806E+00
15020	5.57850E+02	4.65026E+01	5.56955E+02	1	4.42894E-03	5.57855E+02	0.00000E+00	1.44884E+00	3.50083E+02	9.34513E+00
15030	5.57848E+02	4.65021E+01	5.56955E+02	1	6.14211E-03	5.57856E+02	0.00000E+00	2.00927E+00	4.85499E+02	1.29599E+01
15040	5.57846E+02	4.65016E+01	5.56955E+02	1	6.97051E-03	5.57856E+02	0.00000E+00	2.28027E+00	5.50979E+02	1.47079E+01
15050	5.57845E+02	4.65011E+01	5.56956E+02	1	6.81437E-03	5.57854E+02	0.00000E+00	2.22919E+00	5.38637E+02	1.43784E+01
15060	5.57843E+02	4.65005E+01	5.56956E+02	1	5.76631E-03	5.57851E+02	0.00000E+00	1.88634E+00	4.55794E+02	1.21670E+01
15070	5.57842E+02	4.65000E+01	5.56956E+02	1	4.25147E-03	5.57847E+02	0.00000E+00	1.39079E+00	3.36054E+02	8.97065E+00
15080	5.57840E+02	4.64995E+01	5.56956E+02	1	2.94408E-03	5.57844E+02	0.00000E+00	9.63099E-01	2.32713E+02	6.21205E+00
15090	5.57839E+02	4.64990E+01	5.56956E+02	1	1.95839E-03	5.57841E+02	0.00000E+00	6.40649E-01	1.54799E+02	4.13222E+00
15100	5.57837E+02	4.64985E+01	5.56956E+02	1	1.22335E-03	5.57839E+02	0.00000E+00	4.00195E-01	9.66988E+01	2.58128E+00
15110	5.57836E+02	4.64980E+01	5.56956E+02	1	6.85995E-04	5.57836E+02	0.00000E+00	2.24410E-01	5.42240E+01	1.44746E+00
15120	5.57834E+02	4.64975E+01	5.56956E+02	1	2.77947E-04	5.57834E+02	0.00000E+00	9.09251E-02	2.19701E+01	5.86472E-01
CHANNEL 16										
16010	5.57851E+02	4.65031E+01	5.56955E+02	1	1.20462E-03	5.57853E+02	0.00000E+00	3.94068E-01	2.27466E+02	6.07200E+00
16020	5.57850E+02	4.65026E+01	5.56955E+02	1	2.57355E-03	5.57853E+02	0.00000E+00	8.41886E-01	4.85958E+02	1.29722E+01
16030	5.57848E+02	4.65021E+01	5.56955E+02	1	3.56063E-03	5.57853E+02	0.00000E+00	1.16479E+00	6.72346E+02	1.79476E+01
16040	5.57846E+02	4.65016E+01	5.56955E+02	1	4.02102E-03	5.57852E+02	0.00000E+00	1.31540E+00	7.59281E+02	2.02683E+01
16050	5.57845E+02	4.65011E+01	5.56955E+02	1	3.88322E-03	5.57850E+02	0.00000E+00	1.27032E+00	7.33261E+02	1.95737E+01
16060	5.57843E+02	4.65006E+01	5.56955E+02	1	3.15819E-03	5.57847E+02	0.00000E+00	1.03314E+00	5.96354E+02	1.59191E+01
16070	5.57842E+02	4.65000E+01	5.56956E+02	1	2.08794E-03	5.57844E+02	0.00000E+00	6.83030E-01	3.94262E+02	1.05245E+01
16080	5.57840E+02	4.64995E+01	5.56956E+02	1	1.35817E-03	5.57842E+02	0.00000E+00	4.44299E-01	2.56460E+02	6.84596E+00
16090	5.57839E+02	4.64990E+01	5.56956E+02	1	8.71805E-04	5.57840E+02	0.00000E+00	2.85194E-01	1.64621E+02	4.39441E+00
16100	5.57837E+02	4.64985E+01	5.56956E+02	1	5.29264E-04	5.57838E+02	0.00000E+00	1.73138E-01	9.99398E+01	2.66780E+00
16110	5.57835E+02	4.64980E+01	5.56956E+02	1	2.90730E-04	5.57836E+02	0.00000E+00	9.51065E-02	5.48979E+01	1.46545E+00
16120	5.57834E+02	4.64975E+01	5.56956E+02	1	1.16543E-04	5.57834E+02	0.00000E+00	3.81248E-02	2.20066E+01	5.87445E-01
CHANNEL 17										
17010	5.57851E+02	4.65031E+01	5.56955E+02	1	1.62133E-03	5.57853E+02	0.00000E+00	5.30386E-01	1.99355E+02	5.32159E+00
17020	5.57850E+02	4.65026E+01	5.56955E+02	1	3.46444E-03	5.57854E+02	0.00000E+00	1.13333E+00	4.25980E+02	1.13711E+01
17030	5.57848E+02	4.65021E+01	5.56955E+02	1	4.77530E-03	5.57854E+02	0.00000E+00	1.56215E+00	5.87160E+02	1.56737E+01
17040	5.57846E+02	4.65016E+01	5.56955E+02	1	5.35519E-03	5.57853E+02	0.00000E+00	1.75185E+00	6.58462E+02	1.75770E+01
17050	5.57845E+02	4.65011E+01	5.56955E+02	1	5.08410E-03	5.57851E+02	0.00000E+00	1.66317E+00	6.25130E+02	1.66872E+01
17060	5.57843E+02	4.65006E+01	5.56956E+02	1	3.90273E-03	5.57848E+02	0.00000E+00	1.27670E+00	4.79871E+02	1.28097E+01
17070	5.57842E+02	4.65000E+01	5.56956E+02	1	2.13871E-03	5.57845E+02	0.00000E+00	6.99639E-01	2.62972E+02	7.01977E+00
17080	5.57840E+02	4.64995E+01	5.56956E+02	1	1.21937E-03	5.57842E+02	0.00000E+00	3.98893E-01	1.49931E+02	4.00227E+00
17090	5.57839E+02	4.64990E+01	5.56956E+02	1	7.03032E-04	5.57839E+02	0.00000E+00	2.29983E-01	8.64432E+01	2.30752E+00
17100	5.57837E+02	4.64985E+01	5.56956E+02	1	3.48183E-04	5.57837E+02	0.00000E+00	1.13901E-01	4.28118E+01	1.14282E+00
17110	5.57835E+02	4.64980E+01	5.56956E+02	1	1.58412E-04	5.57836E+02	0.00000E+00	5.18213E-02	1.94779E+01	5.19945E-01
17120	5.57834E+02	4.64975E+01	5.56956E+02	1	5.83452E-05	5.57834E+02	0.00000E+00	1.90865E-02	7.17400E+00	1.91503E-01

APPROXIMATE POINT KINETICS REACTIVITY DATA

	K-INFINITY	TOTAL REACTIVITY	CONTROL REACTIVITY	MODERATOR REACTIVITY	DENSITY REACTIVITY	DOPPLER REACTIVITY	RESIDUAL REACTIVITY
ADJOINT FLUX WTS	1.000936E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	-3.848868E-02

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   79
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:59:26
 STEAMLINE BREAK - RETRAN-3D SAMPLE PROBLEM - 1/2 CORE, 17 CHAN/ 2 BYP, FILL BC                                 CPU TIME =     2.605
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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SYSTEM ELAPSED TIME (SEC)	SYSTEM ELAPSED TIME (SEC)	TIME STP ACTUAL	SYSTEM CORE POWER (MW)	CORE-PHY ADJ TOT REAC (K-1)/K	CORE-PHY ADJ CTR REAC (K-1)/K	CORE-PHY ADJ DOP REAC (K-1)/K	CORE-PHY ADJ MOD REAC (K-1)/K	CORE-PHY ADJ DEN REAC (K-1)/K
0.00000E+00	0.00000E+00	0.00000E+00	1.00000E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
1.00000E-02	1.00000E-02	1.00000E+00	1.00000E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
2.00000E-02	2.00000E-02	2.00000E+00	3.58430E-03	-1.88356E-02	-2.07409E-02	0.00000E+00	1.24076E-10	-3.98029E-09
3.00000E-02	3.00000E-02	3.00000E+00	3.01819E-03	-1.82637E-02	-2.01309E-02	0.00000E+00	4.16835E-08	-4.04795E-07
4.00000E-02	4.00000E-02	4.00000E+00	2.94380E-03	-1.83357E-02	-2.02108E-02	3.75775E-10	8.48779E-08	-8.70894E-07
5.00000E-02	5.00000E-02	5.00000E+00	2.92828E-03	-1.83393E-02	-2.02144E-02	1.07047E-09	1.21354E-07	-1.30795E-06
6.00000E-02	6.00000E-02	6.00000E+00	2.91829E-03	-1.83349E-02	-2.02090E-02	1.96777E-09	1.55522E-07	-1.75658E-06
7.00000E-02	7.00000E-02	7.00000E+00	2.90921E-03	-1.83288E-02	-2.02018E-02	2.13465E-09	1.89330E-07	-2.20444E-06
8.00000E-02	8.00000E-02	8.00000E+00	2.90047E-03	-1.83225E-02	-2.01945E-02	2.61533E-09	2.26162E-07	-2.65656E-06
9.00000E-02	9.00000E-02	9.00000E+00	2.89180E-03	-1.83165E-02	-2.01873E-02	3.38044E-09	2.64520E-07	-3.09377E-06
1.00000E-01	1.00000E-01	1.00000E+01	2.88322E-03	-1.83106E-02	-2.01804E-02	4.73611E-09	3.03822E-07	-3.53923E-06
1.10000E-01	1.10000E-01	1.10000E+01	2.87476E-03	-1.83048E-02	-2.01735E-02	5.01901E-09	3.37292E-07	-3.99599E-06
1.20000E-01	1.20000E-01	1.20000E+01	2.86642E-03	-1.82990E-02	-2.01667E-02	5.32370E-09	3.73511E-07	-4.43337E-06
1.30000E-01	1.30000E-01	1.30000E+01	2.85819E-03	-1.82934E-02	-2.01600E-02	6.10435E-09	4.07971E-07	-4.86940E-06
1.40000E-01	1.40000E-01	1.40000E+01	2.85007E-03	-1.82878E-02	-2.01534E-02	7.57801E-09	4.47443E-07	-5.30055E-06
1.50000E-01	1.50000E-01	1.50000E+01	2.84206E-03	-1.82822E-02	-2.01469E-02	8.60136E-09	4.84169E-07	-5.73765E-06
1.60000E-01	1.60000E-01	1.60000E+01	2.83416E-03	-1.82768E-02	-2.01404E-02	1.01265E-08	5.19732E-07	-6.16287E-06
1.70000E-01	1.70000E-01	1.70000E+01	2.82636E-03	-1.82714E-02	-2.01340E-02	1.11744E-08	5.44428E-07	-6.58059E-06
1.80000E-01	1.80000E-01	1.80000E+01	2.81865E-03	-1.82661E-02	-2.01277E-02	1.16015E-08	5.82580E-07	-6.99713E-06
1.90000E-01	1.90000E-01	1.90000E+01	2.81105E-03	-1.82608E-02	-2.01215E-02	1.23404E-08	6.21455E-07	-7.41152E-06
2.00000E-01	2.00000E-01	2.00000E+01	2.80354E-03	-1.82556E-02	-2.01153E-02	1.36587E-08	6.64499E-07	-7.80987E-06
2.10000E-01	2.10000E-01	2.10000E+01	2.79613E-03	-1.82504E-02	-2.01092E-02	1.47762E-08	7.11363E-07	-8.20252E-06
2.20000E-01	2.20000E-01	2.20000E+01	2.78880E-03	-1.82453E-02	-2.01032E-02	1.63920E-08	7.50935E-07	-8.59232E-06
2.30000E-01	2.30000E-01	2.30000E+01	2.78156E-03	-1.82403E-02	-2.00973E-02	1.86443E-08	7.87934E-07	-8.97705E-06
2.40000E-01	2.40000E-01	2.40000E+01	2.77441E-03	-1.82353E-02	-2.00914E-02	2.03548E-08	8.28689E-07	-9.34218E-06
2.50000E-01	2.50000E-01	2.50000E+01	2.76734E-03	-1.82303E-02	-2.00856E-02	2.24241E-08	8.71825E-07	-9.70470E-06
2.60000E-01	2.60000E-01	2.60000E+01	2.76036E-03	-1.82254E-02	-2.00798E-02	2.42645E-08	9.21753E-07	-1.00563E-05
2.70000E-01	2.70000E-01	2.70000E+01	2.75345E-03	-1.82205E-02	-2.00741E-02	2.57511E-08	9.87281E-07	-1.03965E-05
2.80000E-01	2.80000E-01	2.80000E+01	2.74663E-03	-1.82157E-02	-2.00685E-02	2.72247E-08	1.02740E-06	-1.07262E-05
2.90000E-01	2.90000E-01	2.90000E+01	2.73987E-03	-1.82109E-02	-2.00629E-02	2.93232E-08	1.07005E-06	-1.10460E-05
3.00000E-01	3.00000E-01	3.00000E+01	2.73320E-03	-1.82062E-02	-2.00574E-02	3.26469E-08	1.11732E-06	-1.13646E-05
3.10000E-01	3.10000E-01	3.10000E+01	2.72659E-03	-1.82015E-02	-2.00519E-02	3.42968E-08	1.16051E-06	-1.16639E-05
3.20000E-01	3.20000E-01	3.20000E+01	2.72006E-03	-1.81968E-02	-2.00465E-02	3.86436E-08	1.21551E-06	-1.19607E-05
3.30000E-01	3.30000E-01	3.30000E+01	2.71360E-03	-1.81922E-02	-2.00411E-02	4.06139E-08	1.27742E-06	-1.22414E-05
3.40000E-01	3.40000E-01	3.40000E+01	2.70721E-03	-1.81876E-02	-2.00358E-02	4.40772E-08	1.33635E-06	-1.25085E-05
3.50000E-01	3.50000E-01	3.50000E+01	2.70088E-03	-1.81830E-02	-2.00305E-02	4.75981E-08	1.39196E-06	-1.27690E-05
3.60000E-01	3.60000E-01	3.60000E+01	2.69462E-03	-1.81785E-02	-2.00253E-02	4.88152E-08	1.44404E-06	-1.30272E-05
3.70000E-01	3.70000E-01	3.70000E+01	2.68842E-03	-1.81740E-02	-2.00202E-02	5.17327E-08	1.49742E-06	-1.32729E-05
3.80000E-01	3.80000E-01	3.80000E+01	2.68228E-03	-1.81695E-02	-2.00151E-02	5.35457E-08	1.55667E-06	-1.35053E-05
3.90000E-01	3.90000E-01	3.90000E+01	2.67621E-03	-1.81651E-02	-2.00100E-02	5.64691E-08	1.62178E-06	-1.37239E-05
4.00000E-01	4.00000E-01	4.00000E+01	2.67019E-03	-1.81607E-02	-2.00050E-02	5.99612E-08	1.68488E-06	-1.39438E-05
4.10000E-01	4.10000E-01	4.10000E+01	2.66423E-03	-1.81564E-02	-2.00000E-02	6.33941E-08	1.73463E-06	-1.41504E-05
4.20000E-01	4.20000E-01	4.20000E+01	2.65833E-03	-1.81520E-02	-1.99951E-02	6.65942E-08	1.79438E-06	-1.43501E-05
4.30000E-01	4.30000E-01	4.30000E+01	2.65248E-03	-1.81477E-02	-1.99902E-02	7.00573E-08	1.85658E-06	-1.45340E-05
4.40000E-01	4.40000E-01	4.40000E+01	2.64669E-03	-1.81435E-02	-1.99853E-02	7.26853E-08	1.91636E-06	-1.47237E-05
4.50000E-01	4.50000E-01	4.50000E+01	2.64096E-03	-1.81393E-02	-1.99805E-02	7.51200E-08	1.97328E-06	-1.48993E-05
4.60000E-01	4.60000E-01	4.60000E+01	2.63527E-03	-1.81350E-02	-1.99758E-02	7.96443E-08	2.04229E-06	-1.50651E-05
4.70000E-01	4.70000E-01	4.70000E+01	2.62964E-03	-1.81309E-02	-1.99711E-02	8.47204E-08	2.09752E-06	-1.52293E-05
4.80000E-01	4.80000E-01	4.80000E+01	2.62406E-03	-1.81267E-02	-1.99664E-02	8.89714E-08	2.16391E-06	-1.53815E-05
4.90000E-01	4.90000E-01	4.90000E+01	2.61852E-03	-1.81226E-02	-1.99617E-02	9.29914E-08	2.23331E-06	-1.55288E-05

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   80
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:59:28
 STEAMLINE BREAK - RETRAN-3D SAMPLE PROBLEM - 1/2 CORE, 17 CHAN/ 2 BYP, FILL BC                                 CPU TIME =     4.555
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *
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SYSTEM ELAPSED TIME (SEC)	SYSTEM ELAPSED TIME (SEC)	TIME STP ACTUAL	SYSTEM CORE POWER (MW)	CORE-PHY ADJ TOT REAC (K-1)/K	CORE-PHY ADJ CTR REAC (K-1)/K	CORE-PHY ADJ DOP REAC (K-1)/K	CORE-PHY ADJ MOD REAC (K-1)/K	CORE-PHY ADJ DEN REAC (K-1)/K
5.00000E-01	5.00000E-01	5.00000E+01	2.61304E-03	-1.81185E-02	-1.99571E-02	9.78352E-08	2.29861E-06	-1.56822E-05
5.10000E-01	5.10000E-01	5.10000E+01	2.60760E-03	-1.81144E-02	-1.99525E-02	1.01586E-07	2.35395E-06	-1.58224E-05
5.20000E-01	5.20000E-01	5.20000E+01	2.60221E-03	-1.81104E-02	-1.99480E-02	1.05552E-07	2.42804E-06	-1.59566E-05
5.30000E-01	5.30000E-01	5.30000E+01	2.59686E-03	-1.81063E-02	-1.99435E-02	1.11494E-07	2.49709E-06	-1.60844E-05
5.40000E-01	5.40000E-01	5.40000E+01	2.59156E-03	-1.81024E-02	-1.99390E-02	1.16599E-07	2.55581E-06	-1.62150E-05
5.50000E-01	5.50000E-01	5.50000E+01	2.58631E-03	-1.80984E-02	-1.99346E-02	1.20997E-07	2.61919E-06	-1.63388E-05
5.60000E-01	5.60000E-01	5.60000E+01	2.58109E-03	-1.80945E-02	-1.99302E-02	1.26309E-07	2.69284E-06	-1.64574E-05
5.70000E-01	5.70000E-01	5.70000E+01	2.57592E-03	-1.80906E-02	-1.99258E-02	1.32060E-07	2.75729E-06	-1.65743E-05
5.80000E-01	5.80000E-01	5.80000E+01	2.57079E-03	-1.80867E-02	-1.99215E-02	1.36872E-07	2.82880E-06	-1.66876E-05
5.90000E-01	5.90000E-01	5.90000E+01	2.56570E-03	-1.80828E-02	-1.99172E-02	1.42340E-07	2.89453E-06	-1.68033E-05
6.00000E-01	6.00000E-01	6.00000E+01	2.56065E-03	-1.80790E-02	-1.99129E-02	1.47622E-07	2.96133E-06	-1.69201E-05
6.10000E-01	6.10000E-01	6.10000E+01	2.55564E-03	-1.80752E-02	-1.99087E-02	1.53133E-07	3.02779E-06	-1.70247E-05
6.20000E-01	6.20000E-01	6.20000E+01	2.55067E-03	-1.80714E-02	-1.99044E-02	1.57874E-07	3.10151E-06	-1.71296E-05
6.30000E-01	6.30000E-01	6.30000E+01	2.54573E-03	-1.80676E-02	-1.99003E-02	1.66640E-07	3.17221E-06	-1.72318E-05
6.40000E-01	6.40000E-01	6.40000E+01	2.54084E-03	-1.80639E-02	-1.98961E-02	1.72078E-07	3.23655E-06	-1.73386E-05
6.50000E-01	6.50000E-01	6.50000E+01	2.53597E-03	-1.80602E-02	-1.98920E-02	1.76599E-07	3.30744E-06	-1.74409E-05
6.60000E-01	6.60000E-01	6.60000E+01	2.53115E-03	-1.80565E-02	-1.98879E-02	1.83473E-07	3.38026E-06	-1.75404E-05
6.70000E-01	6.70000E-01	6.70000E+01	2.52636E-03	-1.80529E-02	-1.98838E-02	1.89636E-07	3.44673E-06	-1.76355E-05
6.80000E-01	6.80000E-01	6.80000E+01	2.52160E-03	-1.80492E-02	-1.98798E-02	1.95851E-07	3.51557E-06	-1.77363E-05
6.90000E-01	6.90000E-01	6.90000E+01	2.51688E-03	-1.80456E-02	-1.98758E-02	2.03245E-07	3.58724E-06	-1.78341E-05
7.00000E-01	7.00000E-01	7.00000E+01	2.51220E-03	-1.80420E-02	-1.98718E-02	2.11979E-07	3.65752E-06	-1.79215E-05
7.10000E-01	7.10000E-01	7.10000E+01	2.50754E-03	-1.80384E-02	-1.98678E-02	2.16351E-07	3.73240E-06	-1.80142E-05
7.20000E-01	7.20000E-01	7.20000E+01	2.50292E-03	-1.80349E-02	-1.98639E-02	2.22859E-07	3.80552E-06	-1.81108E-05
7.30000E-01	7.30000E-01	7.30000E+01	2.49833E-03	-1.80314E-02	-1.98600E-02	2.31280E-07	3.86924E-06	-1.82093E-05
7.40000E-01	7.40000E-01	7.40000E+01	2.49377E-03	-1.80279E-02	-1.98561E-02	2.39367E-07	3.93944E-06	-1.82991E-05
7.50000E-01	7.50000E-01	7.50000E+01	2.48924E-03	-1.80244E-02	-1.98522E-02	2.46127E-07	4.01823E-06	-1.83922E-05
7.60000E-01	7.60000E-01	7.60000E+01	2.48474E-03	-1.80210E-02	-1.98484E-02	2.53852E-07	4.08251E-06	-1.84871E-05
7.70000E-01	7.70000E-01	7.70000E+01	2.48027E-03	-1.80175E-02	-1.98446E-02	2.62680E-07	4.15453E-06	-1.85854E-05
7.80000E-01	7.80000E-01	7.80000E+01	2.47583E-03	-1.80141E-02	-1.98408E-02	2.71574E-07	4.22274E-06	-1.86747E-05
7.90000E-01	7.90000E-01	7.90000E+01	2.47142E-03	-1.80107E-02	-1.98371E-02	2.78255E-07	4.29443E-06	-1.87640E-05
8.00000E-01	8.00000E-01	8.00000E+01	2.46703E-03	-1.80073E-02	-1.98333E-02	2.86008E-07	4.36844E-06	-1.88531E-05
8.10000E-01	8.10000E-01	8.10000E+01	2.46268E-03	-1.80040E-02	-1.98296E-02	2.93485E-07	4.43318E-06	-1.89499E-05
8.20000E-01	8.20000E-01	8.20000E+01	2.45835E-03	-1.80007E-02	-1.98259E-02	3.02352E-07	4.50670E-06	-1.90412E-05
8.30000E-01	8.30000E-01	8.30000E+01	2.45405E-03	-1.79974E-02	-1.98223E-02	3.09886E-07	4.57260E-06	-1.91363E-05
8.40000E-01	8.40000E-01	8.40000E+01	2.44978E-03	-1.79941E-02	-1.98186E-02	3.18686E-07	4.63789E-06	-1.92222E-05
8.50000E-01	8.50000E-01	8.50000E+01	2.44553E-03	-1.79908E-02	-1.98150E-02	3.28705E-07	4.71283E-06	-1.93108E-05
8.60000E-01	8.60000E-01	8.60000E+01	2.44131E-03	-1.79876E-02	-1.98114E-02	3.37023E-07	4.78296E-06	-1.94034E-05
8.70000E-01	8.70000E-01	8.70000E+01	2.43711E-03	-1.79844E-02	-1.98078E-02	3.43589E-07	4.85033E-06	-1.94908E-05
8.80000E-01	8.80000E-01	8.80000E+01	2.43294E-03	-1.79811E-02	-1.98043E-02	3.56249E-07	4.92526E-06	-1.95848E-05
8.90000E-01	8.90000E-01	8.90000E+01	2.42879E-03	-1.79780E-02	-1.98007E-02	3.62394E-07	4.99064E-06	-1.96781E-05
9.00000E-01	9.00000E-01	9.00000E+01	2.42467E-03	-1.79748E-02	-1.97972E-02	3.72028E-07	5.06160E-06	-1.97647E-05
9.10000E-01	9.10000E-01	9.10000E+01	2.42058E-03	-1.79716E-02	-1.97937E-02	3.81803E-07	5.13489E-06	-1.98519E-05
9.20000E-01	9.20000E-01	9.20000E+01	2.41650E-03	-1.79685E-02	-1.97902E-02	3.92723E-07	5.20036E-06	-1.99441E-05
9.30000E-01	9.30000E-01	9.30000E+01	2.41245E-03	-1.79654E-02	-1.97868E-02	3.98732E-07	5.27424E-06	-2.00361E-05
9.40000E-01	9.40000E-01	9.40000E+01	2.40842E-03	-1.79623E-02	-1.97833E-02	4.11734E-07	5.34319E-06	-2.01280E-05
9.50000E-01	9.50000E-01	9.50000E+01	2.40442E-03	-1.79592E-02	-1.97799E-02	4.20278E-07	5.41801E-06	-2.02140E-05
9.60000E-01	9.60000E-01	9.60000E+01	2.40044E-03	-1.79561E-02	-1.97765E-02	4.31124E-07	5.48907E-06	-2.03027E-05
9.70000E-01	9.70000E-01	9.70000E+01	2.39648E-03	-1.79531E-02	-1.97732E-02	4.43191E-07	5.55925E-06	-2.03937E-05
9.80000E-01	9.80000E-01	9.80000E+01	2.39254E-03	-1.79500E-02	-1.97698E-02	4.51669E-07	5.63328E-06	-2.04812E-05
9.90000E-01	9.90000E-01	9.90000E+01	2.38863E-03	-1.79470E-02	-1.97665E-02	4.62157E-07	5.69746E-06	-2.05631E-05

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   84
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:59:28
 STEAMLINE BREAK - RETRAN-3D SAMPLE PROBLEM - 1/2 CORE, 17 CHAN/ 2 BYP, FILL BC                                 CPU TIME =     4.586
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *
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NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	ENERGY BALANCE (BTU)	TOTAL MASS BALANCE (LBM)	NCG MASS BALANCE (LBM)	AVERAGE TIME STEP (SEC)	CURRENT TIME STEP (SEC)	ELAPSED TIME (SEC)	TIME STEP NUM STANDRD/ACTUL
2.38473E-01	2.38473E-03	8.13910E+03	3.70071E+07	6.75355E+04	0.00000E+00	1.00000E-02	1.00000E-02	1.00000E+00	100 / 100

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	VOID FRAC.	POWR TO H2O (BTU/SEC)
21	2.24707E+03	1.22870E+01	5.56560E+02	4.65064E+01	5.57484E+02	0.00000E+00	0.00000E+00	0.00000E+00
22	2.24592E+03	3.68604E+01	5.56560E+02	4.65057E+01	5.57482E+02	0.00000E+00	0.00000E+00	0.00000E+00
23	2.24592E+03	9.82943E+01	5.56560E+02	4.65057E+01	5.57482E+02	0.00000E+00	0.00000E+00	0.00000E+00
24	2.24592E+03	1.96589E+02	5.56560E+02	4.65057E+01	5.57482E+02	0.00000E+00	0.00000E+00	0.00000E+00
25	2.24592E+03	1.10581E+02	5.56560E+02	4.65057E+01	5.57482E+02	0.00000E+00	0.00000E+00	0.00000E+00
26	2.24592E+03	2.64166E+02	5.56560E+02	4.65057E+01	5.57482E+02	0.00000E+00	0.00000E+00	0.00000E+00
27	2.24592E+03	1.72015E+02	5.56560E+02	4.65057E+01	5.57482E+02	0.00000E+00	0.00000E+00	0.00000E+00
28	2.24592E+03	7.74068E+02	5.56560E+02	4.65057E+01	5.57482E+02	0.00000E+00	0.00000E+00	0.00000E+00
29	2.23460E+03	2.90335E+04	5.56996E+02	4.64745E+01	5.57800E+02	0.00000E+00	0.00000E+00	0.00000E+00
30	2.24593E+03	6.14182E+00	5.56778E+02	4.64937E+01	5.57653E+02	0.00000E+00	0.00000E+00	0.00000E+00
31	2.24593E+03	1.22836E+01	5.56778E+02	4.64937E+01	5.57653E+02	0.00000E+00	0.00000E+00	0.00000E+00
32	2.24593E+03	6.14182E+00	5.56778E+02	4.64937E+01	5.57653E+02	0.00000E+00	0.00000E+00	0.00000E+00
33	2.24593E+03	1.22836E+01	5.56778E+02	4.64937E+01	5.57653E+02	0.00000E+00	0.00000E+00	0.00000E+00
34	2.24593E+03	1.84255E+01	5.56778E+02	4.64937E+01	5.57653E+02	0.00000E+00	0.00000E+00	0.00000E+00
35	2.24593E+03	3.68509E+01	5.56778E+02	4.64937E+01	5.57653E+02	0.00000E+00	0.00000E+00	0.00000E+00
36	2.24593E+03	7.98436E+01	5.56778E+02	4.64937E+01	5.57653E+02	0.00000E+00	0.00000E+00	0.00000E+00
37	2.24593E+03	1.10553E+02	5.56778E+02	4.64937E+01	5.57653E+02	0.00000E+00	0.00000E+00	0.00000E+00
38	2.24593E+03	2.57956E+02	5.56778E+02	4.64937E+01	5.57653E+02	0.00000E+00	0.00000E+00	0.00000E+00
39	2.23460E+03	9.67785E+03	5.56996E+02	4.64745E+01	5.57800E+02	0.00000E+00	0.00000E+00	0.00000E+00
68	2.24708E+03	6.14191E+00	5.56778E+02	4.64944E+01	5.57655E+02	0.00000E+00	0.00000E+00	0.00000E+00
69	2.24593E+03	6.14182E+00	5.56778E+02	4.64937E+01	5.57653E+02	0.00000E+00	0.00000E+00	0.00000E+00
322	2.24537E+03	2.57953E+02	5.56782E+02	4.64931E+01	5.57654E+02	0.00000E+00	0.00000E+00	0.00000E+00
323	2.24458E+03	2.57949E+02	5.56785E+02	4.64924E+01	5.57656E+02	0.00000E+00	0.00000E+00	0.00000E+00
324	2.24379E+03	2.57945E+02	5.56789E+02	4.64917E+01	5.57657E+02	0.00000E+00	0.00000E+00	0.00000E+00
325	2.24299E+03	2.57941E+02	5.56793E+02	4.64910E+01	5.57658E+02	0.00000E+00	0.00000E+00	0.00000E+00
326	2.24220E+03	2.57937E+02	5.56796E+02	4.64903E+01	5.57660E+02	0.00000E+00	0.00000E+00	0.00000E+00
327	2.24141E+03	2.57934E+02	5.56800E+02	4.64896E+01	5.57661E+02	0.00000E+00	0.00000E+00	0.00000E+00
328	2.24062E+03	2.57930E+02	5.56804E+02	4.64889E+01	5.57662E+02	0.00000E+00	0.00000E+00	0.00000E+00
329	2.23983E+03	2.57926E+02	5.56807E+02	4.64882E+01	5.57663E+02	0.00000E+00	0.00000E+00	0.00000E+00
330	2.23904E+03	2.57922E+02	5.56811E+02	4.64875E+01	5.57664E+02	0.00000E+00	0.00000E+00	0.00000E+00
331	2.23825E+03	2.57918E+02	5.56814E+02	4.64868E+01	5.57665E+02	0.00000E+00	0.00000E+00	0.00000E+00
332	2.23746E+03	2.57914E+02	5.56817E+02	4.64861E+01	5.57666E+02	0.00000E+00	0.00000E+00	0.00000E+00
333	2.23667E+03	2.57911E+02	5.56820E+02	4.64854E+01	5.57667E+02	0.00000E+00	0.00000E+00	0.00000E+00
335	2.24536E+03	7.74045E+02	5.56578E+02	4.65043E+01	5.57495E+02	0.00000E+00	0.00000E+00	0.00000E+00
336	2.24457E+03	7.74020E+02	5.56596E+02	4.65028E+01	5.57508E+02	0.00000E+00	0.00000E+00	0.00000E+00
337	2.24378E+03	7.73995E+02	5.56615E+02	4.65013E+01	5.57521E+02	0.00000E+00	0.00000E+00	0.00000E+00
338	2.24299E+03	7.73970E+02	5.56633E+02	4.64998E+01	5.57533E+02	0.00000E+00	0.00000E+00	0.00000E+00
339	2.24219E+03	7.73945E+02	5.56651E+02	4.64983E+01	5.57546E+02	0.00000E+00	0.00000E+00	0.00000E+00
340	2.24140E+03	7.73920E+02	5.56669E+02	4.64967E+01	5.57559E+02	0.00000E+00	0.00000E+00	0.00000E+00
341	2.24061E+03	7.73895E+02	5.56687E+02	4.64953E+01	5.57571E+02	0.00000E+00	0.00000E+00	0.00000E+00
342	2.23982E+03	7.73870E+02	5.56705E+02	4.64938E+01	5.57584E+02	0.00000E+00	0.00000E+00	0.00000E+00
343	2.23903E+03	7.73846E+02	5.56723E+02	4.64923E+01	5.57595E+02	0.00000E+00	0.00000E+00	0.00000E+00
344	2.23824E+03	7.73822E+02	5.56739E+02	4.64909E+01	5.57607E+02	0.00000E+00	0.00000E+00	0.00000E+00
345	2.23745E+03	7.73800E+02	5.56755E+02	4.64895E+01	5.57617E+02	0.00000E+00	0.00000E+00	0.00000E+00
346	2.23666E+03	7.73778E+02	5.56769E+02	4.64882E+01	5.57627E+02	0.00000E+00	0.00000E+00	0.00000E+00

JUNCTION NUMBER	CONNECTS VOLUMES	CHOK/ PATH	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E D I F F E R E N T I A L S: VEL. PSI	ELEV. PSI	FRIC. PSI	ACCL. PSI	PUMP PSI
322	38 TO 322		4.10275E+03	5.56780E+02	2.15082E-02	1.12960E-04	-3.22872E-01	-2.38289E-01	-4.20387E-04	0.00000E+00
323	322 TO 323		4.10281E+03	5.56784E+02	2.15085E-02	-1.01768E-04	-3.22867E-01	-4.68481E-01	-3.64177E-04	0.00000E+00
324	323 TO 324		4.10286E+03	5.56787E+02	2.15088E-02	-1.05807E-04	-3.22862E-01	-4.68497E-01	-3.64174E-04	0.00000E+00
325	324 TO 325		4.10292E+03	5.56791E+02	2.15092E-02	-1.05819E-04	-3.22857E-01	-4.68513E-01	-3.64174E-04	0.00000E+00
326	325 TO 326		4.10297E+03	5.56795E+02	2.15095E-02	-1.05836E-04	-3.22852E-01	-4.68530E-01	-3.64178E-04	0.00000E+00
327	326 TO 327		4.10303E+03	5.56798E+02	2.15098E-02	-1.05870E-04	-3.22848E-01	-4.68546E-01	-3.64195E-04	0.00000E+00
328	327 TO 328		4.10308E+03	5.56802E+02	2.15101E-02	-1.05936E-04	-3.22843E-01	-4.68562E-01	-3.64240E-04	0.00000E+00
329	328 TO 329		4.10313E+03	5.56806E+02	2.15105E-02	-1.06057E-04	-3.22838E-01	-4.68579E-01	-3.64335E-04	0.00000E+00
330	329 TO 330		4.10319E+03	5.56809E+02	2.15108E-02	-1.06264E-04	-3.22833E-01	-4.68595E-01	-3.64511E-04	0.00000E+00
331	330 TO 331		4.10324E+03	5.56813E+02	2.15111E-02	-1.06588E-04	-3.22828E-01	-4.68611E-01	-3.64803E-04	0.00000E+00
332	331 TO 332		4.10330E+03	5.56816E+02	2.15114E-02	-1.07057E-04	-3.22823E-01	-4.68628E-01	-3.65239E-04	0.00000E+00
333	332 TO 333		4.10336E+03	5.56819E+02	2.15118E-02	-1.07682E-04	-3.22819E-01	-4.68645E-01	-3.65840E-04	0.00000E+00
334	333 TO 39		4.10341E+03	5.56822E+02	2.15121E-02	1.39511E+00	-1.64892E+00	-1.50536E+00	3.06477E-01	0.00000E+00
335	28 TO 335		1.23080E+04	5.56564E+02	2.15028E-02	1.52892E-04	-3.22951E-01	-2.38239E-01	-4.19924E-04	0.00000E+00
336	335 TO 336		1.23080E+04	5.56582E+02	2.15034E-02	-5.78075E-05	-3.22941E-01	-4.68374E-01	-3.63293E-04	0.00000E+00
337	336 TO 337		1.23079E+04	5.56600E+02	2.15041E-02	-6.18539E-05	-3.22931E-01	-4.68381E-01	-3.63299E-04	0.00000E+00
338	337 TO 338		1.23079E+04	5.56619E+02	2.15048E-02	-6.18930E-05	-3.22920E-01	-4.68388E-01	-3.63316E-04	0.00000E+00
339	338 TO 339		1.23078E+04	5.56637E+02	2.15055E-02	-6.19723E-05	-3.22910E-01	-4.68396E-01	-3.63363E-04	0.00000E+00
340	339 TO 340		1.23078E+04	5.56655E+02	2.15062E-02	-6.21442E-05	-3.22899E-01	-4.68403E-01	-3.63487E-04	0.00000E+00
341	340 TO 341		1.23078E+04	5.56674E+02	2.15069E-02	-6.24975E-05	-3.22889E-01	-4.68410E-01	-3.63768E-04	0.00000E+00
342	341 TO 342		1.23077E+04	5.56692E+02	2.15076E-02	-6.31608E-05	-3.22878E-01	-4.68418E-01	-3.64334E-04	0.00000E+00
343	342 TO 343		1.23077E+04	5.56709E+02	2.15083E-02	-6.42906E-05	-3.22868E-01	-4.68425E-01	-3.65344E-04	0.00000E+00
344	343 TO 344		1.23076E+04	5.56727E+02	2.15089E-02	-6.60450E-05	-3.22858E-01	-4.68433E-01	-3.66971E-04	0.00000E+00
345	344 TO 345		1.23076E+04	5.56743E+02	2.15096E-02	-6.85458E-05	-3.22849E-01	-4.68441E-01	-3.69357E-04	0.00000E+00
346	345 TO 346		1.23076E+04	5.56759E+02	2.15102E-02	-7.18411E-05	-3.22840E-01	-4.68450E-01	-3.72574E-04	0.00000E+00
347	346 TO 29		1.23076E+04	5.56773E+02	2.15108E-02	1.40197E+00	-1.64893E+00	-1.50464E+00	3.06463E-01	0.00000E+00
CHANNEL JUNCTIONS										
1010	68 TO 1010	CHI	9.76846E+01	5.56778E+02	2.15079E-02	1.30900E-04	-3.22877E-01	-2.38286E-01	-4.20410E-04	
1130	1120 TO 39	CHX	9.77010E+01	5.56850E+02	2.15124E-02	1.39515E+00	-1.64892E+00	-2.65287E+00	3.06810E-01	
2010	69 TO 2010	CHI	9.76846E+01	5.56778E+02	2.15082E-02	1.10799E-04	-3.22872E-01	-2.38289E-01	-4.20409E-04	
2130	2120 TO 39	CHX	9.77010E+01	5.56850E+02	2.15128E-02	1.39517E+00	-1.64892E+00	-1.50436E+00	3.06812E-01	
3010	30 TO 3010	CHI	9.76846E+01	5.56778E+02	2.15082E-02	1.10771E-04	-3.22872E-01	-2.38289E-01	-4.20409E-04	
3130	3120 TO 39	CHX	9.77010E+01	5.56851E+02	2.15128E-02	1.39517E+00	-1.64892E+00	-1.50436E+00	3.06812E-01	
4010	31 TO 4010	CHI	1.95369E+02	5.56778E+02	2.15082E-02	1.10790E-04	-3.22872E-01	-2.38289E-01	-4.20409E-04	
4130	4120 TO 39	CHX	1.95402E+02	5.56851E+02	2.15128E-02	1.39517E+00	-1.64892E+00	-1.50436E+00	3.06805E-01	
5010	32 TO 5010	CHI	9.76846E+01	5.56778E+02	2.15082E-02	1.10780E-04	-3.22872E-01	-2.38289E-01	-4.20409E-04	
5130	5120 TO 39	CHX	9.77010E+01	5.56851E+02	2.15128E-02	1.39517E+00	-1.64892E+00	-1.50436E+00	3.06812E-01	
6010	33 TO 6010	CHI	1.95369E+02	5.56778E+02	2.15082E-02	1.10772E-04	-3.22872E-01	-2.38289E-01	-4.20409E-04	
6130	6120 TO 39	CHX	1.95402E+02	5.56851E+02	2.15128E-02	1.39517E+00	-1.64892E+00	-1.50436E+00	3.06805E-01	
7010	34 TO 7010	CHI	2.93054E+02	5.56778E+02	2.15082E-02	1.10797E-04	-3.22872E-01	-2.38289E-01	-4.20409E-04	
7130	7120 TO 39	CHX	2.93103E+02	5.56850E+02	2.15128E-02	1.39517E+00	-1.64892E+00	-1.50437E+00	3.06797E-01	
8010	35 TO 8010	CHI	5.86108E+02	5.56778E+02	2.15082E-02	1.10792E-04	-3.22872E-01	-2.38289E-01	-4.20409E-04	

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8130	8120 TO 39	CHX 5.86206E+02	5.56850E+02	2.15128E-02	1.39517E+00	-1.64892E+00	-1.50439E+00	3.06773E-01		
9010	36 TO 9010	CHI 1.26990E+03	5.56778E+02	2.15082E-02	1.10813E-04	-3.22872E-01	-2.38289E-01	-4.20409E-04		
9130	9120 TO 39	CHX 1.27011E+03	5.56850E+02	2.15128E-02	1.39517E+00	-1.64892E+00	-1.50448E+00	3.06717E-01		
10010	37 TO 10010	CHI 1.75832E+03	5.56778E+02	2.15082E-02	1.10831E-04	-3.22872E-01	-2.38289E-01	-4.20409E-04		
10130	10120 TO 39	CHX 1.75862E+03	5.56850E+02	2.15128E-02	1.39517E+00	-1.64892E+00	-1.50458E+00	3.06677E-01		
11010	21 TO 11010	CHI 1.95366E+02	5.56560E+02	2.15024E-02	1.70219E-04	-3.22958E-01	-2.38237E-01	-4.19970E-04		
11130	11120 TO 29	CHX 1.95360E+02	5.56826E+02	2.15118E-02	1.40205E+00	-1.64893E+00	-2.65918E+00	3.06813E-01		
12010	22 TO 12010	CHI 5.86098E+02	5.56560E+02	2.15028E-02	1.50085E-04	-3.22953E-01	-2.38239E-01	-4.19969E-04		
12130	12120 TO 29	CHX 5.86079E+02	5.56826E+02	2.15122E-02	1.40208E+00	-1.64892E+00	-1.50368E+00	3.06802E-01		
13010	23 TO 13010	CHI 1.56293E+03	5.56560E+02	2.15028E-02	1.50061E-04	-3.22953E-01	-2.38239E-01	-4.19969E-04		
13130	13120 TO 29	CHX 1.56288E+03	5.56826E+02	2.15122E-02	1.40208E+00	-1.64892E+00	-1.50370E+00	3.06775E-01		
14010	24 TO 14010	CHI 3.12585E+03	5.56560E+02	2.15028E-02	1.50083E-04	-3.22953E-01	-2.38239E-01	-4.19969E-04		
14130	14120 TO 29	CHX 3.12575E+03	5.56826E+02	2.15122E-02	1.40208E+00	-1.64892E+00	-1.50376E+00	3.06732E-01		
15010	25 TO 15010	CHI 1.75829E+03	5.56560E+02	2.15028E-02	1.50082E-04	-3.22953E-01	-2.38239E-01	-4.19969E-04		
15130	15120 TO 29	CHX 1.75824E+03	5.56826E+02	2.15122E-02	1.40208E+00	-1.64892E+00	-1.50371E+00	3.06770E-01		
16010	26 TO 16010	CHI 4.20037E+03	5.56560E+02	2.15028E-02	1.50097E-04	-3.22953E-01	-2.38239E-01	-4.19969E-04		
16130	16120 TO 29	CHX 4.20023E+03	5.56826E+02	2.15122E-02	1.40208E+00	-1.64892E+00	-1.50382E+00	3.06703E-01		
17010	27 TO 17010	CHI 2.73512E+03	5.56560E+02	2.15028E-02	1.50090E-04	-3.22953E-01	-2.38239E-01	-4.19969E-04		
17130	17120 TO 29	CHX 2.73503E+03	5.56826E+02	2.15122E-02	1.40208E+00	-1.64892E+00	-1.50374E+00	3.06743E-01		
78	0 TO 38	4.10270E+03	5.56774E+02	2.15116E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	
77	0 TO 37	1.75830E+03	5.56774E+02	2.15116E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	
76	0 TO 36	1.26988E+03	5.56774E+02	2.15116E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	
75	0 TO 35	5.86100E+02	5.56774E+02	2.15116E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	
74	0 TO 34	2.93050E+02	5.56774E+02	2.15116E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	
73	0 TO 33	1.95367E+02	5.56774E+02	2.15116E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	
72	0 TO 32	9.76833E+01	5.56774E+02	2.15116E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	
71	0 TO 31	1.95367E+02	5.56774E+02	2.15116E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	
70	0 TO 30	9.76833E+01	5.56774E+02	2.15116E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	
69	0 TO 69	9.76833E+01	5.56774E+02	2.15116E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	
68	0 TO 68	9.76833E+01	5.56774E+02	2.15116E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	
28	0 TO 28	1.23081E+04	5.56541E+02	2.15056E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	
27	0 TO 27	2.73513E+03	5.56541E+02	2.15056E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	
26	0 TO 26	4.20038E+03	5.56541E+02	2.15056E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	
25	0 TO 25	1.75830E+03	5.56541E+02	2.15056E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	
24	0 TO 24	3.12587E+03	5.56541E+02	2.15056E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	
23	0 TO 23	1.56293E+03	5.56541E+02	2.15056E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	
22	0 TO 22	5.86100E+02	5.56541E+02	2.15056E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	
21	0 TO 21	1.95367E+02	5.56541E+02	2.15056E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	

RETRAN CHANNEL EDIT - (VOLUMES AND CONDUCTORS ARE IDENTICALLY NUMBERED)

VOLUME NUMBER	MODERATOR TEMPERATURE (DEG. F)	MODERATOR DENSITY (LBM/FT**3)	MODERATOR ENTHALPY (BTU/LBM)	HEAT TRANSFER MODE	POWER DENSITY	FUEL TEMPERATURE (DEG. F)	FUEL ENTHALPY (CAL/GM)	HEAT FLUX (BTU/HR/FT**2)	CONDUCTOR HEATING RATE (BTU/HR)	DIR. MOD HEATING RATE (BTU/HR)
CHANNEL 1										
1010	5.57654E+02	4.64941E+01	5.56778E+02	1	1.80071E-03	5.57830E+02	0.00000E+00	8.37847E+01	1.88576E+00	5.03277E-02
1020	5.57657E+02	4.64932E+01	5.56785E+02	1	3.84491E-03	5.57831E+02	0.00000E+00	8.29091E+01	4.02649E+00	1.07460E-01
1030	5.57661E+02	4.64923E+01	5.56791E+02	1	5.43223E-03	5.57831E+02	0.00000E+00	8.18663E+01	5.68878E+00	1.51822E-01
1040	5.57664E+02	4.64915E+01	5.56798E+02	1	6.36804E-03	5.57831E+02	0.00000E+00	8.06845E+01	6.66878E+00	1.77975E-01
1050	5.57668E+02	4.64906E+01	5.56804E+02	1	6.60818E-03	5.57831E+02	0.00000E+00	7.93528E+01	6.92027E+00	1.84685E-01
1060	5.57671E+02	4.64898E+01	5.56810E+02	1	6.23598E-03	5.57829E+02	0.00000E+00	7.78923E+01	6.53049E+00	1.74281E-01
1070	5.57674E+02	4.64889E+01	5.56816E+02	1	5.43152E-03	5.57828E+02	0.00000E+00	7.63644E+01	5.68804E+00	1.51797E-01
1080	5.57677E+02	4.64881E+01	5.56822E+02	1	4.41646E-03	5.57826E+02	0.00000E+00	7.47849E+01	4.62504E+00	1.23428E-01
1090	5.57680E+02	4.64873E+01	5.56828E+02	1	3.35835E-03	5.57824E+02	0.00000E+00	7.30996E+01	3.51696E+00	9.38562E-02
1100	5.57683E+02	4.64865E+01	5.56833E+02	1	2.35930E-03	5.57822E+02	0.00000E+00	7.15442E+01	2.47072E+00	6.59351E-02
1110	5.57685E+02	4.64857E+01	5.56838E+02	1	1.45050E-03	5.57820E+02	0.00000E+00	7.04208E+01	1.51900E+00	4.05367E-02
1120	5.57688E+02	4.64849E+01	5.56844E+02	1	6.25021E-04	5.57819E+02	0.00000E+00	6.89951E+01	6.54540E-01	1.74672E-02
CHANNEL 2										
2010	5.57652E+02	4.64933E+01	5.56778E+02	1	4.28748E-03	5.57829E+02	0.00000E+00	8.42432E+01	4.48997E+00	1.19830E-01
2020	5.57655E+02	4.64925E+01	5.56785E+02	1	9.24675E-03	5.57833E+02	0.00000E+00	8.39061E+01	9.68344E+00	2.58433E-01
2030	5.57659E+02	4.64916E+01	5.56791E+02	1	1.30588E-02	5.57835E+02	0.00000E+00	8.32639E+01	1.36755E+01	3.64971E-01
2040	5.57662E+02	4.64907E+01	5.56798E+02	1	1.53180E-02	5.57836E+02	0.00000E+00	8.23006E+01	1.60414E+01	4.28108E-01
2050	5.57666E+02	4.64899E+01	5.56804E+02	1	1.59062E-02	5.57835E+02	0.00000E+00	8.09895E+01	1.66574E+01	4.44544E-01
2060	5.57669E+02	4.64890E+01	5.56811E+02	1	1.50213E-02	5.57833E+02	0.00000E+00	7.93789E+01	1.57308E+01	4.19812E-01
2070	5.57672E+02	4.64882E+01	5.56817E+02	1	1.30976E-02	5.57831E+02	0.00000E+00	7.75962E+01	1.37162E+01	3.66046E-01
2080	5.57675E+02	4.64874E+01	5.56823E+02	1	1.06616E-02	5.57828E+02	0.00000E+00	7.57341E+01	1.11651E+01	2.97963E-01
2090	5.57678E+02	4.64865E+01	5.56828E+02	1	8.11946E-03	5.57825E+02	0.00000E+00	7.37884E+01	8.50293E+00	2.26916E-01
2100	5.57681E+02	4.64857E+01	5.56834E+02	1	5.71456E-03	5.57822E+02	0.00000E+00	7.20118E+01	5.98445E+00	1.59704E-01
2110	5.57683E+02	4.64849E+01	5.56839E+02	1	3.52305E-03	5.57820E+02	0.00000E+00	7.07036E+01	3.68943E+00	9.84578E-02
2120	5.57686E+02	4.64841E+01	5.56844E+02	1	1.50972E-03	5.57817E+02	0.00000E+00	6.91184E+01	1.58103E+00	4.21917E-02
CHANNEL 3										
3010	5.57652E+02	4.64933E+01	5.56778E+02	1	6.65119E-03	5.57831E+02	0.00000E+00	8.47181E+01	6.96530E+00	1.85892E-01
3020	5.57655E+02	4.64925E+01	5.56785E+02	1	1.44520E-02	5.57837E+02	0.00000E+00	8.49435E+01	1.51345E+01	4.03912E-01
3030	5.57659E+02	4.64916E+01	5.56791E+02	1	2.03934E-02	5.57841E+02	0.00000E+00	8.47125E+01	2.13565E+01	5.69960E-01
3040	5.57662E+02	4.64907E+01	5.56798E+02	1	2.39139E-02	5.57842E+02	0.00000E+00	8.39704E+01	2.50433E+01	6.68349E-01
3050	5.57666E+02	4.64899E+01	5.56805E+02	1	2.48065E-02	5.57842E+02	0.00000E+00	8.26673E+01	2.59780E+01	6.93289E-01
3060	5.57669E+02	4.64890E+01	5.56811E+02	1	2.33849E-02	5.57839E+02	0.00000E+00	8.08774E+01	2.44893E+01	6.53553E-01
3070	5.57672E+02	4.64882E+01	5.56817E+02	1	2.03527E-02	5.57836E+02	0.00000E+00	7.88073E+01	2.13140E+01	5.68808E-01
3080	5.57675E+02	4.64873E+01	5.56823E+02	1	1.65319E-02	5.57832E+02	0.00000E+00	7.66479E+01	1.73127E+01	4.62023E-01
3090	5.57678E+02	4.64865E+01	5.56829E+02	1	1.25754E-02	5.57828E+02	0.00000E+00	7.44454E+01	1.31693E+01	3.51446E-01
3100	5.57681E+02	4.64857E+01	5.56834E+02	1	8.84888E-03	5.57824E+02	0.00000E+00	7.24578E+01	9.26679E+00	2.47299E-01
3110	5.57683E+02	4.64849E+01	5.56839E+02	1	5.45989E-03	5.57821E+02	0.00000E+00	7.09770E+01	5.71775E+00	1.52586E-01
3120	5.57686E+02	4.64841E+01	5.56845E+02	1	2.32720E-03	5.57818E+02	0.00000E+00	6.92421E+01	2.43711E+00	6.50373E-02
CHANNEL 4										
4010	5.57652E+02	4.64933E+01	5.56778E+02	1	4.87634E-03	5.57830E+02	0.00000E+00	8.43984E+01	1.02133E+01	2.72575E-01
4020	5.57655E+02	4.64925E+01	5.56785E+02	1	1.05498E-02	5.57834E+02	0.00000E+00	8.42390E+01	2.20960E+01	5.89702E-01
4030	5.57659E+02	4.64916E+01	5.56791E+02	1	1.49045E-02	5.57837E+02	0.00000E+00	8.37280E+01	3.12168E+01	8.33111E-01
4040	5.57662E+02	4.64907E+01	5.56798E+02	1	1.74645E-02	5.57838E+02	0.00000E+00	8.28302E+01	3.65787E+01	9.76201E-01
4050	5.57666E+02	4.64899E+01	5.56804E+02	1	1.80941E-02	5.57837E+02	0.00000E+00	8.15094E+01	3.78973E+01	1.01138E+00
4060	5.57669E+02	4.64890E+01	5.56811E+02	1	1.70260E-02	5.57835E+02	0.00000E+00	7.98210E+01	3.56601E+01	9.51672E-01
4070	5.57672E+02	4.64882E+01	5.56817E+02	1	1.47848E-02	5.57832E+02	0.00000E+00	7.79261E+01	3.09660E+01	8.26394E-01
4080	5.57675E+02	4.64873E+01	5.56823E+02	1	1.19814E-02	5.57829E+02	0.00000E+00	7.59640E+01	2.50944E+01	6.69694E-01
4090	5.57678E+02	4.64865E+01	5.56828E+02	1	9.09336E-03	5.57826E+02	0.00000E+00	7.39445E+01	1.90456E+01	5.08266E-01
4100	5.57681E+02	4.64857E+01	5.56834E+02	1	6.38785E-03	5.57823E+02	0.00000E+00	7.21145E+01	1.33791E+01	3.57042E-01
4110	5.57683E+02	4.64849E+01	5.56839E+02	1	3.93331E-03	5.57820E+02	0.00000E+00	7.07668E+01	8.23815E+00	2.19847E-01
4120	5.57686E+02	4.64841E+01	5.56844E+02	1	1.68388E-03	5.57817E+02	0.00000E+00	6.91506E+01	3.52681E+00	9.41174E-02
CHANNEL 5										
5010	5.57652E+02	4.64933E+01	5.56778E+02	1	5.49584E-03	5.57831E+02	0.00000E+00	8.45668E+01	5.75539E+00	1.53602E-01
5020	5.57655E+02	4.64925E+01	5.56785E+02	1	1.18801E-02	5.57835E+02	0.00000E+00	8.46049E+01	1.24412E+01	3.32032E-01
5030	5.57659E+02	4.64916E+01	5.56791E+02	1	1.67690E-02	5.57839E+02	0.00000E+00	8.42388E+01	1.75609E+01	4.68665E-01
5040	5.57662E+02	4.64907E+01	5.56798E+02	1	1.96459E-02	5.57840E+02	0.00000E+00	8.34157E+01	2.05738E+01	5.49067E-01
5050	5.57666E+02	4.64899E+01	5.56804E+02	1	2.03367E-02	5.57840E+02	0.00000E+00	8.20843E+01	2.12972E+01	5.68369E-01

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   5060    5.57669E+02  4.64890E+01  5.56811E+02    1   1.90915E-02  5.57837E+02  0.00000E+00  8.02971E+01  1.99932E+01  5.33564E-01
   5070    5.57672E+02  4.64882E+01  5.56817E+02    1   1.65496E-02  5.57833E+02  0.00000E+00  7.82604E+01  1.73312E+01  4.62519E-01
   5080    5.57675E+02  4.64873E+01  5.56823E+02    1   1.33755E-02  5.57830E+02  0.00000E+00  7.61885E+01  1.40072E+01  3.73808E-01
   5090    5.57678E+02  4.64865E+01  5.56829E+02    1   1.01512E-02  5.57826E+02  0.00000E+00  7.41011E+01  1.06307E+01  2.83698E-01
   5100    5.57681E+02  4.64857E+01  5.56834E+02    1   7.13717E-03  5.57823E+02  0.00000E+00  7.22214E+01  7.47425E+00  1.99462E-01
   5110    5.57683E+02  4.64849E+01  5.56839E+02    1   4.39891E-03  5.57820E+02  0.00000E+00  7.08325E+01  4.60666E+00  1.22935E-01
   5120    5.57686E+02  4.64841E+01  5.56844E+02    1   1.88153E-03  5.57818E+02  0.00000E+00  6.91794E+01  1.97039E+00  5.25823E-02
CHANNEL  6
   6010    5.57652E+02  4.64933E+01  5.56778E+02    1   5.96232E-03  5.57831E+02  0.00000E+00  8.46985E+01  1.24878E+01  3.33279E-01
   6020    5.57655E+02  4.64925E+01  5.56785E+02    1   1.29810E-02  5.57837E+02  0.00000E+00  8.48973E+01  2.71881E+01  7.25599E-01
   6030    5.57659E+02  4.64916E+01  5.56791E+02    1   1.83250E-02  5.57840E+02  0.00000E+00  8.46440E+01  3.83808E+01  1.02430E+00
   6040    5.57662E+02  4.64907E+01  5.56798E+02    1   2.14518E-02  5.57842E+02  0.00000E+00  8.38777E+01  4.49298E+01  1.19907E+00
   6050    5.57666E+02  4.64899E+01  5.56805E+02    1   2.21688E-02  5.57841E+02  0.00000E+00  8.25377E+01  4.64316E+01  1.23914E+00
   6060    5.57669E+02  4.64890E+01  5.56811E+02    1   2.07598E-02  5.57839E+02  0.00000E+00  8.06825E+01  4.34804E+01  1.16038E+00
   6070    5.57672E+02  4.64882E+01  5.56817E+02    1   1.79664E-02  5.57835E+02  0.00000E+00  7.85462E+01  3.76298E+01  1.00423E+00
   6080    5.57675E+02  4.64873E+01  5.56823E+02    1   1.44669E-02  5.57831E+02  0.00000E+00  7.63872E+01  3.03004E+01  8.08624E-01
   6090    5.57678E+02  4.64865E+01  5.56829E+02    1   1.09481E-02  5.57827E+02  0.00000E+00  7.42355E+01  2.29302E+01  6.11933E-01
   6100    5.57681E+02  4.64857E+01  5.56834E+02    1   7.67855E-03  5.57824E+02  0.00000E+00  7.23082E+01  1.60824E+01  4.29184E-01
   6110    5.57683E+02  4.64849E+01  5.56839E+02    1   4.72646E-03  5.57821E+02  0.00000E+00  7.08855E+01  9.89937E+00  2.64179E-01
   6120    5.57686E+02  4.64841E+01  5.56845E+02    1   2.01349E-03  5.57818E+02  0.00000E+00  6.92060E+01  4.21717E+00  1.12540E-01
CHANNEL  7
   7010    5.57652E+02  4.64933E+01  5.56778E+02    1   3.18870E-03  5.57829E+02  0.00000E+00  8.42659E+01  1.00179E+01  2.67360E-01
   7020    5.57655E+02  4.64925E+01  5.56785E+02    1   6.87680E-03  5.57833E+02  0.00000E+00  8.39526E+01  2.16047E+01  5.76590E-01
   7030    5.57659E+02  4.64916E+01  5.56791E+02    1   9.70480E-03  5.57835E+02  0.00000E+00  8.33228E+01  3.04894E+01  8.13698E-01
   7040    5.57662E+02  4.64907E+01  5.56798E+02    1   1.13446E-02  5.57836E+02  0.00000E+00  8.23481E+01  3.56411E+01  9.51180E-01
   7050    5.57666E+02  4.64899E+01  5.56804E+02    1   1.16936E-02  5.57835E+02  0.00000E+00  8.09781E+01  3.67376E+01  9.80436E-01
   7060    5.57669E+02  4.64890E+01  5.56811E+02    1   1.08533E-02  5.57833E+02  0.00000E+00  7.91996E+01  3.40976E+01  9.09973E-01
   7070    5.57672E+02  4.64882E+01  5.56817E+02    1   9.31067E-03  5.57829E+02  0.00000E+00  7.71762E+01  2.92512E+01  7.80630E-01
   7080    5.57675E+02  4.64874E+01  5.56823E+02    1   7.42990E-03  5.57826E+02  0.00000E+00  7.53040E+01  2.33424E+01  6.22937E-01
   7090    5.57678E+02  4.64865E+01  5.56828E+02    1   5.61464E-03  5.57823E+02  0.00000E+00  7.34530E+01  1.76394E+01  4.70739E-01
   7100    5.57681E+02  4.64857E+01  5.56834E+02    1   3.93214E-03  5.57821E+02  0.00000E+00  7.17791E+01  1.23535E+01  3.29674E-01
   7110    5.57683E+02  4.64849E+01  5.56839E+02    1   2.41740E-03  5.57819E+02  0.00000E+00  7.05651E+01  7.59470E+00  2.02675E-01
   7120    5.57686E+02  4.64841E+01  5.56844E+02    1   1.03559E-03  5.57817E+02  0.00000E+00  6.90649E+01  3.25351E+00  8.68239E-02
CHANNEL  8
   8010    5.57652E+02  4.64933E+01  5.56778E+02    1   3.92405E-03  5.57830E+02  0.00000E+00  8.43518E+01  2.46562E+01  6.58034E-01
   8020    5.57655E+02  4.64925E+01  5.56785E+02    1   8.48914E-03  5.57833E+02  0.00000E+00  8.41405E+01  5.33403E+01  1.42355E+00
   8030    5.57659E+02  4.64916E+01  5.56791E+02    1   1.19704E-02  5.57836E+02  0.00000E+00  8.35831E+01  7.52142E+01  2.00731E+00
   8040    5.57662E+02  4.64907E+01  5.56798E+02    1   1.39787E-02  5.57837E+02  0.00000E+00  8.26460E+01  8.78334E+01  2.34407E+00
   8050    5.57666E+02  4.64899E+01  5.56804E+02    1   1.43872E-02  5.57836E+02  0.00000E+00  8.12825E+01  9.03999E+01  2.41255E+00
   8060    5.57669E+02  4.64890E+01  5.56811E+02    1   1.33727E-02  5.57834E+02  0.00000E+00  7.95287E+01  8.40257E+01  2.24242E+00
   8070    5.57672E+02  4.64882E+01  5.56817E+02    1   1.14433E-02  5.57831E+02  0.00000E+00  7.75705E+01  7.19023E+01  1.91886E+00
   8080    5.57675E+02  4.64874E+01  5.56823E+02    1   9.13292E-03  5.57827E+02  0.00000E+00  7.56246E+01  5.73855E+01  1.53144E+00
   8090    5.57678E+02  4.64865E+01  5.56828E+02    1   6.86507E-03  5.57824E+02  0.00000E+00  7.36724E+01  4.31357E+01  1.15115E+00
   8100    5.57681E+02  4.64857E+01  5.56834E+02    1   4.78961E-03  5.57822E+02  0.00000E+00  7.19180E+01  3.00949E+01  8.03130E-01
   8110    5.57683E+02  4.64849E+01  5.56839E+02    1   2.93548E-03  5.57819E+02  0.00000E+00  7.06438E+01  1.84447E+01  4.92223E-01
   8120    5.57686E+02  4.64841E+01  5.56844E+02    1   1.25193E-03  5.57817E+02  0.00000E+00  6.90973E+01  7.86634E+00  2.09923E-01
CHANNEL  9
   9010    5.57652E+02  4.64933E+01  5.56778E+02    1   1.54834E-03  5.57828E+02  0.00000E+00  8.39958E+01  2.10791E+01  5.62566E-01
   9020    5.57655E+02  4.64925E+01  5.56785E+02    1   3.31558E-03  5.57830E+02  0.00000E+00  8.33692E+01  4.51381E+01  1.20465E+00
   9030    5.57659E+02  4.64916E+01  5.56791E+02    1   4.66591E-03  5.57832E+02  0.00000E+00  8.25028E+01  6.35215E+01  1.69526E+00
   9040    5.57662E+02  4.64907E+01  5.56798E+02    1   5.42388E-03  5.57832E+02  0.00000E+00  8.13952E+01  7.38405E+01  1.97063E+00
   9050    5.57666E+02  4.64899E+01  5.56804E+02    1   5.53304E-03  5.57831E+02  0.00000E+00  8.00071E+01  7.53265E+01  2.01028E+00
   9060    5.57669E+02  4.64890E+01  5.56810E+02    1   5.05336E-03  5.57829E+02  0.00000E+00  7.83164E+01  6.87963E+01  1.83599E+00
   9070    5.57672E+02  4.64882E+01  5.56816E+02    1   4.24645E-03  5.57826E+02  0.00000E+00  7.64130E+01  5.78109E+01  1.54281E+00
   9080    5.57675E+02  4.64874E+01  5.56822E+02    1   3.31992E-03  5.57823E+02  0.00000E+00  7.47236E+01  4.51973E+01  1.20618E+00
   9090    5.57678E+02  4.64865E+01  5.56828E+02    1   2.46530E-03  5.57822E+02  0.00000E+00  7.30238E+01  3.35626E+01  8.95676E-01
   9100    5.57680E+02  4.64857E+01  5.56833E+02    1   1.70496E-03  5.57820E+02  0.00000E+00  7.14793E+01  2.32113E+01  6.19431E-01
   9110    5.57683E+02  4.64850E+01  5.56839E+02    1   1.03780E-03  5.57818E+02  0.00000E+00  7.03779E+01  1.41286E+01  3.77042E-01
   9120    5.57685E+02  4.64842E+01  5.56844E+02    1   4.43587E-04  5.57816E+02  0.00000E+00  6.89793E+01  6.03898E+00  1.61158E-01
CHANNEL 10
  10010    5.57652E+02  4.64933E+01  5.56778E+02    1   6.32310E-04  5.57827E+02  0.00000E+00  8.37135E+01  1.19191E+01  3.18101E-01
  10020    5.57655E+02  4.64925E+01  5.56785E+02    1   1.34676E-03  5.57828E+02  0.00000E+00  8.27646E+01  2.53866E+01  6.77521E-01
  10030    5.57659E+02  4.64916E+01  5.56791E+02    1   1.88818E-03  5.57828E+02  0.00000E+00  8.16580E+01  3.55923E+01  9.49885E-01
  10040    5.57662E+02  4.64907E+01  5.56798E+02    1   2.18235E-03  5.57828E+02  0.00000E+00  8.04274E+01  4.11374E+01  1.09786E+00
  10050    5.57665E+02  4.64899E+01  5.56804E+02    1   2.19605E-03  5.57827E+02  0.00000E+00  7.90465E+01  4.13957E+01  1.10475E+00
  10060    5.57669E+02  4.64890E+01  5.56810E+02    1   1.94904E-03  5.57825E+02  0.00000E+00  7.74983E+01  3.67396E+01  9.80481E-01
  10070    5.57672E+02  4.64882E+01  5.56816E+02    1   1.57647E-03  5.57823E+02  0.00000E+00  7.58575E+01  2.97166E+01  7.93051E-01
  10080    5.57675E+02  4.64874E+01  5.56822E+02    1   1.18660E-03  5.57822E+02  0.00000E+00  7.43250E+01  2.23676E+01  5.96923E-01
  10090    5.57678E+02  4.64866E+01  5.56828E+02    1   8.64849E-04  5.57820E+02  0.00000E+00  7.27468E+01  1.63025E+01  4.35061E-01
  10100    5.57680E+02  4.64858E+01  5.56833E+02    1   5.93489E-04  5.57819E+02  0.00000E+00  7.12987E+01  1.11873E+01  2.98552E-01
  10110    5.57683E+02  4.64850E+01  5.56838E+02    1   3.60719E-04  5.57817E+02  0.00000E+00  7.02701E+01  6.79959E+00  1.81457E-01
  10120    5.57685E+02  4.64842E+01  5.56844E+02    1   1.54382E-04  5.57816E+02  0.00000E+00  6.89276E+01  2.91012E+00  7.76601E-02
CHANNEL 11
  11010    5.57489E+02  4.65056E+01  5.56567E+02    1   4.56762E-03  5.57813E+02  0.00000E+00  1.56362E+02  9.56661E+00  2.55382E-01
  11020    5.57505E+02  4.65039E+01  5.56590E+02    1   9.92931E-03  5.57819E+02  0.00000E+00  1.53195E+02  2.07963E+01  5.55145E-01
  11030    5.57522E+02  4.65021E+01  5.56614E+02    1   1.40252E-02  5.57824E+02  0.00000E+00  1.49561E+02  2.93749E+01  7.84123E-01
  11040    5.57539E+02  4.65003E+01  5.56637E+02    1   1.64394E-02  5.57828E+02  0.00000E+00  1.45526E+02  3.44313E+01  9.19069E-01
  11050    5.57555E+02  4.64985E+01  5.56660E+02    1   1.70431E-02  5.57829E+02  0.00000E+00  1.41057E+02  3.56959E+01  9.52799E-01
  11060    5.57571E+02  4.64968E+01  5.56683E+02    1   1.60589E-02  5.57829E+02  0.00000E+00  1.36207E+02  3.36346E+01  8.97754E-01
  11070    5.57587E+02  4.64950E+01  5.56705E+02    1   1.39664E-02  5.57828E+02  0.00000E+00  1.31047E+02  2.92520E+01  7.80755E-01
  11080    5.57603E+02  4.64933E+01  5.56727E+02    1   1.13340E-02  5.57826E+02  0.00000E+00  1.25631E+02  2.37385E+01  6.33581E-01
  11090    5.57618E+02  4.64917E+01  5.56748E+02    1   8.60762E-03  5.57825E+02  0.00000E+00  1.20397E+02  1.80282E+01  4.81161E-01
  11100    5.57632E+02  4.64900E+01  5.56769E+02    1   6.04406E-03  5.57823E+02  0.00000E+00  1.15988E+02  1.26590E+01  3.37851E-01
  11110    5.57647E+02  4.64884E+01  5.56789E+02    1   3.72146E-03  5.57821E+02  0.00000E+00  1.11026E+02  7.79443E+00  2.08017E-01
  11120    5.57662E+02  4.64867E+01  5.56811E+02    1   1.58841E-03  5.57819E+02  0.00000E+00  1.01891E+02  3.32686E+00  8.87847E-02
CHANNEL 12
  12010    5.57487E+02  4.65049E+01  5.56567E+02    1   2.42075E-03  5.57809E+02  0.00000E+00  1.55983E+02  1.52103E+01  4.06041E-01
  12020    5.57503E+02  4.65031E+01  5.56590E+02    1   5.20254E-03  5.57813E+02  0.00000E+00  1.52378E+02  3.26892E+01  8.72618E-01
  12030    5.57520E+02  4.65013E+01  5.56613E+02    1   7.34120E-03  5.57817E+02  0.00000E+00  1.48420E+02  4.61271E+01  1.23130E+00
  12040    5.57537E+02  4.64995E+01  5.56637E+02    1   8.58269E-03  5.57820E+02  0.00000E+00  1.44203E+02  5.39279E+01  1.43949E+00
  12050    5.57553E+02  4.64978E+01  5.56660E+02    1   8.86186E-03  5.57821E+02  0.00000E+00  1.39708E+02  5.56820E+01  1.48627E+00
  12060    5.57569E+02  4.64960E+01  5.56682E+02    1   8.30051E-03  5.57822E+02  0.00000E+00  1.34963E+02  5.21549E+01  1.39209E+00
  12070    5.57585E+02  4.64943E+01  5.56705E+02    1   7.16604E-03  5.57821E+02  0.00000E+00  1.29994E+02  4.50267E+01  1.20179E+00
  12080    5.57600E+02  4.64926E+01  5.56726E+02    1   5.77163E-03  5.57821E+02  0.00000E+00  1.24803E+02  3.62651E+01  9.67915E-01
  12090    5.57615E+02  4.64909E+01  5.56748E+02    1   4.35286E-03  5.57820E+02  0.00000E+00  1.19786E+02  2.73506E+01  7.29967E-01
  12100    5.57630E+02  4.64893E+01  5.56768E+02    1   3.03964E-03  5.57819E+02  0.00000E+00  1.15566E+02  1.90991E+01  5.09730E-01
  12110    5.57644E+02  4.64877E+01  5.56789E+02    1   1.86186E-03  5.57817E+02  0.00000E+00  1.10763E+02  1.16987E+01  3.12215E-01
  12120    5.57659E+02  4.64860E+01  5.56810E+02    1   7.97845E-04  5.57816E+02  0.00000E+00  1.01769E+02  5.01315E+00  1.33787E-01
CHANNEL 13
  13010    5.57487E+02  4.65049E+01  5.56567E+02    1   3.17724E-03  5.57811E+02  0.00000E+00  1.56397E+02  5.32363E+01  1.42115E+00
  13020    5.57503E+02  4.65031E+01  5.56590E+02    1   6.86337E-03  5.57817E+02  0.00000E+00  1.53273E+02  1.14999E+02  3.06983E+00
  13030    5.57520E+02  4.65013E+01  5.56614E+02    1   9.65058E-03  5.57822E+02  0.00000E+00  1.49658E+02  1.61701E+02  4.31637E+00
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13040	5.57537E+02	4.64995E+01	5.56637E+02	1	1.12170E-02	5.57826E+02	0.00000E+00	1.45600E+02	1.87947E+02	5.01684E+00
13050	5.57553E+02	4.64978E+01	5.56660E+02	1	1.14522E-02	5.57827E+02	0.00000E+00	1.41046E+02	1.91889E+02	5.12192E+00
13060	5.57569E+02	4.64960E+01	5.56683E+02	1	1.05126E-02	5.57826E+02	0.00000E+00	1.36027E+02	1.76145E+02	4.70155E+00
13070	5.57585E+02	4.64943E+01	5.56705E+02	1	8.86479E-03	5.57824E+02	0.00000E+00	1.30679E+02	1.48535E+02	3.96449E+00
13080	5.57600E+02	4.64926E+01	5.56727E+02	1	6.95614E-03	5.57822E+02	0.00000E+00	1.25217E+02	1.16554E+02	3.11083E+00
13090	5.57615E+02	4.64909E+01	5.56748E+02	1	5.14869E-03	5.57821E+02	0.00000E+00	1.20036E+02	8.62694E+01	2.30247E+00
13100	5.57630E+02	4.64893E+01	5.56769E+02	1	3.54579E-03	5.57819E+02	0.00000E+00	1.15706E+02	5.94119E+01	1.58562E+00
13110	5.57644E+02	4.64876E+01	5.56789E+02	1	2.14923E-03	5.57818E+02	0.00000E+00	1.10839E+02	3.60117E+01	9.61077E-01
13120	5.57659E+02	4.64860E+01	5.56811E+02	1	9.10188E-04	5.57816E+02	0.00000E+00	1.01808E+02	1.52508E+01	4.07002E-01
CHANNEL 14										
14010	5.57487E+02	4.65049E+01	5.56567E+02	1	8.73529E-04	5.57809E+02	0.00000E+00	1.56022E+02	2.92728E+01	7.81441E-01
14020	5.57503E+02	4.65031E+01	5.56590E+02	1	1.85329E-03	5.57814E+02	0.00000E+00	1.52465E+02	6.21057E+01	1.65787E+00
14030	5.57520E+02	4.65013E+01	5.56613E+02	1	2.58874E-03	5.57818E+02	0.00000E+00	1.48526E+02	8.67513E+01	2.31570E+00
14040	5.57537E+02	4.64995E+01	5.56637E+02	1	2.97309E-03	5.57820E+02	0.00000E+00	1.44293E+02	9.96316E+01	2.65945E+00
14050	5.57553E+02	4.64978E+01	5.56660E+02	1	2.96381E-03	5.57821E+02	0.00000E+00	1.39721E+02	9.93205E+01	2.65107E+00
14060	5.57569E+02	4.64960E+01	5.56682E+02	1	2.59034E-03	5.57821E+02	0.00000E+00	1.34784E+02	8.68053E+01	2.31695E+00
14070	5.57585E+02	4.64943E+01	5.56705E+02	1	2.04639E-03	5.57819E+02	0.00000E+00	1.29532E+02	6.85769E+01	1.83036E+00
14080	5.57600E+02	4.64926E+01	5.56726E+02	1	1.50238E-03	5.57819E+02	0.00000E+00	1.24339E+02	5.03464E+01	1.34374E+00
14090	5.57615E+02	4.64909E+01	5.56748E+02	1	1.06360E-03	5.57818E+02	0.00000E+00	1.19413E+02	3.56426E+01	9.51276E-01
14100	5.57630E+02	4.64893E+01	5.56768E+02	1	7.07015E-04	5.57817E+02	0.00000E+00	1.15285E+02	2.36929E+01	6.32332E-01
14110	5.57644E+02	4.64877E+01	5.56789E+02	1	4.16844E-04	5.57817E+02	0.00000E+00	1.10585E+02	1.39690E+01	3.72803E-01
14120	5.57659E+02	4.64860E+01	5.56810E+02	1	1.74989E-04	5.57816E+02	0.00000E+00	1.01695E+02	5.86412E+00	1.56497E-01
CHANNEL 15										
15010	5.57487E+02	4.65049E+01	5.56567E+02	1	2.07318E-03	5.57809E+02	0.00000E+00	1.56035E+02	3.90793E+01	1.04323E+00
15020	5.57503E+02	4.65031E+01	5.56590E+02	1	4.46688E-03	5.57814E+02	0.00000E+00	1.52495E+02	8.42005E+01	2.24768E+00
15030	5.57520E+02	4.65013E+01	5.56613E+02	1	6.27485E-03	5.57818E+02	0.00000E+00	1.48573E+02	1.18281E+02	3.15734E+00
15040	5.57537E+02	4.64995E+01	5.56637E+02	1	7.28271E-03	5.57820E+02	0.00000E+00	1.44362E+02	1.37279E+02	3.66437E+00
15050	5.57553E+02	4.64978E+01	5.56660E+02	1	7.42623E-03	5.57822E+02	0.00000E+00	1.39831E+02	1.39985E+02	3.73648E+00
15060	5.57569E+02	4.64960E+01	5.56682E+02	1	6.81657E-03	5.57822E+02	0.00000E+00	1.35003E+02	1.28493E+02	3.42964E+00
15070	5.57585E+02	4.64943E+01	5.56705E+02	1	5.74658E-03	5.57821E+02	0.00000E+00	1.29934E+02	1.08323E+02	2.89122E+00
15080	5.57600E+02	4.64926E+01	5.56726E+02	1	4.50643E-03	5.57820E+02	0.00000E+00	1.24704E+02	8.49463E+01	2.26721E+00
15090	5.57615E+02	4.64909E+01	5.56748E+02	1	3.32589E-03	5.57819E+02	0.00000E+00	1.19691E+02	6.26932E+01	1.67323E+00
15100	5.57630E+02	4.64893E+01	5.56768E+02	1	2.28148E-03	5.57818E+02	0.00000E+00	1.15489E+02	4.30061E+01	1.14777E+00
15110	5.57644E+02	4.64877E+01	5.56789E+02	1	1.37909E-03	5.57817E+02	0.00000E+00	1.10713E+02	2.59960E+01	6.93779E-01
15120	5.57659E+02	4.64860E+01	5.56810E+02	1	5.84459E-04	5.57816E+02	0.00000E+00	1.01748E+02	1.10171E+01	2.94016E-01
CHANNEL 16										
16010	5.57487E+02	4.65049E+01	5.56567E+02	1	9.55890E-04	5.57808E+02	0.00000E+00	1.55798E+02	4.30442E+01	1.14907E+00
16020	5.57503E+02	4.65031E+01	5.56590E+02	1	2.05490E-03	5.57812E+02	0.00000E+00	1.51984E+02	9.25330E+01	2.47011E+00
16030	5.57520E+02	4.65013E+01	5.56613E+02	1	2.87831E-03	5.57815E+02	0.00000E+00	1.47861E+02	1.29612E+02	3.45981E+00
16040	5.57536E+02	4.64995E+01	5.56637E+02	1	3.32323E-03	5.57817E+02	0.00000E+00	1.43545E+02	1.49647E+02	3.99450E+00
16050	5.57553E+02	4.64978E+01	5.56660E+02	1	3.35648E-03	5.57818E+02	0.00000E+00	1.39015E+02	1.51144E+02	4.03435E+00
16060	5.57569E+02	4.64960E+01	5.56682E+02	1	3.02809E-03	5.57819E+02	0.00000E+00	1.34271E+02	1.36357E+02	3.63955E+00
16070	5.57585E+02	4.64943E+01	5.56705E+02	1	2.49826E-03	5.57818E+02	0.00000E+00	1.29323E+02	1.12498E+02	3.00265E+00
16080	5.57600E+02	4.64926E+01	5.56726E+02	1	1.91417E-03	5.57818E+02	0.00000E+00	1.24248E+02	8.61966E+01	2.30058E+00
16090	5.57615E+02	4.64910E+01	5.56747E+02	1	1.38949E-03	5.57818E+02	0.00000E+00	1.19372E+02	6.25696E+01	1.66994E+00
16100	5.57629E+02	4.64893E+01	5.56768E+02	1	9.41907E-04	5.57817E+02	0.00000E+00	1.15280E+02	4.24148E+01	1.13199E+00
16110	5.57644E+02	4.64877E+01	5.56789E+02	1	5.64716E-04	5.57817E+02	0.00000E+00	1.10588E+02	2.54296E+01	6.78663E-01
16120	5.57659E+02	4.64860E+01	5.56810E+02	1	2.38135E-04	5.57816E+02	0.00000E+00	1.01691E+02	1.07234E+01	2.86179E-01
CHANNEL 17										
17010	5.57487E+02	4.65049E+01	5.56567E+02	1	6.21618E-04	5.57809E+02	0.00000E+00	1.55894E+02	1.82272E+01	4.86576E-01
17020	5.57503E+02	4.65031E+01	5.56590E+02	1	1.31577E-03	5.57813E+02	0.00000E+00	1.52190E+02	3.85812E+01	1.02990E+00
17030	5.57520E+02	4.65013E+01	5.56613E+02	1	1.83136E-03	5.57816E+02	0.00000E+00	1.48142E+02	5.36994E+01	1.43343E+00
17040	5.57536E+02	4.64995E+01	5.56637E+02	1	2.09100E-03	5.57818E+02	0.00000E+00	1.43853E+02	6.13126E+01	1.63661E+00
17050	5.57553E+02	4.64978E+01	5.56660E+02	1	2.06463E-03	5.57820E+02	0.00000E+00	1.39290E+02	6.05397E+01	1.61593E+00
17060	5.57569E+02	4.64960E+01	5.56682E+02	1	1.77835E-03	5.57819E+02	0.00000E+00	1.34436E+02	5.21454E+01	1.39183E+00
17070	5.57585E+02	4.64943E+01	5.56705E+02	1	1.37527E-03	5.57819E+02	0.00000E+00	1.29319E+02	4.03259E+01	1.07633E+00
17080	5.57600E+02	4.64926E+01	5.56726E+02	1	9.84939E-04	5.57818E+02	0.00000E+00	1.24201E+02	2.88807E+01	7.70824E-01
17090	5.57615E+02	4.64910E+01	5.56748E+02	1	6.80684E-04	5.57818E+02	0.00000E+00	1.19322E+02	1.99592E+01	5.32697E-01
17100	5.57629E+02	4.64893E+01	5.56768E+02	1	4.43143E-04	5.57817E+02	0.00000E+00	1.15231E+02	1.29940E+01	3.46792E-01
17110	5.57644E+02	4.64877E+01	5.56789E+02	1	2.57028E-04	5.57816E+02	0.00000E+00	1.10555E+02	7.53668E+00	2.01138E-01
17120	5.57659E+02	4.64860E+01	5.56810E+02	1	1.06856E-04	5.57816E+02	0.00000E+00	1.01680E+02	3.13327E+00	8.36183E-02

APPROXIMATE POINT KINETICS REACTIVITY DATA

	K-INFINITY	TOTAL REACTIVITY	CONTROL REACTIVITY	MODERATOR REACTIVITY	DENSITY REACTIVITY	DOPPLER REACTIVITY	RESIDUAL REACTIVITY
ADJOINT FLUX WTS	9.829465E-01	-1.794401E-02	-1.976313E-02	5.777248E-06	-2.065750E-05	4.734591E-07	-3.637856E-06

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   85
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:59:28
 STEAMLINE BREAK - RETRAN-3D SAMPLE PROBLEM - 1/2 CORE, 17 CHAN/ 2 BYP, FILL BC                                 CPU TIME =    4.586
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *


     SYSTEM        SYSTEM        TIME STP       SYSTEM        CORE-PHY      CORE-PHY      CORE-PHY      CORE-PHY      CORE-PHY
  ELAPSED TIME  ELAPSED TIME      ACTUAL      CORE POWER   ADJ TOT REAC  ADJ CTR REAC  ADJ DOP REAC  ADJ MOD REAC  ADJ DEN REAC
     (SEC)         (SEC)                         (MW)         (K-1)/K       (K-1)/K       (K-1)/K       (K-1)/K       (K-1)/K
  1.00000E+00   1.00000E+00   1.00000E+02   2.38473E-03  -1.79440E-02  -1.97631E-02   4.73459E-07   5.77725E-06  -2.06575E-05
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PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

16.0 FIVE-CHANNEL BWR PROBLEM

The BWR sample problem is a simple test case and is similar to the PWR sample problem in layout as discussed Section 14.0. The sample problem is shown in Figure VII.16-1. The neutronics model is a quarter-core with 52 active fuel regions. The RETRAN-3D model consists of five thermal-hydraulic channels that are overlaid on the 10x10 neutronics grid. Channel 5 is designated as the 'bypass' channel which means in this model, the flow through the bypass is 'noncore' flow.

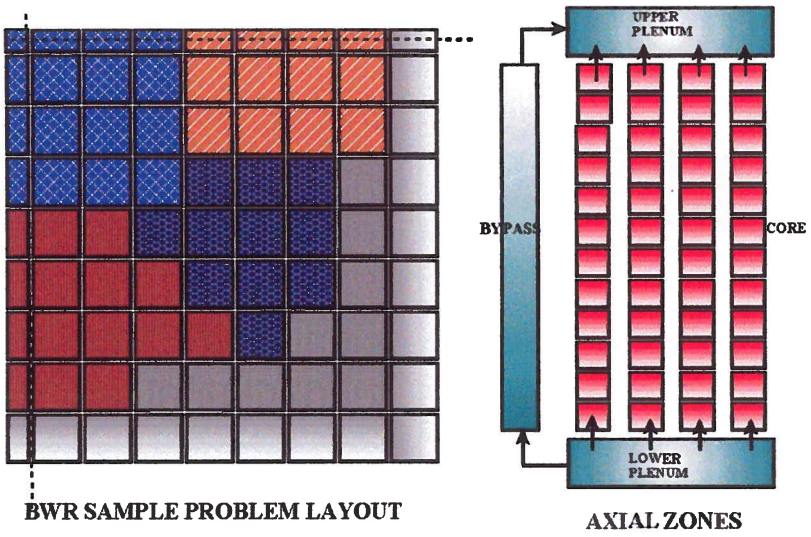


Figure VIII.16-1. BWR Sample Problem Layout

All of the information required to initialize the core is contained in the CDI file. This includes loss coefficients and other geometric information. The neutronics model encompasses the cross-section data, the layout of the fuel assemblies and the axial composition of the fuel assemblies, the control rod descriptions, and the neutronics calculation options and boundary conditions. The BWR sample problem uses the steady-state flow split calculation option. This option will compute the steady-state flows in channels bounded by volumes with user-specified pressures and junctions with user-supplied loss coefficients (in this case, specified by the CDI file data). This problem uses the Purude numerics option for three-dimensional kinetics.

The RETRAN-3D channel model internally generates the flow paths beginning in channel one. The first junction in this channel is assigned 1010 for Channel 1, Junction 1. The second junction in Channel 1 is 1020 and the last junction is 1120. Channel 4 begins with Junction 4010. The bypass flow path must be supplied by the users and is not part of the channel model.

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The initial power for this problem is 250 Mw, the core flow is 13,320 lbm/sec, and the initial inlet temperature is 540 °F. A short null transient is executed for 1.0 second followed by a transient that is initiated by decreasing the core inlet temperature to 500 °F over a one-second interval. The problem is terminated at 5.0 seconds.

The input listing and selected output are given below.

```
 LISTING OF INPUT DATA FOR CASE  1

     1    =BWR - RETRAN-3D SAMPLE PROBEM - 4 CHAN/ 1 BYP - FLOW SPLITS CALCULATED
     2    *
     3    ********************************************************************************
     4    *
     5    *  There are four nearly equal channels and one bypass.
     6    *  There are 12 axial powered nodes
     7    *
     8    *  PROBLEM DIMENSIONS
     9    *
    10    *        1     2     3     4     5     6     7     8     9    10    11    12
    11    *      TAPE PRNPLT  POW   SS  NVOID GENTRN HTMAP SLIP  5EQ  NCOND  NSOL  PNMTH
    12    010001   0     0     3     0     0     0     1     0     0     0     2     0
    13    *
    14    *
    15    *       Power MW
    16    010005   250.0
    17    *
    18    *
    19    *      MINOR EDITS
    20    *
    21    020000 TIMX    0 NTTS    0
    22    020001 POWR    0 RHOA    0 CTRA    0 DENA    0 PRES    7
    23    020002 PRES 1010 AVED 1010 HW** 1010 VOIV 1010 NVOI 1010
    24    020003 PRES 1120 AVED 1120 HW** 1120 VOIV 1120 NVOI 1120
    25    020006 PRES 3010 AVED 3010 HW** 3010 VOIV 3010 NVOI 3010
    26    020007 PRES 3120 AVED 3120 HW** 3120 VOIV 3120 NVOI 3120
    27    020008 FAEX 1    FAEX 2    FAEX 3    FAEX 4
    28    020009 GPTH 1010 GPTH 3010 GPCN 1010 GPCN 3010
    29    020010 GPTH 1120 GPTH 3120 GPCN 1120 GPCN 3120
    30    020011 FDEX 1010 FDEX 1120 FDEX 3010 FDEX 3120
    31    *
    32    *
    33    * FORMAT FOR TAPE60
    34    *
    35    025000 1
    36    025001 '(5(1X,1P,E15.7))'
    37    *
    38    *
    39    *       TIME STEP CONTROL
    40    *      TRTG  TMIN  TRST  TMAJ  TDMP  NCHK  DELTM  TLASt
    41    *      TRTG  TMIN  TRST  TMAJ  TDMP  NCHK  DELTM  TLAST
    42    030010  0.   0.1   0.0   1.0   50.0    0   0.05     1.5
    43    030020  0.   0.1   0.0   1.0   50.0    0   0.001    5.0
    44    030030  0.   0.1   0.0   1.0   50.0    0   0.05    50.0
    45    030040  0.   5.0   0.0  50.0   50.0    0   1.0    500.0
    46    *
    47    *
    48    *      TRIPS
    49    040010    1      1     0    0    5.0   0.    ' TERMINATION'
    50    040020    2      1     0    0    0.0    0.    ' START THE FILL'
    51    *
    52    *
    53    *  LOWER PLENUM AND UPPER PLENUM AND BOUNDARY DATA FIELDS
    54    *
    55    *     IBUB IREAD PRESSURE   ENTHALPY   QLTY     VOLUME
    56    050071  0   2    1035.0     540.0      0.0     1000.00                  * LOWER
    57    050081  0   1    1020.0       0.0      0.0     1000.00                  * UPPER
    58    *
    59    *         ZVOL    FLOWL    FLOWA   DIAMV    ELEV   EOVRD MESH IHTGL IMAP
    60    050072   10.00    10.00    100.00   6.0     8.000    0.0   0   0     0     * LOW
    61    050082   10.00    10.00    100.00   6.0     30.000   0.0   0   0     0     * UPP
    62    *
    63    *
    64    *     UPPER PLENUM BOUNDARY IS CONSTANT
    65    *
    66    *          TIME       PRESS     TEMP    QUALITY    MIXL
    67    070101  5   0.0      1020.0    00.000    0.120    10.00
    68    070102      1.0      1020.0    00.000    0.120    10.00
    69    070103      3.0      1020.0    00.000    0.120    10.00
    70    070104     10.0      1020.0    00.000    0.120    10.00
    71    070105  10000.0      1020.0    00.000    0.120    10.00
    72    *
    73    *
    74    *    RAMP THE LOWER PLENUM INLET TEMPERATURE DOWN BY 40 DEG
    75    *    OVER .1 SEC AT 1.0 SECONDS INTO THE TRANSIENT
    76    *
    77    070201  4   0.0      1035.0    540.00    0.0      10.00
    78    070202      1.0      1035.0    540.00    0.0      10.00
    79    070203      2.0      1035.0    500.00    0.0      10.00
    80    070204     20.0      1035.0    500.00    0.0      10.00
    81    *
    82    *
    83    *
    84    * THERM COND  UO2 (REF. GEMP-482  FIG-13 86 W/CM)
    85    180101   -11                                          *THERM COND UO2 1
    86    180102   212.  4.28   392.  3.47   752.  2.66  1112.  2.20   *THERM COND UO2 2
    87    180103  1472.  1.88  1832.  1.62  2192.  1.44  2912.  1.21   *THERM COND UO2 3
    88    180104  3632.  1.16  5072.  1.16  5500.  1.16                *THERM COND UO2 4
    89    *
    90    * CONSTANT GAP CONDUCTANCE
    91    180201    -2
    92    180202   100.  0.375  * H = 1000.0 BTU/HR-FT**2-F
    93    180203  5100.  0.375
    94    *
    95    * THERM COND  ZR-4  (REF. BRASSFIELD(1968) GEMP-482 RECOM...LWR LOCA)
    96    180301    -8                                           *THERM COND ZR-4 1
    97    180302     0.  8.    1490.  12.32  2150.  17.50  2372.  19.7 *THERM COND ZR-4 2
    98    180303  2552. 21.8   2732.  24.0   3292.  28.9   3360.  33.1 *THERM COND ZR-4 3
    99    *
   100    *
```

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```
190101   -19                                                    *VOL HT CAP UO2 1
190102    77.  36.22  100.  37.12  200.  40.05   300.  41.98  *VOL HT CAP UO2 2
190103   400.  43.88  600.  45.18  800.  46.41  1000.  47.32  *VOL HT CAP UO2 3
190104                                          2400.  50.77  *VOL HT CAP UO2 4
190105  2600.  51.43 2800.  52.61 3000.  54.57  3200.  57.42  *VOL HT CAP UO2 5
190106  3400.  61.23 3600.  65.93 4600.  95.15 4800.  99.31   *VOL HT CAP UO2 6
190107  5000. 101.57 5074. 101.76
*
*  ACTIVATE FUEL ENTHALPY EDIT
*
*      NRO  TEMP (F)    DENSITY      DESCRIPTION
1190101 -3   500.0       645.43     * DENSITY UO2 - LB/FT^3
1190102      1200.0      685.49
1190103      2240.0      655.77
*
* SPEC HEAT  HELIUM (REF  KREITH  AT 1 ATM  DEN 0.012 LB/FT3)
190201   -2                                    * VOL HT CAP HELIUM 1
190202    32.   .0149   3400.  .0149            * VOL HT CAP HELIUM 2
*
* SPEC HEAT  ZR-2  (REF BMI-1803 ELDR1DGE ET AL (1967))
190301   -15                                                    *VOL HT CAP ZR-2 1
190302    32.  28.75  932.  32.56 1112.  34.40  1184.  35.22  *VOL HT CAP ZR-2 2
190303  1490.  35.22 1508.  49.14 1544.  57.74  1580.  60.20  *VOL HT CAP ZR-2 3
190304  1616.  70.43 1652.  79.85 1688.  75.35  1724.  59.38  *VOL HT CAP ZR-2 4
190305  1760.  45.86 1787.  34.81 3300.  34.81                 *VOL HT CAP ZR-2 5
*
*
*      LCOUNT
230000   30
*
*************************************************************************
*
* R3D - 5 CHANNEL BWR SAMPLE CASE - RETRAN SAMPLE PROBLEM
*
*************************************************************************
*
*   ALL CORE GEOMETRY PROVIDED BY THE CDI FILE DATA:
*
*   CHANNELS             =     5        AXIAL LEVELS         =    12
*
*
*   CHANNEL VOLUMES      =    12
*   CHANNEL JUNCTIONS    =    13
*   CROSS-FLOW JUNCTIONS =     0
*   CHANNEL CONDUCTORS   =    12
*   CHANNEL CORE SECTION =    12
*
*   CHANNEL      NUMBER OF      CORE/BYPASS    POWER
*   NUMBER       ASSEMBLIES     FRACTION       FLAG
*       1          11.25        .254237        1.0
*       2          11.00        .248588        1.0
*       3          11.00        .248588        1.0
*       4          11.00        .248588        1.0
*       5          28.00       1.000000         .0
*
*    TOTAL    =    72.25
*
*************************************************************************
*
*670001 NCHNL NBYPS NCROSS IHQCH JPMJCH  IMC
670001   4    1      0      0      0     0
*
*670002 QPMD QDMD QBMD EWCH WCRECH IEQCH IMPCH MOCCH VELRCH
670002  0.0  0.0  0.0  0.0  9299.82  0     0    0      0
*
*670010 NED1 NED2 NED3 NED4 NED5 NED8 NED9 NED11 NED14
670010   1    1    1    0    0     1    0    0     0
*
*670020 NOTERS MAXOUT MAXRIT NCNCRS NCNCRT  IPURDU
670020   20    500    100      10      2       0
*
*670021 NSERCH NBORON NFREEZ NADJNT ISPECK IEXPAN IFXISP
670021     0      0      0      1      0      0      2
*
*670030    CONEIG    CONDEG    CONSRS    CONSRT CONPOW
670030    1.E-005   5.E-005   5.E-005   5.E-005   5.E-005
*
* assembly -to- channel mapping
*
671011  1  1  1  1  2  2  2  2 -1
671021  1  1  1  2  2  2  2  2 -1
671031  1  1  1  1  2  2  2  2 -1
671041  1  1  1  1  3  3  3 -1 -1
671051  4  4  4  3  3  3  3 -1 -1
671061  4  4  4  3  3  3 -1 -1 -1
671071  4  4  4  4  3 -1 -1 -1 -1
671081  4  4  4 -1 -1 -1 -1 -1 -1
671091 -1 -1 -1 -1 -1 -1 -1 -1 -1
*
*
*675XXY  VOL NODE ...
675011   07 1 129  2 130  3 131  4 132  5 133 6 134 7 135 8
675012  136 9 137 10 138 11 139 12 140 13 08 14
*
*************************************************************************
*
* BY-PASS
*
*     IBUB IREAD  PRES   ENTH   QLTY     VOLUME
051291  0   0      0.0     0.0   0.0    1.000000E+00
051301  0   0      0.0     0.0   0.0    1.000000E+00
051311  0   0      0.0     0.0   0.0    1.000000E+00
```


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```
051321  0   0      0.0     0.0   0.0    1.000000E+00
051331  0   0      0.0     0.0   0.0    1.000000E+00
051341  0   0      0.0     0.0   0.0    1.000000E+00
051351  0   0      0.0     0.0   0.0    1.000000E+00
051361  0   0      0.0     0.0   0.0    1.000000E+00
051371  0   0      0.0     0.0   0.0    1.000000E+00
051381  0   0      0.0     0.0   0.0    1.000000E+00
051391  0   0      0.0     0.0   0.0    1.000000E+00
051401  0   0      0.0     0.0   0.0    1.000000E+00
*
*         HEIGHT      FLOWL        FLOWAREA      HYDIAM      EL
051292   1.0000E+00  1.0000E+00  1.000000E+00  4.4000E-02  1.800000E+01
051302   1.0000E+00  1.0000E+00  1.000000E+00  4.4000E-02  1.900000E+01
051312   1.0000E+00  1.0000E+00  1.000000E+00  4.4000E-02  2.000000E+01
051322   1.0000E+00  1.0000E+00  1.000000E+00  4.4000E-02  2.100000E+01
051332   1.0000E+00  1.0000E+00  1.000000E+00  4.4000E-02  2.200000E+01
051342   1.0000E+00  1.0000E+00  1.000000E+00  4.4000E-02  2.300000E+01
051352   1.0000E+00  1.0000E+00  1.000000E+00  4.4000E-02  2.400000E+01
051362   1.0000E+00  1.0000E+00  1.000000E+00  4.4000E-02  2.500000E+01
051372   1.0000E+00  1.0000E+00  1.000000E+00  4.4000E-02  2.600000E+01
051382   1.0000E+00  1.0000E+00  1.000000E+00  4.4000E-02  2.700000E+01
051392   1.0000E+00  1.0000E+00  1.000000E+00  4.4000E-02  2.800000E+01
051402   1.0000E+00  1.0000E+00  1.000000E+00  4.4000E-02  2.900000E+01
*
*         EOVRD      MESH    IHTGL    IMAP
051293   .00000E+00     0        0        0
051303   .00000E+00     0        0        0
051313   .00000E+00     0        0        0
051323   .00000E+00     0        0        0
051333   .00000E+00     0        0        0
051343   .00000E+00     0        0        0
051353   .00000E+00     0        0        0
051363   .00000E+00     0        0        0
051373   .00000E+00     0        0        0
051383   .00000E+00     0        0        0
051393   .00000E+00     0        0        0
051403   .00000E+00     0        0        0
*
*
081291   7 129  0  0  3.000000E+02  1.000000E+00  1.800000E+01 0.0
081301 129 130  0  0   .000000E+00  1.000000E+00  1.900000E+01 0.0
081311 130 131  0  0   .000000E+00  1.000000E+00  2.000000E+01 0.0
081321 131 132  0  0   .000000E+00  1.000000E+00  2.100000E+01 0.0
081331 132 133  0  0   .000000E+00  1.000000E+00  2.200000E+01 0.0
081341 133 134  0  0   .000000E+00  1.000000E+00  2.300000E+01 0.0
081351 134 135  0  0   .000000E+00  1.000000E+00  2.400000E+01 0.0
081361 135 136  0  0   .000000E+00  1.000000E+00  2.500000E+01 0.0
081371 136 137  0  0   .000000E+00  1.000000E+00  2.600000E+01 0.0
081381 137 138  0  0   .000000E+00  1.000000E+00  2.700000E+01 0.0
081391 138 139  0  0   .000000E+00  1.000000E+00  2.800000E+01 0.0
081401 139 140  0  0   .000000E+00  1.000000E+00  2.900000E+01 0.0
081411 140   8  0  0   .000000E+00  1.000000E+00  3.000000E+01 0.0
*
081292   2.000E+01  2.000E+01  0  0  2  0   4.40000E-02 0.0   0
081302   0.000E+00  0.000E+00  0  0  2  0   4.40000E-02 0.0   0
081312   0.000E+00  0.000E+00  0  0  2  0   4.40000E-02 0.0   0
081322   0.000E+00  0.000E+00  0  0  2  0   4.40000E-02 0.0   0
081332   0.000E+00  0.000E+00  0  0  2  0   4.40000E-02 0.0   0
081342   0.000E+00  0.000E+00  0  0  2  0   4.40000E-02 0.0   0
081352   0.000E+00  0.000E+00  0  0  2  0   4.40000E-02 0.0   0
081362   0.000E+00  0.000E+00  0  0  2  0   4.40000E-02 0.0   0
081372   0.000E+00  0.000E+00  0  0  2  0   4.40000E-02 0.0   0
081382   0.000E+00  0.000E+00  0  0  2  0   4.40000E-02 0.0   0
081392   0.000E+00  0.000E+00  0  0  2  0   4.40000E-02 0.0   0
081402   0.000E+00  0.000E+00  0  0  2  0   4.40000E-02 0.0   0
081412  10.0       10.0        0  0  2  0   4.40000E-02 0.0   0 *
*
*       JTPMJ  IHQCOR   ISP  ANGL1  ANGL2
081293    0       0      0
081303    0       0      0
081313    0       0      0
081323    0       0      0
081333    0       0      0
081343    0       0      0
081353    0       0      0
081363    0       0      0
081373    0       0      0
081383    0       0      0
081393    0       0      0
081403    0       0      0
081413    0       0      0
*
*
*************************************************************************
*
*  STEADY STATE FLOW CALCULATION FOR CHANNEL INLET JUNCTIONS
*  WITH LOSS COEFFICIENTS SPECIFIED AT OUTLET JUNCTIONS.
*
*232XXX   JUN  JESTW     WP       V1   V2
232001    129     2    300.00      7    8   *
232002   1010     2      0         7    8   *
232003   2010     2      0         7    8   *
232004   3010     2      0         7    8   *
232005   4010     2      0         7    8   *
*
*672XXX INLET OUTLET KFLAG WNORM IGAP IVFIT IFRIC
672001    07    08    0    0.0
672002    07    08    0    0.0
672003    07    08    0    0.0
672004    07    08    0    0.0
*
*
```

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```
   305    ************************************************************************
   306    * 225XXY
   307    225010    1109.1519775
   308    +            0.0000790
   309    +            0.0000210
   310    +            0.9180000
   311    +            0.5862266
   312    +            0.9446100
   313    +            0.0072450
   314    +            0.0102921
   315    +            0.0012785
   316    +            0.0000000
   317    +            0.0365744
   318    ************************
   319    *
   320    *
   321    *670020 NOTERS MAXOUT MAXRIT NCNCRS NCNCRT  IPURDU
   322    670020   20    500    100      10      2       1
+                                                                  *** THIS CARD IS A REPLACEMENT CARD. ***
   323    *
   324    *  PNM Neutronics Numerics Option - Iteration control variables
   325    *
   326    *672XXX INLET OUTLET KFLAG WNORM IGAP IVFIT IFRIC
   327    672001    07    08    0    0.0   -1
+                                                                  *** THIS CARD IS A REPLACEMENT CARD. ***
   328    672002    07    08    0    0.0   -1
+                                                                  *** THIS CARD IS A REPLACEMENT CARD. ***
   329    672003    07    08    0    0.0   -1
+                                                                  *** THIS CARD IS A REPLACEMENT CARD. ***
   330    672004    07    08    0    0.0   -1
+                                                                  *** THIS CARD IS A REPLACEMENT CARD. ***
   331    *
   332    *
   333    *670040 IFUPD  NODOPT NEMCY  IFSACC ICHEB0 IRAGGED
   334    670040  0      2      5      0      3      0
   335    *
   336    *670041 EPSNEM EPSXEC EPSL2  EPSINF EPSR2  EPSERF  ESHIFT CETAK
   337    670041  0.001  0.001   .00001 .0001  .001   .005    .04    1.0
   338    *
   339    *
   340    *672XXX INLET OUTLET KFLAG WNORM IGAP IVFIT IFRIC
   341    672001    07    08    0    0.0   -1
+                                                                  *** THIS CARD IS A REPLACEMENT CARD. ***
   342    672002    07    08    0    0.0   -1
+                                                                  *** THIS CARD IS A REPLACEMENT CARD. ***
   343    672003    07    08    0    0.0   -2
+                                                                  *** THIS CARD IS A REPLACEMENT CARD. ***
   344    672004    07    08    0    0.0   -2
+                                                                  *** THIS CARD IS A REPLACEMENT CARD. ***
   345    *
   346    225020    1109.1519775
   347    +            0.0000790
   348    +            0.0000210
   349    +            0.9180000
   350    +            0.5862266
   351    +            0.9446100
   352    +            0.0072450
   353    +            0.0102921
   354    +            0.0012785
   355    +            0.0000000
   356    +            0.0365744
   357    *
   358    *
   359    . ENDECK
```


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```
RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page    1
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:59:34
 BWR - RETRAN-3D SAMPLE PROBEM - 4 CHAN/ 1 BYP - FLOW SPLITS CALCULATED                                         CPU TIME =    0.016
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *

RETRAN PROBLEM CONTROL AND DESCRIPTION DATA.

    WORD  DESCRIPTION
    ====  ===================================================================
      1   RESTART FILE OPTION (SAVE=-1 / NO SAVE=0) ..................... =    0
      2   PRINTER PLOT OPTION (YES=1 / NO=0) ............................ =    0
      3   POWER OPTION (TAPE OPTNS<0 / NO/TBL=0 / PT KIN=1 / 1D=2 / 3D=3) =    3
      4   USE STEADY-STATE SOLUTION (YES=0 / NO=1) ...................... =    0
      5   USE NEUTRON VOID MODEL (YES=1 / NO=0) ......................... =    0
      6   USE GENERALIZED TRANSPORT MODEL (NO=0 / VAP=1 / LIQ=-1) ....... =    0
      7   HEAT TRANSFER MAP OPTION (FORCED=0 / NAT CONV=1) .............. =    1
      8   SLIP OPTION (DYN=1 / Z-L=2 / C-L=3 / Z-L TAUGL=4 / C-L TAUGL=5) =    0
      9   FIVE-EQUATION OPTION (NO= 0 / YES=1) .......................... =    0
     10   NONCONDENSABLE GAS FLOW OPTION (NO=0 / YES=1) ................. =    0
     11   TH MATRIX DIRECT SOLVER OPTION (4-EQ=2 / 6-EQ=3) .............. =    2
     12   TH MATRIX ITERATIVE SOLVER OPTION (NO<=1 / YES=2) ............. =    0

    (DIMENSIONS AND OPTIONS AUTOMATICALLY DETERMINED BY CONTENT OF INPUT DATA)

          NUMBER OF MINOR EDIT SETS (0200XX DATA )....................... =   43
          NUMBER OF TIME-STEP CONTROL SETS (03XXX0 DATA )................ =    4
          NUMBER OF TRIP CONTROL SETS (04XXX0 DATA )..................... =    2
          NUMBER OF CONTROL VOLUME DESCRIPTIONS (05XXXY DATA )........... =   14
          NUMBER OF BUBBLE RISE DESCRIPTIONS (060XXY DATA) .............. =    0
          NUMBER OF TIME DEPENDENT VOLUMES FORM CARDS (07XXYY DATA) ..... =    2
          NUMBER OF JUNCTION DESCRIPTIONS (08XXXY DATA) ................. =   13
          NUMBER OF CENTRIFUGAL PUMP DESCRIPTIONS (090XXY DATA )......... =    0
          NUMBER OF VALVE DESCRIPTIONS (11XXXY DATA) .................... =    0
          NUMBER OF GENERAL DATA TABLE DESCRIPTIONS (12XXYY DATA) ....... =    0
          NUMBER OF FILL DESCRIPTIONS (13XXYY DATA )..................... =    0
          NUMBER OF HEAT CONDUCTOR DESCRIPTIONS (15XXXY DATA) ........... =    0
          NUMBER OF HEAT CONDUCTOR GEOMETRY DESCRIPTIONS (17XXYY DATA) .. =    0
          NUMBER OF HEAT CONDUCTOR MATERIAL DESCRIPTIONS (18XXYY DATA) .. =    3
          NUMBER OF CORE SECTION DESCRIPTIONS (16XXXY DATA) ............. =    0
          NUMBER OF NON-CONDUCTNG HEAT EXCHNGR DESCRIPTIONS (21XXYY DATA) =    0
          NUMBER OF TIME DEP BCS FROM TAPE (IREAD<0 ON 05XXXY DATA) ..... =    0
          NUMBER OF SPECIFIED HEAT TRAN COEF DESCRIPTIONS (015XXX DATA) . =    0
          TWO-REGION NONEQ VOL DESCRIPTIONS (610XXX OR 611XXX DATA) ..... =    0
          TEMP. TRANSPORT DELAY OPTION (MESH>0 ON 05XXXY DATA) .......... =    0
          AUXILIARY DNB MODEL (8001XX DATA INCLUDED) .................... =    0
          CONTROL SYSTEM MODEL (702XXX OR 702XXXX DATA) ................. =    0
          ACCUMULATOR MODEL DESCRIPTIONS (620XXX OR 621XXX DATA)......... =    0
          DYNAMIC GAP CONDUCTANCE MODEL DESCRIPTIONS (225XX0 DATA) ...... =    2
          NUMBER OF HT CONDUCTOR STACK DESCRIPTIONS (2200XY DATA) ....... =    0
          NUMBER OF TURBINE SHAFT DESCRIPTIONS (500XXY DATA) ............ =    0
          NUMBER OF PROFILE FIT DESCRIPTIONS (061XX1 DATA) .............. =    0
          NUMBER OF STEAM-WATER SEPARATOR DESCRIPTIONS (60XXX0 DATA) .... =    0


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                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * *                                                 * * *
                   * * *          STEADY-STATE OPTION    =   0          * * *
                   * * *                                                 * * *
                   * * *          SLIP OPTION            =   0          * * *
                   * * *                                                 * * *
                   * * *          NUMERICS OPTION        =   2          * * *
                   * * *                                                 * * *
                   * * *          HEAT TRANSFER OPTION   =   1          * * *
                   * * *                                                 * * *
                   * * *          NEW EQUATIONS OPTION   =   0          * * *
                   * * *                                                 * * *
                   * * *         USING THE 4-EQ SOLVER - SOLVE3          * * *
                   * * *                                                 * * *
                   * * *      USING STANDARD STEADY-STATE SOLUTION       * * *
                   * * *                                                 * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *


INITIAL THERMAL POWER (MEGAWATTS) =  2.50000E+02


AIR IS THE DEFAULT NONCONDENSABLE GAS.
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PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   33
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:59:34
 BWR - RETRAN-3D SAMPLE PROBEM - 4 CHAN/ 1 BYP - FLOW SPLITS CALCULATED                                        CPU TIME =    0.281
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	ENERGY BALANCE (BTU)	TOTAL MASS BALANCE (LBM)	NCG MASS BALANCE (LBM)	AVERAGE TIME STEP (SEC)	CURRENT TIME STEP (SEC)	ELAPSED TIME (SEC)	TIME STEP NUM STANDRD/ACTUL
1.00000E+00	2.50000E+02	8.53250E+08	4.41612E+07	8.05508E+04	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0 0

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	VOID FRAC.	POWR TO H2O (BTU/SEC)
7	1.03500E+03	4.68111E+04	5.37145E+02	4.68111E+01	5.40000E+02	0.00000E+00	0.00000E+00	0.00000E+00
8	1.02000E+03	1.39453E+04	6.23211E+02	1.39453E+01	5.46601E+02	1.20000E-01	7.35080E-01	0.00000E+00
129	1.02762E+03	4.68065E+01	5.37145E+02	4.68065E+01	5.39987E+02	0.00000E+00	0.00000E+00	0.00000E+00
130	1.02720E+03	4.68062E+01	5.37145E+02	4.68062E+01	5.39987E+02	0.00000E+00	0.00000E+00	0.00000E+00
131	1.02678E+03	4.68059E+01	5.37145E+02	4.68059E+01	5.39986E+02	0.00000E+00	0.00000E+00	0.00000E+00
132	1.02637E+03	4.68057E+01	5.37145E+02	4.68057E+01	5.39985E+02	0.00000E+00	0.00000E+00	0.00000E+00
133	1.02595E+03	4.68054E+01	5.37145E+02	4.68054E+01	5.39984E+02	0.00000E+00	0.00000E+00	0.00000E+00
134	1.02553E+03	4.68052E+01	5.37145E+02	4.68052E+01	5.39984E+02	0.00000E+00	0.00000E+00	0.00000E+00
135	1.02512E+03	4.68049E+01	5.37145E+02	4.68049E+01	5.39983E+02	0.00000E+00	0.00000E+00	0.00000E+00
136	1.02470E+03	4.68046E+01	5.37145E+02	4.68046E+01	5.39982E+02	0.00000E+00	0.00000E+00	0.00000E+00
137	1.02428E+03	4.68044E+01	5.37145E+02	4.68044E+01	5.39982E+02	0.00000E+00	0.00000E+00	0.00000E+00
138	1.02386E+03	4.68041E+01	5.37145E+02	4.68041E+01	5.39981E+02	0.00000E+00	0.00000E+00	0.00000E+00
139	1.02345E+03	4.68039E+01	5.37145E+02	4.68039E+01	5.39980E+02	0.00000E+00	0.00000E+00	0.00000E+00
140	1.02303E+03	4.68036E+01	5.37145E+02	4.68036E+01	5.39979E+02	0.00000E+00	0.00000E+00	0.00000E+00

JUNCTION NUMBER	CONNECTS VOLUMES	CHOK/ PATH	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E VEL. PSI	ELEV. PSI	D I F F E R E N T I A L S FRIC. PSI	ACCL. PSI	PUMP PSI
129	7 TO 129		3.37542E+02	5.37145E+02	2.13625E-02	-2.95535E-01	-1.78791E+00	-5.29937E+00	3.97466E-09	0.00000E+00
130	129 TO 130		3.37542E+02	5.37145E+02	2.13646E-02	-2.72916E-05	-3.25044E-01	-9.19531E-02	6.56486E-12	0.00000E+00
131	130 TO 131		3.37542E+02	5.37145E+02	2.13647E-02	-2.91923E-06	-3.25042E-01	-9.19534E-02	6.16585E-12	0.00000E+00
132	131 TO 132		3.37542E+02	5.37145E+02	2.13648E-02	-2.91924E-06	-3.25040E-01	-9.19538E-02	6.38034E-12	0.00000E+00
133	132 TO 133		3.37542E+02	5.37145E+02	2.13649E-02	-2.91934E-06	-3.25039E-01	-9.19541E-02	6.19443E-12	0.00000E+00
134	133 TO 134		3.37542E+02	5.37145E+02	2.13650E-02	-2.91944E-06	-3.25037E-01	-9.19545E-02	6.51618E-12	0.00000E+00
135	134 TO 135		3.37542E+02	5.37145E+02	2.13652E-02	-2.91953E-06	-3.25035E-01	-9.19548E-02	6.20737E-12	0.00000E+00
136	135 TO 136		3.37542E+02	5.37145E+02	2.13653E-02	-2.91963E-06	-3.25033E-01	-9.19552E-02	6.40310E-12	0.00000E+00
137	136 TO 137		3.37542E+02	5.37145E+02	2.13654E-02	-2.91972E-06	-3.25031E-01	-9.19555E-02	5.96495E-12	0.00000E+00
138	137 TO 138		3.37542E+02	5.37145E+02	2.13655E-02	-2.91982E-06	-3.25030E-01	-9.19559E-02	6.48304E-12	0.00000E+00
139	138 TO 139		3.37542E+02	5.37145E+02	2.13656E-02	-2.91992E-06	-3.25028E-01	-9.19562E-02	6.36424E-12	0.00000E+00
140	139 TO 140		3.37542E+02	5.37145E+02	2.13658E-02	-2.92001E-06	-3.25026E-01	-9.19566E-02	6.28919E-12	0.00000E+00
141	140 TO 8		3.37542E+02	5.37145E+02	2.13659E-02	2.89578E-01	-6.46726E-01	-2.67310E+00	-1.47885E-08	0.00000E+00
CHANNEL	JUNCTIONS									
1010	7 TO 1010	CHI	4.62561E+03	5.37145E+02	2.13625E-02	-4.87849E-01	-1.78769E+00	-4.15993E-02	2.63369E-10	
1130	1120 TO 8	CHX	4.62561E+03	5.55024E+02	2.75371E-02	6.18569E-01	-6.10306E-01	-1.23260E+00	1.22125E-06	
2010	7 TO 2010	CHI	4.09302E+03	5.37145E+02	2.13625E-02	-5.06942E-01	-1.78777E+00	-4.31928E-02	4.10605E-09	
2130	2120 TO 8	CHX	4.09302E+03	5.50929E+02	2.48969E-02	5.79329E-01	-6.23677E-01	-1.15940E+00	-8.45724E-08	
3010	7 TO 3010	CHI	3.47408E+03	5.37145E+02	2.13625E-02	-5.09845E-01	-1.78778E+00	-4.34291E-02	3.45966E-09	
3130	3120 TO 8	CHX	3.47408E+03	5.50168E+02	2.44063E-02	5.70940E-01	-6.26481E-01	-1.14324E+00	-1.51511E-07	
4010	7 TO 4010	CHI	4.10964E+03	5.37145E+02	2.13625E-02	-5.10759E-01	-1.78778E+00	-4.35125E-02	3.79344E-09	
4130	4120 TO 8	CHX	4.10964E+03	5.49956E+02	2.42694E-02	5.68410E-01	-6.27283E-01	-1.13890E+00	-1.31956E-07	

RETRAN CHANNEL EDIT - (VOLUMES AND CONDUCTORS ARE IDENTICALLY NUMBERED)

VOLUME NUMBER	MODERATOR TEMPERATURE (DEG. F)	MODERATOR VOID FRAC	MODERATOR ENTHALPY (BTU/LBM)	HEAT TRANSFER MODE	POWER DENSITY	FUEL TEMPERATURE (DEG. F)	FUEL ENTHALPY (CAL/GM)	HEAT FLUX (BTU/HR/FT**2)	CONDUCTOR HEATING RATE (BTU/HR)	DIR. MOD HEATING RATE (BTU/HR)
CHANNEL 1										
1010	5.40905E+02	0.00000E+00	5.38301E+02	1	2.16564E-03	8.56913E+02	2.91651E+01	4.25591E+04	1.92533E+07	0.00000E+00
1020	5.42399E+02	0.00000E+00	5.40208E+02	2	3.57254E-03	1.04424E+03	3.66044E+01	7.02072E+04	3.17610E+07	0.00000E+00
1030	5.43975E+02	0.00000E+00	5.42227E+02	2	3.78191E-03	1.07109E+03	3.76950E+01	7.43218E+04	3.36224E+07	0.00000E+00
1040	5.45464E+02	0.00000E+00	5.44138E+02	2	3.57865E-03	1.04487E+03	3.66301E+01	7.03273E+04	3.18153E+07	0.00000E+00
1050	5.46837E+02	0.00000E+00	5.45909E+02	2	3.31666E-03	1.01077E+03	3.52516E+01	6.51787E+04	2.94861E+07	0.00000E+00
1060	5.47551E+02	2.19758E-02	5.47548E+02	2	3.07056E-03	9.78591E+02	3.39544E+01	6.03425E+04	2.72983E+07	0.00000E+00
1070	5.47386E+02	7.14067E-02	5.49070E+02	2	2.85099E-03	9.49609E+02	3.27979E+01	5.60275E+04	2.53463E+07	0.00000E+00
1080	5.47216E+02	1.14599E-01	5.50511E+02	2	2.69786E-03	9.29247E+02	3.19910E+01	5.30181E+04	2.39848E+07	0.00000E+00
1090	5.47164E+02	1.49368E-01	5.51895E+02	2	2.59389E-03	9.15420E+02	3.14458E+01	5.09750E+04	2.30605E+07	0.00000E+00
1100	5.46985E+02	1.83851E-01	5.53212E+02	2	2.46649E-03	8.98320E+02	3.07773E+01	4.84714E+04	2.19279E+07	0.00000E+00
1110	5.46935E+02	2.08958E-01	5.54356E+02	2	2.14237E-03	8.54800E+02	2.90828E+01	4.21017E+04	1.90464E+07	0.00000E+00
1120	5.46749E+02	2.27063E-01	5.55024E+02	2	1.25070E-03	7.31365E+02	2.42887E+01	2.45788E+04	1.11192E+07	0.00000E+00
CHANNEL 2										
2010	5.40612E+02	0.00000E+00	5.37928E+02	1	1.49798E-03	7.62437E+02	2.54926E+01	2.94382E+04	1.15419E+07	0.00000E+00
2020	5.41691E+02	0.00000E+00	5.39306E+02	2	2.63466E-03	9.21059E+02	3.16679E+01	5.17761E+04	2.02999E+07	0.00000E+00
2030	5.42884E+02	0.00000E+00	5.40832E+02	2	2.91833E-03	9.58358E+02	3.31470E+01	5.73509E+04	2.24856E+07	0.00000E+00
2040	5.44039E+02	0.00000E+00	5.42311E+02	2	2.82845E-03	9.46493E+02	3.26736E+01	5.55846E+04	2.17931E+07	0.00000E+00
2050	5.45117E+02	0.00000E+00	5.43697E+02	2	2.65061E-03	9.22875E+02	3.17396E+01	5.20896E+04	2.04228E+07	0.00000E+00
2060	5.46129E+02	0.00000E+00	5.44998E+02	2	2.48794E-03	9.01237E+02	3.08909E+01	4.88927E+04	1.91694E+07	0.00000E+00
2070	5.47086E+02	0.00000E+00	5.46234E+02	2	2.36320E-03	8.84465E+02	3.02377E+01	4.64414E+04	1.82083E+07	0.00000E+00
2080	5.47204E+02	3.09687E-02	5.47408E+02	2	2.24638E-03	8.68680E+02	2.96232E+01	4.41457E+04	1.73082E+07	0.00000E+00
2090	5.47152E+02	6.48419E-02	5.48529E+02	2	2.14283E-03	8.54706E+02	2.90791E+01	4.21107E+04	1.65104E+07	0.00000E+00
2100	5.46978E+02	9.87250E-02	5.49574E+02	2	1.99907E-03	8.35129E+02	2.83170E+01	3.92856E+04	1.54027E+07	0.00000E+00
2110	5.46927E+02	1.22375E-01	5.50449E+02	2	1.67307E-03	7.90444E+02	2.65795E+01	3.28791E+04	1.28909E+07	0.00000E+00
2120	5.46746E+02	1.39610E-01	5.50929E+02	2	9.18720E-04	6.83732E+02	2.24439E+01	1.80546E+04	7.07869E+06	0.00000E+00
CHANNEL 3										
3010	5.40545E+02	0.00000E+00	5.37843E+02	1	1.33845E-03	7.39382E+02	2.45992E+01	2.63032E+04	8.72614E+06	0.00000E+00
3020	5.41536E+02	0.00000E+00	5.39108E+02	1	2.42786E-03	8.92892E+02	3.05658E+01	4.77121E+04	1.58286E+07	0.00000E+00
3030	5.42657E+02	0.00000E+00	5.40541E+02	2	2.74909E-03	9.35982E+02	3.22568E+01	5.40250E+04	1.79229E+07	0.00000E+00
3040	5.43754E+02	0.00000E+00	5.41946E+02	2	2.69441E-03	9.28719E+02	3.19702E+01	5.29504E+04	1.75664E+07	0.00000E+00
3050	5.44784E+02	0.00000E+00	5.43268E+02	2	2.53718E-03	9.07748E+02	3.11455E+01	4.98604E+04	1.65413E+07	0.00000E+00
3060	5.45751E+02	0.00000E+00	5.44512E+02	2	2.38655E-03	8.87643E+02	3.03614E+01	4.69003E+04	1.55593E+07	0.00000E+00
3070	5.46669E+02	0.00000E+00	5.45696E+02	2	2.27081E-03	8.72020E+02	2.97532E+01	4.46258E+04	1.48047E+07	0.00000E+00
3080	5.47201E+02	1.37741E-02	5.46831E+02	2	2.17607E-03	8.59157E+02	2.92524E+01	4.27640E+04	1.41870E+07	0.00000E+00
3090	5.47149E+02	4.75873E-02	5.47910E+02	2	2.07155E-03	8.45019E+02	2.87020E+01	4.07100E+04	1.35056E+07	0.00000E+00
3100	5.46976E+02	8.13514E-02	5.48910E+02	2	1.91654E-03	8.23859E+02	2.78784E+01	3.76636E+04	1.24950E+07	0.00000E+00
3110	5.46925E+02	1.04491E-01	5.49730E+02	2	1.57476E-03	7.76797E+02	2.60497E+01	3.09471E+04	1.02668E+07	0.00000E+00
3120	5.46746E+02	1.21274E-01	5.50168E+02	2	8.39982E-04	6.72361E+02	2.20035E+01	1.65073E+04	5.47632E+06	0.00000E+00
CHANNEL 4										
4010	5.40553E+02	0.00000E+00	5.37853E+02	1	1.36021E-03	7.42516E+02	2.47206E+01	2.67308E+04	1.04804E+07	0.00000E+00
4020	5.41541E+02	0.00000E+00	5.39114E+02	1	2.42161E-03	8.92014E+02	3.05317E+01	4.75892E+04	1.86583E+07	0.00000E+00
4030	5.42643E+02	0.00000E+00	5.40523E+02	2	2.70522E-03	9.30165E+02	3.20273E+01	5.31627E+04	2.08435E+07	0.00000E+00
4040	5.43714E+02	0.00000E+00	5.41895E+02	2	2.63324E-03	9.20602E+02	3.16499E+01	5.17482E+04	2.02890E+07	0.00000E+00
4050	5.44716E+02	0.00000E+00	5.43182E+02	2	2.47234E-03	8.99103E+02	3.08078E+01	4.85862E+04	1.90492E+07	0.00000E+00

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   4060    5.45658E+02  0.00000E+00  5.44392E+02    2   2.32311E-03  8.79142E+02  3.00305E+01  4.56536E+04  1.78994E+07  0.00000E+00
   4070    5.46550E+02  0.00000E+00  5.45543E+02    2   2.21090E-03  8.63958E+02  2.94393E+01  4.34484E+04  1.70348E+07  0.00000E+00
   4080    5.47200E+02  8.31202E-03  5.46651E+02    2   2.12679E-03  8.52500E+02  2.89933E+01  4.17955E+04  1.63868E+07  0.00000E+00
   4090    5.47149E+02  4.18193E-02  5.47709E+02    2   2.03077E-03  8.39486E+02  2.84866E+01  3.99085E+04  1.56470E+07  0.00000E+00
   4100    5.46975E+02  7.55505E-02  5.48693E+02    2   1.89031E-03  8.20260E+02  2.77385E+01  3.71483E+04  1.45648E+07  0.00000E+00
   4110    5.46924E+02  9.89092E-02  5.49512E+02    2   1.57206E-03  7.76410E+02  2.60346E+01  3.08941E+04  1.21127E+07  0.00000E+00
   4120    5.46746E+02  1.16025E-01  5.49956E+02    2   8.52794E-04  6.74201E+02  2.20748E+01  1.67591E+04  6.57073E+06  0.00000E+00

               APPROXIMATE POINT KINETICS REACTIVITY DATA

                        K-INFINITY        TOTAL        CONTROL      MODERATOR      DENSITY       DOPPLER       RESIDUAL
                                        REACTIVITY    REACTIVITY    REACTIVITY    REACTIVITY    REACTIVITY    REACTIVITY

  ADJOINT FLUX WTS     9.712936E-01   0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00 -4.146989E-02

0     CONTROL ROD POSITION
0                1           2           3           4           5           6           7           8           9
      1  3.0480E+01  0.0000E+00  0.0000E+00  3.0480E+01  3.0480E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
      2  0.0000E+00  3.0480E+01  3.0480E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
      3  0.0000E+00  3.0480E+01  3.0480E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
      4  3.0480E+01  0.0000E+00  0.0000E+00  3.0480E+01  3.0480E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
      5  3.0480E+01  0.0000E+00  0.0000E+00  3.0480E+01  3.0480E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
      6  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
      7  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
      8  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
      9  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
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PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   40
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:59:57
 BWR - RETRAN-3D SAMPLE PROBEM - 4 CHAN/ 1 BYP - FLOW SPLITS CALCULATED                                         CPU TIME =    19.625
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *
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SYSTEM ELAPSED TIME (SEC)	SYSTEM ELAPSED TIME (SEC)	TIME STP ACTUAL	SYSTEM CORE POWER (MW)	CORE-PHY ADJ TOT REAC (K-1)/K	CORE-PHY ADJ CTR REAC (K-1)/K	CORE-PHY ADJ DEN REAC (K-1)/K	VOL 7 AVG. PRESS. (PSIA)	VOL 1010 AVG. PRESS. (PSIA)
0.00000E+00	0.00000E+00	0.00000E+00	2.50000E+02	0.00000E+00	0.00000E+00	0.00000E+00	1.03500E+03	1.03268E+03
1.00000E-01	1.00000E-01	2.00000E+00	2.49999E+02	1.65065E-10	0.00000E+00	1.65065E-10	1.03500E+03	1.03268E+03
2.00000E-01	2.00000E-01	4.00000E+00	2.49998E+02	3.82749E-11	0.00000E+00	1.65064E-10	1.03500E+03	1.03268E+03
3.00000E-01	3.00000E-01	6.00000E+00	2.49998E+02	8.39429E-10	0.00000E+00	2.99203E-10	1.03500E+03	1.03268E+03
4.00000E-01	4.00000E-01	8.00000E+00	2.49998E+02	-3.76108E-10	0.00000E+00	2.97684E-10	1.03500E+03	1.03268E+03
5.00000E-01	5.00000E-01	1.00000E+01	2.49998E+02	1.11783E-09	0.00000E+00	1.58876E-09	1.03500E+03	1.03268E+03
6.00000E-01	6.00000E-01	1.20000E+01	2.49998E+02	9.45638E-10	0.00000E+00	1.49452E-09	1.03500E+03	1.03268E+03
7.00000E-01	7.00000E-01	1.40000E+01	2.49998E+02	1.60470E-09	0.00000E+00	1.75931E-09	1.03500E+03	1.03268E+03
8.00000E-01	8.00000E-01	1.60000E+01	2.49998E+02	1.69339E-09	0.00000E+00	1.52296E-09	1.03500E+03	1.03268E+03
9.00000E-01	9.00000E-01	1.80000E+01	2.49998E+02	3.63998E-09	0.00000E+00	2.91104E-09	1.03500E+03	1.03268E+03
1.00000E+00	1.00000E+00	2.00000E+01	2.49998E+02	4.11669E-09	0.00000E+00	3.30758E-09	1.03500E+03	1.03268E+03
1.10000E+00	1.10000E+00	2.20000E+01	2.50018E+02	1.33724E-06	0.00000E+00	1.33703E-06	1.03500E+03	1.03293E+03
1.20000E+00	1.20000E+00	2.40000E+01	2.50144E+02	4.13729E-06	0.00000E+00	4.14298E-06	1.03500E+03	1.03380E+03
1.30000E+00	1.30000E+00	2.60000E+01	2.50268E+02	3.62057E-06	0.00000E+00	1.06018E-05	1.03500E+03	1.03441E+03
1.40000E+00	1.40000E+00	5.80000E+01	2.51530E+02	3.29074E-05	0.00000E+00	4.59929E-05	1.03500E+03	1.03264E+03
1.50000E+00	1.50000E+00	8.10000E+01	2.53972E+02	7.90765E-05	0.00000E+00	9.84431E-05	1.03500E+03	1.03259E+03
1.60000E+00	1.60000E+00	1.85000E+02	2.58587E+02	1.64075E-04	0.00000E+00	1.88423E-04	1.03500E+03	1.03262E+03
1.70000E+00	1.70000E+00	2.87000E+02	2.66148E+02	2.88606E-04	0.00000E+00	3.20501E-04	1.03500E+03	1.03253E+03
1.80000E+00	1.80000E+00	3.96000E+02	2.76457E+02	4.40371E-04	0.00000E+00	4.81789E-04	1.03500E+03	1.03249E+03
1.90000E+00	1.90000E+00	5.10000E+02	2.90843E+02	6.34026E-04	0.00000E+00	6.88389E-04	1.03500E+03	1.03258E+03
2.00000E+00	2.00000E+00	6.16000E+02	3.06002E+02	8.06608E-04	0.00000E+00	8.74543E-04	1.03500E+03	1.03249E+03
2.10000E+00	2.10000E+00	7.25000E+02	3.20835E+02	9.46313E-04	0.00000E+00	1.02683E-03	1.03500E+03	1.03252E+03
2.20000E+00	2.20000E+00	8.31000E+02	3.31012E+02	1.01637E-03	0.00000E+00	1.10897E-03	1.03500E+03	1.03252E+03
2.30000E+00	2.30000E+00	9.32000E+02	3.37255E+02	1.04214E-03	0.00000E+00	1.14634E-03	1.03500E+03	1.03255E+03
2.40000E+00	2.40000E+00	1.03200E+03	3.39683E+02	1.03460E-03	0.00000E+00	1.15077E-03	1.03500E+03	1.03255E+03
2.50000E+00	2.50000E+00	1.13200E+03	3.41851E+02	1.02655E-03	0.00000E+00	1.15476E-03	1.03500E+03	1.03256E+03
2.60000E+00	2.60000E+00	1.23200E+03	3.43814E+02	1.01808E-03	0.00000E+00	1.15829E-03	1.03500E+03	1.03256E+03
2.70000E+00	2.70000E+00	1.33200E+03	3.45582E+02	1.00906E-03	0.00000E+00	1.16123E-03	1.03500E+03	1.03256E+03
2.80000E+00	2.80000E+00	1.43200E+03	3.47178E+02	9.99518E-04	0.00000E+00	1.16360E-03	1.03500E+03	1.03256E+03
2.90000E+00	2.90000E+00	1.53200E+03	3.48618E+02	9.89534E-04	0.00000E+00	1.16551E-03	1.03500E+03	1.03256E+03
3.00000E+00	3.00000E+00	1.63200E+03	3.49902E+02	9.79071E-04	0.00000E+00	1.16692E-03	1.03500E+03	1.03256E+03
3.10000E+00	3.10000E+00	1.73200E+03	3.51047E+02	9.68131E-04	0.00000E+00	1.16782E-03	1.03500E+03	1.03256E+03
3.20000E+00	3.20000E+00	1.83200E+03	3.52081E+02	9.57003E-04	0.00000E+00	1.16853E-03	1.03500E+03	1.03256E+03
3.30000E+00	3.30000E+00	1.93200E+03	3.53014E+02	9.45726E-04	0.00000E+00	1.16907E-03	1.03500E+03	1.03256E+03
3.40000E+00	3.40000E+00	2.03200E+03	3.53863E+02	9.34374E-04	0.00000E+00	1.16953E-03	1.03500E+03	1.03256E+03
3.50000E+00	3.50000E+00	2.13200E+03	3.54633E+02	9.22947E-04	0.00000E+00	1.16991E-03	1.03500E+03	1.03256E+03
3.60000E+00	3.60000E+00	2.23200E+03	3.55329E+02	9.11466E-04	0.00000E+00	1.17021E-03	1.03500E+03	1.03256E+03
3.70000E+00	3.70000E+00	2.33200E+03	3.55956E+02	8.99947E-04	0.00000E+00	1.17045E-03	1.03500E+03	1.03256E+03
3.80000E+00	3.80000E+00	2.43200E+03	3.56520E+02	8.88394E-04	0.00000E+00	1.17063E-03	1.03500E+03	1.03256E+03
3.90000E+00	3.90000E+00	2.53200E+03	3.57024E+02	8.76828E-04	0.00000E+00	1.17076E-03	1.03500E+03	1.03256E+03
4.00000E+00	4.00000E+00	2.63200E+03	3.57472E+02	8.65257E-04	0.00000E+00	1.17083E-03	1.03500E+03	1.03256E+03
4.10000E+00	4.10000E+00	2.73200E+03	3.57869E+02	8.53700E-04	0.00000E+00	1.17086E-03	1.03500E+03	1.03256E+03
4.20000E+00	4.20000E+00	2.83200E+03	3.58218E+02	8.42165E-04	0.00000E+00	1.17085E-03	1.03500E+03	1.03256E+03
4.30000E+00	4.30000E+00	2.93200E+03	3.58522E+02	8.30668E-04	0.00000E+00	1.17080E-03	1.03500E+03	1.03256E+03
4.40000E+00	4.40000E+00	3.03200E+03	3.58784E+02	8.19214E-04	0.00000E+00	1.17072E-03	1.03500E+03	1.03256E+03
4.50000E+00	4.50000E+00	3.13200E+03	3.59007E+02	8.07817E-04	0.00000E+00	1.17060E-03	1.03500E+03	1.03256E+03
4.60000E+00	4.60000E+00	3.23200E+03	3.59193E+02	7.96481E-04	0.00000E+00	1.17045E-03	1.03500E+03	1.03256E+03
4.70000E+00	4.70000E+00	3.33200E+03	3.59346E+02	7.85219E-04	0.00000E+00	1.17028E-03	1.03500E+03	1.03256E+03
4.80000E+00	4.80000E+00	3.43200E+03	3.59467E+02	7.74039E-04	0.00000E+00	1.17009E-03	1.03500E+03	1.03256E+03
4.90000E+00	4.90000E+00	3.53200E+03	3.59558E+02	7.62943E-04	0.00000E+00	1.16988E-03	1.03500E+03	1.03256E+03

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   41
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:59:57
 BWR - RETRAN-3D SAMPLE PROBEM - 4 CHAN/ 1 BYP - FLOW SPLITS CALCULATED                                         CPU TIME =   19.625
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *
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SYSTEM ELAPSED TIME (SEC)	VOL 1010 AVG. DENSITY (LB/FT3)	VOL 1010 AVG ENTHALPY (BTU/LB)	VOL 1010 VOID FRACTN	VOL 1010 NEUTRON VOID	VOL 1120 AVG. PRESS. (PSIA)	VOL 1120 AVG. DENSITY (LB/FT3)	VOL 1120 AVG ENTHALPY (BTU/LB)	VOL 1120 VOID FRACTN
0.00000E+00	4.67452E+01	5.38301E+02	0.00000E+00	0.00000E+00	1.02122E+03	3.63147E+01	5.55024E+02	2.27063E-01
1.00000E-01	4.67452E+01	5.38301E+02	0.00000E+00	0.00000E+00	1.02122E+03	3.63147E+01	5.55024E+02	2.27063E-01
2.00000E-01	4.67452E+01	5.38301E+02	0.00000E+00	0.00000E+00	1.02122E+03	3.63147E+01	5.55024E+02	2.27063E-01
3.00000E-01	4.67452E+01	5.38301E+02	0.00000E+00	0.00000E+00	1.02122E+03	3.63147E+01	5.55024E+02	2.27063E-01
4.00000E-01	4.67452E+01	5.38301E+02	0.00000E+00	0.00000E+00	1.02122E+03	3.63147E+01	5.55024E+02	2.27063E-01
5.00000E-01	4.67452E+01	5.38301E+02	0.00000E+00	0.00000E+00	1.02122E+03	3.63147E+01	5.55024E+02	2.27063E-01
6.00000E-01	4.67452E+01	5.38301E+02	0.00000E+00	0.00000E+00	1.02122E+03	3.63147E+01	5.55024E+02	2.27062E-01
7.00000E-01	4.67452E+01	5.38301E+02	0.00000E+00	0.00000E+00	1.02122E+03	3.63147E+01	5.55024E+02	2.27062E-01
8.00000E-01	4.67452E+01	5.38301E+02	0.00000E+00	0.00000E+00	1.02122E+03	3.63147E+01	5.55024E+02	2.27062E-01
9.00000E-01	4.67452E+01	5.38301E+02	0.00000E+00	0.00000E+00	1.02122E+03	3.63147E+01	5.55024E+02	2.27062E-01
1.00000E+00	4.67452E+01	5.38301E+02	0.00000E+00	0.00000E+00	1.02122E+03	3.63147E+01	5.55024E+02	2.27062E-01
1.10000E+00	4.67895E+01	5.37509E+02	0.00000E+00	0.00000E+00	1.02122E+03	3.63144E+01	5.55024E+02	2.27068E-01
1.20000E+00	4.69560E+01	5.34511E+02	0.00000E+00	0.00000E+00	1.02122E+03	3.63124E+01	5.55025E+02	2.27115E-01
1.30000E+00	4.71761E+01	5.30491E+02	0.00000E+00	0.00000E+00	1.02121E+03	3.63067E+01	5.55030E+02	2.27246E-01
1.40000E+00	4.74635E+01	5.25128E+02	0.00000E+00	0.00000E+00	1.02123E+03	3.63054E+01	5.55035E+02	2.27273E-01
1.50000E+00	4.77777E+01	5.19169E+02	0.00000E+00	0.00000E+00	1.02117E+03	3.63174E+01	5.55011E+02	2.27007E-01
1.60000E+00	4.80458E+01	5.13987E+02	0.00000E+00	0.00000E+00	1.02114E+03	3.63767E+01	5.54938E+02	2.25666E-01
1.70000E+00	4.83028E+01	5.08931E+02	0.00000E+00	0.00000E+00	1.02113E+03	3.65747E+01	5.54705E+02	2.21169E-01
1.80000E+00	4.85464E+01	5.04058E+02	0.00000E+00	0.00000E+00	1.02104E+03	3.69898E+01	5.54216E+02	2.11756E-01
1.90000E+00	4.87915E+01	4.99075E+02	0.00000E+00	0.00000E+00	1.02158E+03	3.78765E+01	5.53318E+02	1.91544E-01
2.00000E+00	4.90285E+01	4.94177E+02	0.00000E+00	0.00000E+00	1.02095E+03	3.91564E+01	5.51885E+02	1.62568E-01
2.10000E+00	4.91778E+01	4.91052E+02	0.00000E+00	0.00000E+00	1.02099E+03	4.13444E+01	5.49797E+02	1.12874E-01
2.20000E+00	4.92293E+01	4.89965E+02	0.00000E+00	0.00000E+00	1.02081E+03	4.42529E+01	5.47308E+02	4.68580E-02
2.30000E+00	4.92492E+01	4.89546E+02	0.00000E+00	0.00000E+00	1.02113E+03	4.63912E+01	5.44444E+02	0.00000E+00
2.40000E+00	4.92566E+01	4.89389E+02	0.00000E+00	0.00000E+00	1.02113E+03	4.65674E+01	5.41340E+02	0.00000E+00
2.50000E+00	4.92596E+01	4.89326E+02	0.00000E+00	0.00000E+00	1.02113E+03	4.67559E+01	5.37980E+02	0.00000E+00
2.60000E+00	4.92608E+01	4.89301E+02	0.00000E+00	0.00000E+00	1.02114E+03	4.69546E+01	5.34395E+02	0.00000E+00
2.70000E+00	4.92612E+01	4.89292E+02	0.00000E+00	0.00000E+00	1.02114E+03	4.71577E+01	5.30684E+02	0.00000E+00
2.80000E+00	4.92614E+01	4.89288E+02	0.00000E+00	0.00000E+00	1.02114E+03	4.73575E+01	5.26983E+02	0.00000E+00
2.90000E+00	4.92614E+01	4.89287E+02	0.00000E+00	0.00000E+00	1.02114E+03	4.75464E+01	5.23442E+02	0.00000E+00
3.00000E+00	4.92614E+01	4.89287E+02	0.00000E+00	0.00000E+00	1.02114E+03	4.77177E+01	5.20192E+02	0.00000E+00
3.10000E+00	4.92614E+01	4.89288E+02	0.00000E+00	0.00000E+00	1.02114E+03	4.78671E+01	5.17327E+02	0.00000E+00
3.20000E+00	4.92614E+01	4.89288E+02	0.00000E+00	0.00000E+00	1.02114E+03	4.79925E+01	5.14902E+02	0.00000E+00
3.30000E+00	4.92614E+01	4.89289E+02	0.00000E+00	0.00000E+00	1.02114E+03	4.80939E+01	5.12924E+02	0.00000E+00
3.40000E+00	4.92613E+01	4.89289E+02	0.00000E+00	0.00000E+00	1.02115E+03	4.81731E+01	5.11370E+02	0.00000E+00
3.50000E+00	4.92613E+01	4.89290E+02	0.00000E+00	0.00000E+00	1.02115E+03	4.82329E+01	5.10191E+02	0.00000E+00
3.60000E+00	4.92613E+01	4.89290E+02	0.00000E+00	0.00000E+00	1.02115E+03	4.82766E+01	5.09328E+02	0.00000E+00
3.70000E+00	4.92613E+01	4.89291E+02	0.00000E+00	0.00000E+00	1.02115E+03	4.83074E+01	5.08717E+02	0.00000E+00
3.80000E+00	4.92613E+01	4.89291E+02	0.00000E+00	0.00000E+00	1.02115E+03	4.83283E+01	5.08303E+02	0.00000E+00
3.90000E+00	4.92612E+01	4.89291E+02	0.00000E+00	0.00000E+00	1.02115E+03	4.83418E+01	5.08034E+02	0.00000E+00
4.00000E+00	4.92612E+01	4.89292E+02	0.00000E+00	0.00000E+00	1.02115E+03	4.83500E+01	5.07870E+02	0.00000E+00
4.10000E+00	4.92612E+01	4.89292E+02	0.00000E+00	0.00000E+00	1.02115E+03	4.83545E+01	5.07781E+02	0.00000E+00
4.20000E+00	4.92612E+01	4.89292E+02	0.00000E+00	0.00000E+00	1.02115E+03	4.83565E+01	5.07742E+02	0.00000E+00
4.30000E+00	4.92612E+01	4.89293E+02	0.00000E+00	0.00000E+00	1.02115E+03	4.83567E+01	5.07737E+02	0.00000E+00
4.40000E+00	4.92612E+01	4.89293E+02	0.00000E+00	0.00000E+00	1.02115E+03	4.83559E+01	5.07754E+02	0.00000E+00
4.50000E+00	4.92611E+01	4.89294E+02	0.00000E+00	0.00000E+00	1.02115E+03	4.83543E+01	5.07785E+02	0.00000E+00
4.60000E+00	4.92611E+01	4.89294E+02	0.00000E+00	0.00000E+00	1.02115E+03	4.83524E+01	5.07824E+02	0.00000E+00
4.70000E+00	4.92611E+01	4.89295E+02	0.00000E+00	0.00000E+00	1.02115E+03	4.83501E+01	5.07869E+02	0.00000E+00
4.80000E+00	4.92611E+01	4.89295E+02	0.00000E+00	0.00000E+00	1.02115E+03	4.83477E+01	5.07917E+02	0.00000E+00
4.90000E+00	4.92610E+01	4.89296E+02	0.00000E+00	0.00000E+00	1.02115E+03	4.83452E+01	5.07966E+02	0.00000E+00

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   42
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:59:57
 BWR - RETRAN-3D SAMPLE PROBEM - 4 CHAN/ 1 BYP - FLOW SPLITS CALCULATED                                         CPU TIME =    19.625
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *
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SYSTEM ELAPSED TIME (SEC)	VOL 1120 NEUTRON VOID	VOL 3010 AVG. PRESS. (PSIA)	VOL 3010 AVG. DENSITY (LB/FT3)	VOL 3010 AVG ENTHALPY (BTU/LB)	VOL 3010 VOID FRACTN	VOL 3010 NEUTRON VOID	VOL 3120 AVG. PRESS. (PSIA)	VOL 3120 AVG. DENSITY (LB/FT3)
0.00000E+00	2.27063E-01	1.03266E+03	4.67708E+01	5.37843E+02	0.00000E+00	0.00000E+00	1.02120E+03	4.09731E+01
1.00000E-01	2.27063E-01	1.03266E+03	4.67708E+01	5.37843E+02	0.00000E+00	0.00000E+00	1.02120E+03	4.09731E+01
2.00000E-01	2.27063E-01	1.03266E+03	4.67708E+01	5.37843E+02	0.00000E+00	0.00000E+00	1.02120E+03	4.09731E+01
3.00000E-01	2.27063E-01	1.03266E+03	4.67708E+01	5.37843E+02	0.00000E+00	0.00000E+00	1.02120E+03	4.09731E+01
4.00000E-01	2.27063E-01	1.03266E+03	4.67708E+01	5.37843E+02	0.00000E+00	0.00000E+00	1.02120E+03	4.09731E+01
5.00000E-01	2.27063E-01	1.03266E+03	4.67708E+01	5.37843E+02	0.00000E+00	0.00000E+00	1.02120E+03	4.09731E+01
6.00000E-01	2.27062E-01	1.03266E+03	4.67708E+01	5.37843E+02	0.00000E+00	0.00000E+00	1.02120E+03	4.09731E+01
7.00000E-01	2.27062E-01	1.03266E+03	4.67708E+01	5.37843E+02	0.00000E+00	0.00000E+00	1.02120E+03	4.09731E+01
8.00000E-01	2.27062E-01	1.03266E+03	4.67708E+01	5.37843E+02	0.00000E+00	0.00000E+00	1.02120E+03	4.09731E+01
9.00000E-01	2.27062E-01	1.03266E+03	4.67708E+01	5.37843E+02	0.00000E+00	0.00000E+00	1.02120E+03	4.09731E+01
1.00000E+00	2.27062E-01	1.03266E+03	4.67708E+01	5.37843E+02	0.00000E+00	0.00000E+00	1.02120E+03	4.09731E+01
1.10000E+00	2.27068E-01	1.03291E+03	4.68157E+01	5.37039E+02	0.00000E+00	0.00000E+00	1.02120E+03	4.09729E+01
1.20000E+00	2.27115E-01	1.03380E+03	4.69834E+01	5.34012E+02	0.00000E+00	0.00000E+00	1.02120E+03	4.09719E+01
1.30000E+00	2.27246E-01	1.03440E+03	4.72035E+01	5.29985E+02	0.00000E+00	0.00000E+00	1.02119E+03	4.09710E+01
1.40000E+00	2.27273E-01	1.03261E+03	4.74899E+01	5.24631E+02	0.00000E+00	0.00000E+00	1.02118E+03	4.09751E+01
1.50000E+00	2.27007E-01	1.03261E+03	4.78029E+01	5.18686E+02	0.00000E+00	0.00000E+00	1.02117E+03	4.10056E+01
1.60000E+00	2.25666E-01	1.03257E+03	4.80672E+01	5.13569E+02	0.00000E+00	0.00000E+00	1.02114E+03	4.10946E+01
1.70000E+00	2.21169E-01	1.03258E+03	4.83236E+01	5.08518E+02	0.00000E+00	0.00000E+00	1.02134E+03	4.13567E+01
1.80000E+00	2.11756E-01	1.03253E+03	4.85657E+01	5.03669E+02	0.00000E+00	0.00000E+00	1.02107E+03	4.18006E+01
1.90000E+00	1.91544E-01	1.03253E+03	4.88088E+01	4.98720E+02	0.00000E+00	0.00000E+00	1.02109E+03	4.27197E+01
2.00000E+00	1.62568E-01	1.03252E+03	4.90456E+01	4.93820E+02	0.00000E+00	0.00000E+00	1.02084E+03	4.41746E+01
2.10000E+00	1.12874E-01	1.03257E+03	4.91955E+01	4.90680E+02	0.00000E+00	0.00000E+00	1.02116E+03	4.63267E+01
2.20000E+00	4.68580E-02	1.03255E+03	4.92476E+01	4.89580E+02	0.00000E+00	0.00000E+00	1.02113E+03	4.64511E+01
2.30000E+00	0.00000E+00	1.03255E+03	4.92681E+01	4.89147E+02	0.00000E+00	0.00000E+00	1.02113E+03	4.66016E+01
2.40000E+00	0.00000E+00	1.03255E+03	4.92760E+01	4.88979E+02	0.00000E+00	0.00000E+00	1.02113E+03	4.67698E+01
2.50000E+00	0.00000E+00	1.03255E+03	4.92793E+01	4.88910E+02	0.00000E+00	0.00000E+00	1.02113E+03	4.69565E+01
2.60000E+00	0.00000E+00	1.03256E+03	4.92806E+01	4.88881E+02	0.00000E+00	0.00000E+00	1.02114E+03	4.71555E+01
2.70000E+00	0.00000E+00	1.03256E+03	4.92812E+01	4.88869E+02	0.00000E+00	0.00000E+00	1.02114E+03	4.73596E+01
2.80000E+00	0.00000E+00	1.03256E+03	4.92814E+01	4.88864E+02	0.00000E+00	0.00000E+00	1.02114E+03	4.75606E+01
2.90000E+00	0.00000E+00	1.03256E+03	4.92815E+01	4.88862E+02	0.00000E+00	0.00000E+00	1.02114E+03	4.77509E+01
3.00000E+00	0.00000E+00	1.03256E+03	4.92816E+01	4.88861E+02	0.00000E+00	0.00000E+00	1.02114E+03	4.79240E+01
3.10000E+00	0.00000E+00	1.03256E+03	4.92816E+01	4.88860E+02	0.00000E+00	0.00000E+00	1.02114E+03	4.80755E+01
3.20000E+00	0.00000E+00	1.03256E+03	4.92816E+01	4.88860E+02	0.00000E+00	0.00000E+00	1.02114E+03	4.82032E+01
3.30000E+00	0.00000E+00	1.03256E+03	4.92816E+01	4.88860E+02	0.00000E+00	0.00000E+00	1.02114E+03	4.83071E+01
3.40000E+00	0.00000E+00	1.03256E+03	4.92817E+01	4.88859E+02	0.00000E+00	0.00000E+00	1.02114E+03	4.83889E+01
3.50000E+00	0.00000E+00	1.03256E+03	4.92817E+01	4.88859E+02	0.00000E+00	0.00000E+00	1.02115E+03	4.84513E+01
3.60000E+00	0.00000E+00	1.03256E+03	4.92817E+01	4.88859E+02	0.00000E+00	0.00000E+00	1.02115E+03	4.84974E+01
3.70000E+00	0.00000E+00	1.03256E+03	4.92817E+01	4.88858E+02	0.00000E+00	0.00000E+00	1.02115E+03	4.85305E+01
3.80000E+00	0.00000E+00	1.03256E+03	4.92817E+01	4.88858E+02	0.00000E+00	0.00000E+00	1.02115E+03	4.85535E+01
3.90000E+00	0.00000E+00	1.03256E+03	4.92817E+01	4.88858E+02	0.00000E+00	0.00000E+00	1.02115E+03	4.85690E+01
4.00000E+00	0.00000E+00	1.03256E+03	4.92817E+01	4.88857E+02	0.00000E+00	0.00000E+00	1.02115E+03	4.85790E+01
4.10000E+00	0.00000E+00	1.03256E+03	4.92818E+01	4.88857E+02	0.00000E+00	0.00000E+00	1.02115E+03	4.85852E+01
4.20000E+00	0.00000E+00	1.03256E+03	4.92818E+01	4.88857E+02	0.00000E+00	0.00000E+00	1.02115E+03	4.85887E+01
4.30000E+00	0.00000E+00	1.03256E+03	4.92818E+01	4.88857E+02	0.00000E+00	0.00000E+00	1.02115E+03	4.85905E+01
4.40000E+00	0.00000E+00	1.03256E+03	4.92818E+01	4.88856E+02	0.00000E+00	0.00000E+00	1.02115E+03	4.85911E+01
4.50000E+00	0.00000E+00	1.03256E+03	4.92818E+01	4.88856E+02	0.00000E+00	0.00000E+00	1.02115E+03	4.85910E+01
4.60000E+00	0.00000E+00	1.03256E+03	4.92818E+01	4.88856E+02	0.00000E+00	0.00000E+00	1.02115E+03	4.85903E+01
4.70000E+00	0.00000E+00	1.03256E+03	4.92818E+01	4.88856E+02	0.00000E+00	0.00000E+00	1.02115E+03	4.85894E+01
4.80000E+00	0.00000E+00	1.03256E+03	4.92818E+01	4.88856E+02	0.00000E+00	0.00000E+00	1.02115E+03	4.85882E+01
4.90000E+00	0.00000E+00	1.03256E+03	4.92818E+01	4.88856E+02	0.00000E+00	0.00000E+00	1.02115E+03	4.85870E+01

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   43
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:59:57
 BWR - RETRAN-3D SAMPLE PROBEM - 4 CHAN/ 1 BYP - FLOW SPLITS CALCULATED                                         CPU TIME =   19.625
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *
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SYSTEM ELAPSED TIME (SEC)	VOL 3120 AVG ENTHALPY (BTU/LB)	VOL 3120 VOID FRACTN	VOL 3120 NEUTRON VOID	GAP 1 FUEL AX EXP (FEET)	GAP 2 FUEL AX EXP (FEET)	GAP 3 FUEL AX EXP (FEET)	GAP 4 FUEL AX EXP (FEET)	GAP1010 GAP WIDTH (FEET)
0.00000E+00	5.50168E+02	1.21274E-01	1.21274E-01	5.81640E-02	5.25866E-02	5.14986E-02	5.12008E-02	5.89002E-04
1.00000E-01	5.50168E+02	1.21274E-01	1.21274E-01	5.81640E-02	5.25866E-02	5.14986E-02	5.12008E-02	5.89002E-04
2.00000E-01	5.50168E+02	1.21274E-01	1.21274E-01	5.81640E-02	5.25866E-02	5.14986E-02	5.12008E-02	5.89002E-04
3.00000E-01	5.50168E+02	1.21274E-01	1.21274E-01	5.81640E-02	5.25866E-02	5.14986E-02	5.12008E-02	5.89002E-04
4.00000E-01	5.50168E+02	1.21274E-01	1.21274E-01	5.81640E-02	5.25866E-02	5.14986E-02	5.12008E-02	5.89002E-04
5.00000E-01	5.50168E+02	1.21274E-01	1.21274E-01	5.81640E-02	5.25866E-02	5.14985E-02	5.12008E-02	5.89002E-04
6.00000E-01	5.50168E+02	1.21274E-01	1.21274E-01	5.81640E-02	5.25866E-02	5.14985E-02	5.12007E-02	5.89002E-04
7.00000E-01	5.50168E+02	1.21274E-01	1.21274E-01	5.81640E-02	5.25866E-02	5.14985E-02	5.12007E-02	5.89002E-04
8.00000E-01	5.50168E+02	1.21274E-01	1.21274E-01	5.81640E-02	5.25866E-02	5.14985E-02	5.12007E-02	5.89002E-04
9.00000E-01	5.50168E+02	1.21274E-01	1.21274E-01	5.81640E-02	5.25866E-02	5.14985E-02	5.12007E-02	5.89002E-04
1.00000E+00	5.50168E+02	1.21274E-01	1.21274E-01	5.81640E-02	5.25866E-02	5.14985E-02	5.12007E-02	5.89002E-04
1.10000E+00	5.50168E+02	1.21279E-01	1.21279E-01	5.81640E-02	5.25866E-02	5.14985E-02	5.12007E-02	5.89002E-04
1.20000E+00	5.50169E+02	1.21302E-01	1.21302E-01	5.81641E-02	5.25867E-02	5.14986E-02	5.12008E-02	5.88975E-04
1.30000E+00	5.50169E+02	1.21323E-01	1.21323E-01	5.81642E-02	5.25867E-02	5.14986E-02	5.12008E-02	5.88875E-04
1.40000E+00	5.50163E+02	1.21233E-01	1.21233E-01	5.81649E-02	5.25867E-02	5.14985E-02	5.12007E-02	5.88599E-04
1.50000E+00	5.50134E+02	1.20539E-01	1.20539E-01	5.81677E-02	5.25878E-02	5.14994E-02	5.12015E-02	5.88305E-04
1.60000E+00	5.50048E+02	1.18523E-01	1.18523E-01	5.81743E-02	5.25913E-02	5.15022E-02	5.12041E-02	5.88046E-04
1.70000E+00	5.49839E+02	1.12539E-01	1.12539E-01	5.81876E-02	5.25992E-02	5.15090E-02	5.12107E-02	5.87813E-04
1.80000E+00	5.49400E+02	1.02502E-01	1.02502E-01	5.82109E-02	5.26140E-02	5.15221E-02	5.12232E-02	5.87589E-04
1.90000E+00	5.48606E+02	8.16260E-02	8.16260E-02	5.82489E-02	5.26389E-02	5.15443E-02	5.12448E-02	5.87357E-04
2.00000E+00	5.47375E+02	4.86302E-02	4.86302E-02	5.83027E-02	5.26750E-02	5.15767E-02	5.12764E-02	5.87135E-04
2.10000E+00	5.45572E+02	0.00000E+00	0.00000E+00	5.83776E-02	5.27253E-02	5.16218E-02	5.13204E-02	5.86942E-04
2.20000E+00	5.43393E+02	0.00000E+00	0.00000E+00	5.84629E-02	5.27822E-02	5.16728E-02	5.13702E-02	5.86848E-04
2.30000E+00	5.40733E+02	0.00000E+00	0.00000E+00	5.85575E-02	5.28446E-02	5.17286E-02	5.14248E-02	5.86797E-04
2.40000E+00	5.37730E+02	0.00000E+00	0.00000E+00	5.86493E-02	5.29046E-02	5.17822E-02	5.14773E-02	5.86756E-04
2.50000E+00	5.34361E+02	0.00000E+00	0.00000E+00	5.87418E-02	5.29648E-02	5.18360E-02	5.15298E-02	5.86717E-04
2.60000E+00	5.30723E+02	0.00000E+00	0.00000E+00	5.88341E-02	5.30247E-02	5.18893E-02	5.15818E-02	5.86679E-04
2.70000E+00	5.26945E+02	0.00000E+00	0.00000E+00	5.89261E-02	5.30841E-02	5.19422E-02	5.16336E-02	5.86641E-04
2.80000E+00	5.23174E+02	0.00000E+00	0.00000E+00	5.90179E-02	5.31433E-02	5.19949E-02	5.16849E-02	5.86603E-04
2.90000E+00	5.19558E+02	0.00000E+00	0.00000E+00	5.91094E-02	5.32022E-02	5.20473E-02	5.17361E-02	5.86566E-04
3.00000E+00	5.16229E+02	0.00000E+00	0.00000E+00	5.92007E-02	5.32609E-02	5.20995E-02	5.17870E-02	5.86532E-04
3.10000E+00	5.13284E+02	0.00000E+00	0.00000E+00	5.92917E-02	5.33195E-02	5.21516E-02	5.18379E-02	5.86502E-04
3.20000E+00	5.10778E+02	0.00000E+00	0.00000E+00	5.93826E-02	5.33780E-02	5.22036E-02	5.18887E-02	5.86475E-04
3.30000E+00	5.08723E+02	0.00000E+00	0.00000E+00	5.94733E-02	5.34364E-02	5.22556E-02	5.19394E-02	5.86452E-04
3.40000E+00	5.07095E+02	0.00000E+00	0.00000E+00	5.95639E-02	5.34949E-02	5.23076E-02	5.19902E-02	5.86433E-04
3.50000E+00	5.05849E+02	0.00000E+00	0.00000E+00	5.96543E-02	5.35533E-02	5.23597E-02	5.20409E-02	5.86418E-04
3.60000E+00	5.04924E+02	0.00000E+00	0.00000E+00	5.97445E-02	5.36117E-02	5.24117E-02	5.20917E-02	5.86405E-04
3.70000E+00	5.04258E+02	0.00000E+00	0.00000E+00	5.98344E-02	5.36701E-02	5.24638E-02	5.21425E-02	5.86395E-04
3.80000E+00	5.03795E+02	0.00000E+00	0.00000E+00	5.99241E-02	5.37284E-02	5.25158E-02	5.21933E-02	5.86386E-04
3.90000E+00	5.03482E+02	0.00000E+00	0.00000E+00	6.00135E-02	5.37866E-02	5.25678E-02	5.22441E-02	5.86379E-04
4.00000E+00	5.03279E+02	0.00000E+00	0.00000E+00	6.01025E-02	5.38446E-02	5.26197E-02	5.22948E-02	5.86372E-04
4.10000E+00	5.03154E+02	0.00000E+00	0.00000E+00	6.01911E-02	5.39025E-02	5.26715E-02	5.23453E-02	5.86366E-04
4.20000E+00	5.03082E+02	0.00000E+00	0.00000E+00	6.02791E-02	5.39602E-02	5.27231E-02	5.23957E-02	5.86361E-04
4.30000E+00	5.03046E+02	0.00000E+00	0.00000E+00	6.03667E-02	5.40175E-02	5.27745E-02	5.24459E-02	5.86356E-04
4.40000E+00	5.03034E+02	0.00000E+00	0.00000E+00	6.04537E-02	5.40746E-02	5.28256E-02	5.24958E-02	5.86351E-04
4.50000E+00	5.03038E+02	0.00000E+00	0.00000E+00	6.05400E-02	5.41314E-02	5.28764E-02	5.25455E-02	5.86346E-04
4.60000E+00	5.03051E+02	0.00000E+00	0.00000E+00	6.06257E-02	5.41877E-02	5.29270E-02	5.25948E-02	5.86341E-04
4.70000E+00	5.03070E+02	0.00000E+00	0.00000E+00	6.07107E-02	5.42437E-02	5.29772E-02	5.26438E-02	5.86336E-04
4.80000E+00	5.03093E+02	0.00000E+00	0.00000E+00	6.07949E-02	5.42992E-02	5.30270E-02	5.26925E-02	5.86331E-04
4.90000E+00	5.03118E+02	0.00000E+00	0.00000E+00	6.08784E-02	5.43543E-02	5.30764E-02	5.27408E-02	5.86326E-04

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   44
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:59:57
 BWR - RETRAN-3D SAMPLE PROBEM - 4 CHAN/ 1 BYP - FLOW SPLITS CALCULATED                                         CPU TIME =   19.625
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *
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SYSTEM ELAPSED TIME (SEC)	GAP3010 GAP WIDTH (FEET)	GAP1010 GAP COND B/H-F-F2	GAP3010 GAP COND B/H-F-F2	GAP1120 GAP WIDTH (FEET)	GAP3120 GAP WIDTH (FEET)	GAP1120 GAP COND B/H-F-F2	GAP3120 GAP COND B/H-F-F2	GAP1010 FUEL DIA EXP (FEET)
0.00000E+00	6.00479E-04	2.23578E+02	2.12737E+02	6.02997E-04	6.08116E-04	2.11804E+02	2.06746E+02	1.58362E-04
1.00000E-01	6.00479E-04	2.23578E+02	2.12737E+02	6.02997E-04	6.08116E-04	2.11804E+02	2.06746E+02	1.58362E-04
2.00000E-01	6.00479E-04	2.23578E+02	2.12737E+02	6.02997E-04	6.08116E-04	2.11804E+02	2.06746E+02	1.58362E-04
3.00000E-01	6.00479E-04	2.23578E+02	2.12737E+02	6.02997E-04	6.08116E-04	2.11804E+02	2.06746E+02	1.58362E-04
4.00000E-01	6.00479E-04	2.23578E+02	2.12737E+02	6.02997E-04	6.08116E-04	2.11804E+02	2.06746E+02	1.58362E-04
5.00000E-01	6.00479E-04	2.23578E+02	2.12737E+02	6.02997E-04	6.08116E-04	2.11804E+02	2.06746E+02	1.58362E-04
6.00000E-01	6.00479E-04	2.23578E+02	2.12737E+02	6.02997E-04	6.08116E-04	2.11804E+02	2.06746E+02	1.58362E-04
7.00000E-01	6.00479E-04	2.23578E+02	2.12737E+02	6.02997E-04	6.08116E-04	2.11804E+02	2.06746E+02	1.58362E-04
8.00000E-01	6.00479E-04	2.23578E+02	2.12737E+02	6.02997E-04	6.08116E-04	2.11804E+02	2.06746E+02	1.58362E-04
9.00000E-01	6.00479E-04	2.23578E+02	2.12737E+02	6.02997E-04	6.08116E-04	2.11804E+02	2.06746E+02	1.58362E-04
1.00000E+00	6.00479E-04	2.23578E+02	2.12737E+02	6.02997E-04	6.08116E-04	2.11804E+02	2.06746E+02	1.58362E-04
1.10000E+00	6.00479E-04	2.23578E+02	2.12737E+02	6.02997E-04	6.08116E-04	2.11804E+02	2.06746E+02	1.58362E-04
1.20000E+00	6.00452E-04	2.23571E+02	2.12729E+02	6.02997E-04	6.08116E-04	2.11804E+02	2.06746E+02	1.58362E-04
1.30000E+00	6.00351E-04	2.23503E+02	2.12658E+02	6.02997E-04	6.08115E-04	2.11804E+02	2.06746E+02	1.58362E-04
1.40000E+00	6.00080E-04	2.23239E+02	2.12394E+02	6.02994E-04	6.08111E-04	2.11805E+02	2.06747E+02	1.58355E-04
1.50000E+00	5.99789E-04	2.22935E+02	2.12090E+02	6.02989E-04	6.08104E-04	2.11808E+02	2.06751E+02	1.58342E-04
1.60000E+00	5.99541E-04	2.22656E+02	2.11819E+02	6.02979E-04	6.08094E-04	2.11816E+02	2.06757E+02	1.58328E-04
1.70000E+00	5.99306E-04	2.22391E+02	2.11553E+02	6.02962E-04	6.08075E-04	2.11833E+02	2.06771E+02	1.58313E-04
1.80000E+00	5.99085E-04	2.22131E+02	2.11296E+02	6.02932E-04	6.08052E-04	2.11864E+02	2.06792E+02	1.58300E-04
1.90000E+00	5.98860E-04	2.21865E+02	2.11032E+02	6.02873E-04	6.08011E-04	2.11921E+02	2.06831E+02	1.58292E-04
2.00000E+00	5.98639E-04	2.21612E+02	2.10771E+02	6.02799E-04	6.07955E-04	2.12005E+02	2.06889E+02	1.58292E-04
2.10000E+00	5.98445E-04	2.21371E+02	2.10523E+02	6.02676E-04	6.07862E-04	2.12136E+02	2.06976E+02	1.58299E-04
2.20000E+00	5.98337E-04	2.21229E+02	2.10378E+02	6.02527E-04	6.07706E-04	2.12296E+02	2.07052E+02	1.58314E-04
2.30000E+00	5.98276E-04	2.21152E+02	2.10294E+02	6.02331E-04	6.07483E-04	2.12493E+02	2.07083E+02	1.58335E-04
2.40000E+00	5.98236E-04	2.21117E+02	2.10246E+02	6.02085E-04	6.07240E-04	2.12662E+02	2.07084E+02	1.58360E-04
2.50000E+00	5.98202E-04	2.21099E+02	2.10214E+02	6.01756E-04	6.06974E-04	2.12755E+02	2.07061E+02	1.58387E-04
2.60000E+00	5.98171E-04	2.21090E+02	2.10193E+02	6.01398E-04	6.06691E-04	2.12812E+02	2.07018E+02	1.58416E-04
2.70000E+00	5.98140E-04	2.21088E+02	2.10178E+02	6.01028E-04	6.06397E-04	2.12849E+02	2.06958E+02	1.58448E-04
2.80000E+00	5.98111E-04	2.21091E+02	2.10167E+02	6.00654E-04	6.06101E-04	2.12872E+02	2.06886E+02	1.58481E-04
2.90000E+00	5.98083E-04	2.21096E+02	2.10158E+02	6.00286E-04	6.05811E-04	2.12887E+02	2.06809E+02	1.58516E-04
3.00000E+00	5.98059E-04	2.21103E+02	2.10151E+02	5.99930E-04	6.05533E-04	2.12903E+02	2.06733E+02	1.58552E-04
3.10000E+00	5.98038E-04	2.21110E+02	2.10145E+02	5.99593E-04	6.05274E-04	2.12924E+02	2.06663E+02	1.58589E-04
3.20000E+00	5.98021E-04	2.21117E+02	2.10138E+02	5.99279E-04	6.05038E-04	2.12954E+02	2.06604E+02	1.58627E-04
3.30000E+00	5.98009E-04	2.21125E+02	2.10132E+02	5.98991E-04	6.04828E-04	2.12998E+02	2.06560E+02	1.58666E-04
3.40000E+00	5.98000E-04	2.21132E+02	2.10125E+02	5.98727E-04	6.04642E-04	2.13057E+02	2.06532E+02	1.58706E-04
3.50000E+00	5.97995E-04	2.21139E+02	2.10119E+02	5.98486E-04	6.04479E-04	2.13131E+02	2.06520E+02	1.58746E-04
3.60000E+00	5.97993E-04	2.21146E+02	2.10112E+02	5.98266E-04	6.04337E-04	2.13218E+02	2.06523E+02	1.58786E-04
3.70000E+00	5.97994E-04	2.21153E+02	2.10105E+02	5.98063E-04	6.04212E-04	2.13316E+02	2.06539E+02	1.58828E-04
3.80000E+00	5.97996E-04	2.21161E+02	2.10098E+02	5.97873E-04	6.04100E-04	2.13425E+02	2.06566E+02	1.58869E-04
3.90000E+00	5.98000E-04	2.21168E+02	2.10092E+02	5.97694E-04	6.03999E-04	2.13541E+02	2.06602E+02	1.58911E-04
4.00000E+00	5.98005E-04	2.21175E+02	2.10085E+02	5.97523E-04	6.03906E-04	2.13664E+02	2.06645E+02	1.58953E-04
4.10000E+00	5.98011E-04	2.21183E+02	2.10079E+02	5.97359E-04	6.03820E-04	2.13790E+02	2.06693E+02	1.58995E-04
4.20000E+00	5.98017E-04	2.21191E+02	2.10074E+02	5.97200E-04	6.03738E-04	2.13920E+02	2.06745E+02	1.59037E-04
4.30000E+00	5.98023E-04	2.21200E+02	2.10069E+02	5.97044E-04	6.03660E-04	2.14051E+02	2.06800E+02	1.59079E-04
4.40000E+00	5.98030E-04	2.21209E+02	2.10064E+02	5.96892E-04	6.03584E-04	2.14184E+02	2.06857E+02	1.59121E-04
4.50000E+00	5.98036E-04	2.21218E+02	2.10059E+02	5.96742E-04	6.03510E-04	2.14316E+02	2.06915E+02	1.59163E-04
4.60000E+00	5.98043E-04	2.21227E+02	2.10055E+02	5.96594E-04	6.03438E-04	2.14449E+02	2.06975E+02	1.59205E-04
4.70000E+00	5.98050E-04	2.21236E+02	2.10051E+02	5.96448E-04	6.03367E-04	2.14582E+02	2.07034E+02	1.59247E-04
4.80000E+00	5.98056E-04	2.21246E+02	2.10047E+02	5.96303E-04	6.03298E-04	2.14714E+02	2.07094E+02	1.59289E-04
4.90000E+00	5.98063E-04	2.21256E+02	2.10044E+02	5.96161E-04	6.03229E-04	2.14846E+02	2.07154E+02	1.59331E-04

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

SYSTEM ELAPSED TIME (SEC)	GAP1120 FUEL DIA EXP (FEET)	GAP3010 FUEL DIA EXP (FEET)	GAP3120 FUEL DIA EXP (FEET)
0.00000E+00	1.30405E-04	1.32241E-04	1.17567E-04
1.00000E-01	1.30405E-04	1.32241E-04	1.17567E-04
2.00000E-01	1.30405E-04	1.32241E-04	1.17567E-04
3.00000E-01	1.30405E-04	1.32241E-04	1.17567E-04
4.00000E-01	1.30405E-04	1.32241E-04	1.17567E-04
5.00000E-01	1.30405E-04	1.32241E-04	1.17567E-04
6.00000E-01	1.30405E-04	1.32241E-04	1.17567E-04
7.00000E-01	1.30405E-04	1.32241E-04	1.17567E-04
8.00000E-01	1.30405E-04	1.32241E-04	1.17567E-04
9.00000E-01	1.30405E-04	1.32241E-04	1.17567E-04
1.00000E+00	1.30405E-04	1.32241E-04	1.17567E-04
1.10000E+00	1.30405E-04	1.32241E-04	1.17567E-04
1.20000E+00	1.30405E-04	1.32241E-04	1.17567E-04
1.30000E+00	1.30405E-04	1.32240E-04	1.17567E-04
1.40000E+00	1.30406E-04	1.32233E-04	1.17568E-04
1.50000E+00	1.30411E-04	1.32220E-04	1.17571E-04
1.60000E+00	1.30424E-04	1.32203E-04	1.17580E-04
1.70000E+00	1.30454E-04	1.32185E-04	1.17601E-04
1.80000E+00	1.30513E-04	1.32166E-04	1.17640E-04
1.90000E+00	1.30621E-04	1.32147E-04	1.17711E-04
2.00000E+00	1.30789E-04	1.32131E-04	1.17822E-04
2.10000E+00	1.31047E-04	1.32117E-04	1.17988E-04
2.20000E+00	1.31370E-04	1.32107E-04	1.18183E-04
2.30000E+00	1.31759E-04	1.32100E-04	1.18400E-04
2.40000E+00	1.32144E-04	1.32095E-04	1.18610E-04
2.50000E+00	1.32536E-04	1.32091E-04	1.18822E-04
2.60000E+00	1.32927E-04	1.32089E-04	1.19033E-04
2.70000E+00	1.33319E-04	1.32087E-04	1.19242E-04
2.80000E+00	1.33708E-04	1.32087E-04	1.19449E-04
2.90000E+00	1.34096E-04	1.32087E-04	1.19653E-04
3.00000E+00	1.34481E-04	1.32087E-04	1.19855E-04
3.10000E+00	1.34863E-04	1.32089E-04	1.20053E-04
3.20000E+00	1.35242E-04	1.32090E-04	1.20248E-04
3.30000E+00	1.35618E-04	1.32092E-04	1.20441E-04
3.40000E+00	1.35991E-04	1.32095E-04	1.20631E-04
3.50000E+00	1.36361E-04	1.32097E-04	1.20818E-04
3.60000E+00	1.36728E-04	1.32100E-04	1.21003E-04
3.70000E+00	1.37093E-04	1.32103E-04	1.21186E-04
3.80000E+00	1.37455E-04	1.32106E-04	1.21366E-04
3.90000E+00	1.37815E-04	1.32109E-04	1.21545E-04
4.00000E+00	1.38172E-04	1.32113E-04	1.21723E-04
4.10000E+00	1.38526E-04	1.32117E-04	1.21898E-04
4.20000E+00	1.38877E-04	1.32120E-04	1.22071E-04
4.30000E+00	1.39225E-04	1.32124E-04	1.22243E-04
4.40000E+00	1.39570E-04	1.32128E-04	1.22413E-04
4.50000E+00	1.39912E-04	1.32132E-04	1.22581E-04
4.60000E+00	1.40251E-04	1.32136E-04	1.22747E-04
4.70000E+00	1.40587E-04	1.32140E-04	1.22911E-04
4.80000E+00	1.40919E-04	1.32144E-04	1.23073E-04
4.90000E+00	1.41248E-04	1.32148E-04	1.23233E-04

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE -- NRC APPROVED VERSION 29/08/14 Page 49
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis 11:59:58
BWR - RETRAN-3D SAMPLE PROBEM - 4 CHAN/ 1 BYP - FLOW SPLITS CALCULATED CPU TIME = 20.109
* *

NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	ENERGY BALANCE (BTU)	TOTAL MASS BALANCE (LBM)	NCG MASS BALANCE (LBM)	AVERAGE TIME STEP (SEC)	CURRENT TIME STEP (SEC)	ELAPSED TIME (SEC)	TIME STEP NUM STANDRD/ACTUL
									3530
1.43849E+00	3.59621E+02	1.22739E+09	4.31222E+07	8.50372E+04	0.00000E+00	1.00000E-03	1.00000E-03	5.00000E+00	3632

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	VOID FRAC.	POWR TO H2O (BTU/SEC)
7	1.03500E+03	4.93208E+04	4.88055E+02	4.93208E+01	5.00000E+02	0.00000E+00	0.00000E+00	0.00000E+00
8	1.02000E+03	1.39453E+04	6.23211E+02	1.39453E+01	5.46601E+02	1.20000E-01	7.35080E-01	0.00000E+00
129	1.02771E+03	4.93172E+01	4.88055E+02	4.93172E+01	4.99994E+02	0.00000E+00	0.00000E+00	0.00000E+00
130	1.02728E+03	4.93170E+01	4.88055E+02	4.93170E+01	4.99993E+02	0.00000E+00	0.00000E+00	0.00000E+00
131	1.02685E+03	4.93168E+01	4.88055E+02	4.93168E+01	4.99993E+02	0.00000E+00	0.00000E+00	0.00000E+00
132	1.02641E+03	4.93165E+01	4.88055E+02	4.93165E+01	4.99992E+02	0.00000E+00	0.00000E+00	0.00000E+00
133	1.02598E+03	4.93163E+01	4.88055E+02	4.93163E+01	4.99992E+02	0.00000E+00	0.00000E+00	0.00000E+00
134	1.02555E+03	4.93161E+01	4.88055E+02	4.93161E+01	4.99992E+02	0.00000E+00	0.00000E+00	0.00000E+00
135	1.02511E+03	4.93158E+01	4.88056E+02	4.93158E+01	4.99992E+02	0.00000E+00	0.00000E+00	0.00000E+00
136	1.02468E+03	4.93155E+01	4.88059E+02	4.93155E+01	4.99994E+02	0.00000E+00	0.00000E+00	0.00000E+00
137	1.02425E+03	4.93149E+01	4.88067E+02	4.93149E+01	5.00000E+02	0.00000E+00	0.00000E+00	0.00000E+00
138	1.02382E+03	4.93138E+01	4.88086E+02	4.93138E+01	5.00016E+02	0.00000E+00	0.00000E+00	0.00000E+00
139	1.02338E+03	4.93116E+01	4.88129E+02	4.93116E+01	5.00052E+02	0.00000E+00	0.00000E+00	0.00000E+00
140	1.02295E+03	4.93072E+01	4.88217E+02	4.93072E+01	5.00126E+02	0.00000E+00	0.00000E+00	0.00000E+00

JUNCTION NUMBER	CONNECTS VOLUMES	CHOK/ PATH	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E D I F F E R E N T I A L S VEL. PSI	ELEV. PSI	FRIC. PSI	ACCL. PSI	PUMP PSI
129	7 TO 129		3.40463E+02	4.88055E+02	2.02754E-02	-2.86737E-01	-1.88377E+00	-5.11791E+00	-5.43172E-06	0.00000E+00
130	129 TO 130		3.40463E+02	4.88055E+02	2.02769E-02	-1.95523E-05	-3.42480E-01	-9.03537E-02	-9.88091E-06	0.00000E+00
131	130 TO 131		3.40463E+02	4.88055E+02	2.02770E-02	-2.18958E-06	-3.42478E-01	-9.03540E-02	-9.87999E-06	0.00000E+00
132	131 TO 132		3.40463E+02	4.88055E+02	2.02771E-02	-2.18626E-06	-3.42477E-01	-9.03542E-02	-9.87823E-06	0.00000E+00
133	132 TO 133		3.40463E+02	4.88055E+02	2.02772E-02	-2.17208E-06	-3.42475E-01	-9.03545E-02	-9.87249E-06	0.00000E+00
134	133 TO 134		3.40463E+02	4.88055E+02	2.02773E-02	-2.11456E-06	-3.42474E-01	-9.03547E-02	-9.84853E-06	0.00000E+00
135	134 TO 135		3.40463E+02	4.88055E+02	2.02774E-02	-1.91144E-06	-3.42472E-01	-9.03550E-02	-9.75461E-06	0.00000E+00
136	135 TO 136		3.40462E+02	4.88056E+02	2.02775E-02	-1.28977E-06	-3.42470E-01	-9.03551E-02	-9.43514E-06	0.00000E+00
137	136 TO 137		3.40462E+02	4.88059E+02	2.02776E-02	3.79223E-07	-3.42467E-01	-9.03551E-02	-8.49323E-06	0.00000E+00
138	137 TO 138		3.40459E+02	4.88067E+02	2.02778E-02	4.36165E-06	-3.42461E-01	-9.03545E-02	-6.05509E-06	0.00000E+00
139	138 TO 139		3.40453E+02	4.88086E+02	2.02783E-02	1.29054E-05	-3.42449E-01	-9.03528E-02	-4.39580E-07	0.00000E+00
140	139 TO 140		3.40439E+02	4.88129E+02	2.02792E-02	2.95459E-05	-3.42426E-01	-9.03485E-02	1.12022E-05	0.00000E+00
141	140 TO 8		3.40410E+02	4.88218E+02	2.02810E-02	2.86226E-01	-6.55418E-01	-2.58145E+00	1.94617E-05	0.00000E+00
CHANNEL JUNCTIONS										
1010	7 TO 1010	CHI	4.84998E+03	4.88055E+02	2.02754E-02	-5.07757E-01	-1.88357E+00	-4.38118E-02	-6.76040E-06	
1130	1120 TO 8	CHX	4.85120E+03	5.08016E+02	2.06856E-02	5.17304E-01	-6.52070E-01	-1.01227E+00	-7.21649E-06	
2010	7 TO 2010	CHI	4.20639E+03	4.88055E+02	2.02754E-02	-5.08289E-01	-1.88363E+00	-4.38607E-02	-4.26387E-06	
2130	2120 TO 8	CHX	4.20703E+03	5.03938E+02	2.05989E-02	5.15741E-01	-6.52777E-01	-1.00934E+00	-3.12848E-06	
3010	7 TO 3010	CHI	3.55976E+03	4.88055E+02	2.02754E-02	-5.08385E-01	-1.88364E+00	-4.38639E-02	-3.59522E-06	
3130	3120 TO 8	CHX	3.56024E+03	5.03144E+02	2.05822E-02	5.15448E-01	-6.52913E-01	-1.00878E+00	-2.29504E-06	
4010	7 TO 4010	CHI	4.20713E+03	4.88055E+02	2.02754E-02	-5.08423E-01	-1.88364E+00	-4.38748E-02	-3.78527E-06	
4130	4120 TO 8	CHX	4.20768E+03	5.02934E+02	2.05778E-02	5.15356E-01	-6.52949E-01	-1.00864E+00	-2.30198E-06	

RETRAN CHANNEL EDIT - (VOLUMES AND CONDUCTORS ARE IDENTICALLY NUMBERED)

VOLUME NUMBER	MODERATOR TEMPERATURE (DEG. F)	MODERATOR VOID FRAC	MODERATOR ENTHALPY (BTU/LBM)	HEAT TRANSFER MODE	POWER DENSITY	FUEL TEMPERATURE (DEG. F)	FUEL ENTHALPY (CAL/GM)	HEAT FLUX (BTU/HR/FT**2)	CONDUCTOR HEATING RATE (BTU/HR)	DIR. MOD HEATING RATE (BTU/HR)
CHANNEL 1										
1010	5.01041E+02	0.00000E+00	4.89296E+02	1	1.77276E-03	8.58684E+02	2.92343E+01	4.79239E+04	2.26711E+07	0.00000E+00
1020	5.02706E+02	0.00000E+00	4.91281E+02	1	2.93469E-03	1.05650E+03	3.71041E+01	7.67093E+04	3.75306E+07	0.00000E+00
1030	5.04460E+02	0.00000E+00	4.93379E+02	1	3.13690E-03	1.08724E+03	3.83587E+01	8.11388E+04	4.01166E+07	0.00000E+00
1040	5.06127E+02	0.00000E+00	4.95377E+02	1	3.02471E-03	1.06328E+03	3.73775E+01	7.73744E+04	3.86818E+07	0.00000E+00
1050	5.07685E+02	0.00000E+00	4.97250E+02	1	2.89390E-03	1.03265E+03	3.61387E+01	7.26611E+04	3.70089E+07	0.00000E+00
1060	5.09156E+02	0.00000E+00	4.99021E+02	1	2.83568E-03	1.00743E+03	3.51184E+01	6.88267E+04	3.62643E+07	0.00000E+00
1070	5.10561E+02	0.00000E+00	5.00717E+02	1	2.87097E-03	9.89610E+02	3.43975E+01	6.61498E+04	3.67157E+07	0.00000E+00
1080	5.11935E+02	0.00000E+00	5.02382E+02	1	2.99884E-03	9.82709E+02	3.41181E+01	6.51140E+04	3.83510E+07	0.00000E+00
1090	5.13306E+02	0.00000E+00	5.04043E+02	1	3.19482E-03	9.83859E+02	3.41628E+01	6.52860E+04	4.08573E+07	0.00000E+00
1100	5.14654E+02	0.00000E+00	5.05682E+02	1	3.35667E-03	9.80467E+02	3.40262E+01	6.47707E+04	4.29271E+07	0.00000E+00
1110	5.15858E+02	0.00000E+00	5.07148E+02	1	3.15999E-03	9.38622E+02	3.23586E+01	5.84499E+04	4.04118E+07	0.00000E+00
1120	5.16569E+02	0.00000E+00	5.08017E+02	1	1.91114E-03	7.82185E+02	2.62589E+01	3.55738E+04	2.44408E+07	0.00000E+00
CHANNEL 2										
2010	5.00742E+02	0.00000E+00	4.88940E+02	1	1.22725E-03	7.60258E+02	2.54084E+01	3.42031E+04	1.36022E+07	0.00000E+00
2020	5.01994E+02	0.00000E+00	4.90433E+02	1	2.16648E-03	9.26543E+02	3.18870E+01	5.76907E+04	2.40121E+07	0.00000E+00
2030	5.03371E+02	0.00000E+00	4.92077E+02	1	2.42311E-03	9.67884E+02	3.35308E+01	6.35962E+04	2.68564E+07	0.00000E+00
2040	5.04711E+02	0.00000E+00	4.93681E+02	1	2.39265E-03	9.58412E+02	3.31526E+01	6.20699E+04	2.65189E+07	0.00000E+00
2050	5.05979E+02	0.00000E+00	4.95201E+02	1	2.31266E-03	9.37817E+02	3.23311E+01	5.89370E+04	2.56322E+07	0.00000E+00
2060	5.07188E+02	0.00000E+00	4.96653E+02	1	2.27332E-03	9.20823E+02	3.16602E+01	5.63630E+04	2.51962E+07	0.00000E+00
2070	5.08359E+02	0.00000E+00	4.98062E+02	1	2.29994E-03	9.10916E+02	3.12699E+01	5.48485E+04	2.54913E+07	0.00000E+00
2080	5.09506E+02	0.00000E+00	4.99446E+02	1	2.39137E-03	9.05386E+02	3.10532E+01	5.40038E+04	2.65046E+07	0.00000E+00
2090	5.10640E+02	0.00000E+00	5.00815E+02	1	2.51837E-03	9.02925E+02	3.09567E+01	5.36187E+04	2.79122E+07	0.00000E+00
2100	5.11733E+02	0.00000E+00	5.02139E+02	1	2.58111E-03	8.92698E+02	3.05584E+01	5.20860E+04	2.86076E+07	0.00000E+00
2110	5.12676E+02	0.00000E+00	5.03281E+02	1	2.32148E-03	8.46655E+02	2.87658E+01	4.53095E+04	2.57301E+07	0.00000E+00
2120	5.13216E+02	0.00000E+00	5.03938E+02	1	1.31683E-03	7.14335E+02	2.36292E+01	2.66118E+04	1.45950E+07	0.00000E+00
CHANNEL 3										
3010	5.00671E+02	0.00000E+00	4.88856E+02	1	1.09687E-03	7.36229E+02	2.44771E+01	3.09304E+04	1.02868E+07	0.00000E+00
3020	5.01831E+02	0.00000E+00	4.90239E+02	1	1.99715E-03	8.97080E+02	3.07293E+01	5.34465E+04	1.87299E+07	0.00000E+00
3030	5.03134E+02	0.00000E+00	4.91794E+02	1	2.28336E-03	9.44188E+02	3.25856E+01	6.01636E+04	2.14141E+07	0.00000E+00
3040	5.04416E+02	0.00000E+00	4.93327E+02	1	2.27984E-03	9.39451E+02	3.23962E+01	5.93417E+04	2.13810E+07	0.00000E+00
3050	5.05634E+02	0.00000E+00	4.94788E+02	1	2.21377E-03	9.21479E+02	3.16865E+01	5.66063E+04	2.07615E+07	0.00000E+00
3060	5.06799E+02	0.00000E+00	4.96185E+02	1	2.17928E-03	9.05819E+02	3.10707E+01	5.42363E+04	2.04380E+07	0.00000E+00
3070	5.07927E+02	0.00000E+00	4.97543E+02	1	2.20433E-03	8.96618E+02	3.07111E+01	5.28280E+04	2.06728E+07	0.00000E+00
3080	5.09038E+02	0.00000E+00	4.98882E+02	1	2.28755E-03	8.92625E+02	3.05556E+01	5.21982E+04	2.14533E+07	0.00000E+00
3090	5.10132E+02	0.00000E+00	5.00202E+02	1	2.39693E-03	8.89118E+02	3.04190E+01	5.16565E+04	2.24791E+07	0.00000E+00
3100	5.11177E+02	0.00000E+00	5.01467E+02	1	2.42866E-03	8.76115E+02	2.99128E+01	4.97207E+04	2.27767E+07	0.00000E+00
3110	5.12063E+02	0.00000E+00	5.02539E+02	1	2.13655E-03	8.26576E+02	2.79842E+01	4.24822E+04	2.00372E+07	0.00000E+00
3120	5.12561E+02	0.00000E+00	5.03145E+02	1	1.17507E-03	6.98044E+02	2.29982E+01	2.44687E+04	1.10202E+07	0.00000E+00
CHANNEL 4										
4010	5.00681E+02	0.00000E+00	4.88867E+02	1	1.11469E-03	7.39499E+02	2.46038E+01	3.13770E+04	1.23546E+07	0.00000E+00
4020	5.01838E+02	0.00000E+00	4.90247E+02	1	1.99193E-03	8.96163E+02	3.06935E+01	5.33166E+04	2.20775E+07	0.00000E+00
4030	5.03121E+02	0.00000E+00	4.91779E+02	1	2.24692E-03	9.38035E+02	3.23403E+01	5.92684E+04	2.49036E+07	0.00000E+00
4040	5.04376E+02	0.00000E+00	4.93280E+02	1	2.22819E-03	9.30818E+02	3.20553E+01	5.80875E+04	2.46960E+07	0.00000E+00
4050	5.05566E+02	0.00000E+00	4.94706E+02	1	2.15744E-03	9.12200E+02	3.13206E+01	5.52653E+04	2.39119E+07	0.00000E+00

4060	5.06702E+02	0.00000E+00	4.96069E+02	1	2.12179E-03	8.96570E+02	3.07093E+01	5.29061E+04	2.35167E+07	0.00000E+00
4070	5.07803E+02	0.00000E+00	4.97394E+02	1	2.14627E-03	8.87644E+02	3.03617E+01	5.15413E+04	2.37881E+07	0.00000E+00
4080	5.08890E+02	0.00000E+00	4.98703E+02	1	2.22967E-03	8.84631E+02	3.02444E+01	5.10522E+04	2.47125E+07	0.00000E+00
4090	5.09963E+02	0.00000E+00	4.99998E+02	1	2.34327E-03	8.82173E+02	3.01487E+01	5.06636E+04	2.59715E+07	0.00000E+00
4100	5.10995E+02	0.00000E+00	5.01247E+02	1	2.39083E-03	8.71432E+02	2.97305E+01	4.90617E+04	2.64986E+07	0.00000E+00
4110	5.11881E+02	0.00000E+00	5.02319E+02	1	2.13193E-03	8.26010E+02	2.79622E+01	4.24279E+04	2.36291E+07	0.00000E+00
4120	5.12388E+02	0.00000E+00	5.02934E+02	1	1.19470E-03	7.00440E+02	2.30910E+01	2.48214E+04	1.32414E+07	0.00000E+00

APPROXIMATE POINT KINETICS REACTIVITY DATA

	K-INFINITY	TOTAL REACTIVITY	CONTROL REACTIVITY	MODERATOR REACTIVITY	DENSITY REACTIVITY	DOPPLER REACTIVITY	RESIDUAL REACTIVITY
ADJOINT FLUX WTS	9.715274E-01	7.519417E-04	0.000000E+00	0.000000E+00	1.169642E-03	-3.653331E-04	-2.686629E-06

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   50
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:59:58
 BWR - RETRAN-3D SAMPLE PROBEM - 4 CHAN/ 1 BYP - FLOW SPLITS CALCULATED                                         CPU TIME =   20.109
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *
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SYSTEM ELAPSED TIME (SEC)	SYSTEM ELAPSED TIME (SEC)	TIME STP ACTUAL	SYSTEM CORE POWER (MW)	CORE-PHY ADJ TOT REAC (K-1)/K	CORE-PHY ADJ CTR REAC (K-1)/K	CORE-PHY ADJ DEN REAC (K-1)/K	VOL 7 AVG. PRESS. (PSIA)	VOL 1010 AVG. PRESS. (PSIA)
5.00000E+00	5.00000E+00	3.63200E+03	3.59621E+02	7.51942E-04	0.00000E+00	1.16964E-03	1.03500E+03	1.03256E+03

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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   51
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:59:58
 BWR - RETRAN-3D SAMPLE PROBEM - 4 CHAN/ 1 BYP - FLOW SPLITS CALCULATED                                         CPU TIME =   20.109
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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SYSTEM ELAPSED TIME (SEC)	VOL 1010 AVG. DENSITY (LB/FT3)	VOL 1010 AVG ENTHALPY (BTU/LB)	VOL 1010 VOID FRACTN	VOL 1010 NEUTRON VOID	VOL 1120 AVG. PRESS. (PSIA)	VOL 1120 AVG. DENSITY (LB/FT3)	VOL 1120 AVG ENTHALPY (BTU/LB)	VOL 1120 VOID FRACTN
5.00000E+00	4.92610E+01	4.89296E+02	0.00000E+00	0.00000E+00	1.02115E+03	4.83427E+01	5.08017E+02	0.00000E+00

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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   52
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:59:58
 BWR - RETRAN-3D SAMPLE PROBEM - 4 CHAN/ 1 BYP - FLOW SPLITS CALCULATED                                         CPU TIME =   20.109
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *
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SYSTEM ELAPSED TIME (SEC)	VOL 1120 NEUTRON VOID	VOL 3010 AVG. PRESS. (PSIA)	VOL 3010 AVG. DENSITY (LB/FT3)	VOL 3010 AVG ENTHALPY (BTU/LB)	VOL 3010 VOID FRACTN	VOL 3010 NEUTRON VOID	VOL 3120 AVG. PRESS. (PSIA)	VOL 3120 AVG. DENSITY (LB/FT3)
5.00000E+00	0.00000E+00	1.03256E+03	4.92818E+01	4.88856E+02	0.00000E+00	0.00000E+00	1.02115E+03	4.85857E+01

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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   53
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:59:58
 BWR - RETRAN-3D SAMPLE PROBEM - 4 CHAN/ 1 BYP - FLOW SPLITS CALCULATED                                         CPU TIME =   20.109
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *



     SYSTEM       VOL 3120      VOL 3120      VOL 3120       GAP   1       GAP   2       GAP   3       GAP   4       GAP1010
  ELAPSED TIME  AVG ENTHALPY  VOID FRACTN   NEUTRON VOID  FUEL AX EXP   FUEL AX EXP   FUEL AX EXP   FUEL AX EXP   GAP WIDTH
     (SEC)        (BTU/LB)                                  (FEET)        (FEET)        (FEET)        (FEET)        (FEET)
  5.00000E+00   5.03145E+02   0.00000E+00   0.00000E+00   6.09611E-02   5.44089E-02   5.31254E-02   5.27886E-02   5.86321E-04
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PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   54
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:59:58
 BWR - RETRAN-3D SAMPLE PROBEM - 4 CHAN/ 1 BYP - FLOW SPLITS CALCULATED                                         CPU TIME =   20.109
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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SYSTEM ELAPSED TIME (SEC)	GAP3010 GAP WIDTH (FEET)	GAP1010 GAP COND B/H-F-F2	GAP3010 GAP COND B/H-F-F2	GAP1120 GAP WIDTH (FEET)	GAP3120 GAP WIDTH (FEET)	GAP1120 GAP COND B/H-F-F2	GAP3120 GAP COND B/H-F-F2	GAP1010 FUEL DIA EXP (FEET)
5.00000E+00	5.98070E-04	2.21266E+02	2.10040E+02	5.96020E-04	6.03162E-04	2.14976E+02	2.07214E+02	1.59372E-04

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


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RETRAN-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   55
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:59:58
 BWR - RETRAN-3D SAMPLE PROBEM - 4 CHAN/ 1 BYP - FLOW SPLITS CALCULATED                                         CPU TIME =   20.109
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *


     SYSTEM        GAP1120       GAP3010       GAP3120
  ELAPSED TIME  FUEL DIA EXP  FUEL DIA EXP  FUEL DIA EXP
     (SEC)         (FEET)        (FEET)        (FEET)
  5.00000E+00   1.41573E-04   1.32153E-04   1.23392E-04
```


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VIII

RESTRT SAMPLE PROBLEMS

The use of the RESTRT program module and the flexibility allowed by this module are briefly outlined in Section II.2.0. Two RESTRT sample problems are presented as examples which illustrate the use of RESTRT. These examples correspond to RETRAN sample problems, the Turbine Trip Without Bypass With Point Kinetics, and the Uncontrolled Rod Withdrawal. The Turbine Trip problem uses the normal restart option while the Uncontrolled Rod Withdrawal uses the generalized restart option.

The RESTRT program module creates a new data file which can be used to start another RESTRT run or to obtain REEDIT output. CPU time requirements for RESTRT jobs are similar to those of the original RETRAN jobs for a given number of actual time steps to be taken.

1.0 TURBINE TRIP WITHOUT BYPASS WITH POINT KINETICS

The Turbine Trip Without Bypass With Point Kinetics RETRAN Sample Problem is discussed in Section VII.5.0. The RESTRT example restarts the transient at 0.5 seconds and continues to 2.0 seconds. The input listing, the listing of the problem dimension information, and output at 2.0 seconds along with the minor edit variable values are given.

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```
 LISTING OF INPUT DATA FOR CASE  1

     1    =TTWOB WITH POINT KINETICS  --  RETRAN SAMPLE PROBLEM
     2    *
     3    ********************************************************************************
     4    *
     5    *  PROBLEM DIMENSIONS
     6    *
     7    *         1     2     3     4
     8    *10001   REC   EDI   NTC   NTR
     9    010001    11    0     0     1
    10    *
    11    *  TRIP DATA CARD
    12    *    IDTRP IDSIG IX1 IX2 SETPT DELAY  DESCRIPTION
    13    040010  1   1    0   0    2.    0.    "END OF PROBLEM TIME            "
    14    *
    15    . END
```


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```
RESTRT-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page    1
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis             11:57:22
 TTWOB WITH POINT KINETICS  --  RETRAN SAMPLE PROBLEM                                                            CPU TIME =     0.000
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *

RESTRT PROBLEM CONTROL AND DESCRIPTION DATA.

    WORD  DESCRIPTION
    ====  ====================================================================
      1   RECORD TO RESTART FROM (>=1).................................. =   11
      2   NUMBER OF MINOR EDIT PAIRS (<0 = PRINTER PLOTS) .............. =    0
      3   NUMBER OF TIME-STEP CONTROL SETS (03XXX0 DATA )............... =    0
      4   NUMBER OF TRIP CONTROL SETS (04XXX0 DATA ).................... =    1
      5   RESTART TYPE (NORMAL=0 / GENERALIZED=1) ...................... =    0
      6   SAVE NEW RESTART FILE (YES=0 / NO=-1)......................... =    0


RETRAN PROBLEM CONTROL AND DESCRIPTION DATA FOR THE INITIAL RETRAN RUN.

    WORD  DESCRIPTION
    ====  ====================================================================
      1   RESTART FILE OPTION (SAVE=-1 / NO SAVE=0) .................... =   -1
      2   NUMBER OF MINOR EDIT PAIRS (<0 = PRINTER PLOTS) .............. =   16
      3   NUMBER OF TIME-STEP CONTROL SETS (03XXX0 DATA )............... =    4
      4   NUMBER OF TRIP CONTROL SETS (04XXX0 DATA ).................... =    9
      5   NUMBER OF CONTROL VOLUME DESCRIPTIONS (05XXXY DATA ).......... =   20
      6   NUMBER OF BUBBLE RISE DESCRIPTIONS (060XXY DATA) ............. =    1
      7   NUMBER OF TIME DEPENDENT VOLUMES FORM CARDS (07XXYY DATA) ..... =    0
      8   NUMBER OF JUNCTION DESCRIPTIONS (08XXXY DATA) ................ =   26
      9   NUMBER OF CENTRIFUGAL PUMP DESCRIPTIONS (090XXY DATA )......... =    1
     10   NUMBER OF VALVE DESCRIPTIONS (11XXXY DATA) ................... =    4
     11   NUMBER OF GENERAL DATA TABLE DESCRIPTIONS (12XXYY DATA) ....... =    5
     12   NUMBER OF FILL DESCRIPTIONS (13XXYY DATA )..................... =    4
     13   NUMBER OF HEAT CONDUCTOR DESCRIPTIONS (15XXXY DATA) ........... =    8
     14   NUMBER OF HEAT CONDUCTOR GEOMETRY DESCRIPTIONS (17XXYY DATA) .. =    4
     15   NUMBER OF HEAT CONDUCTOR MATERIAL DESCRIPTIONS (18XXYY DATA) .. =    5
     16   NUMBER OF CORE SECTION DESCRIPTIONS (16XXXY DATA) ............ =    6
     17   NUMBER OF NON-CONDUCTNG HEAT EXCHNGR DESCRIPTIONS (21XXYY DATA) =    0
     18   INPUT OPTION NO LONGER USED .................................. =
     19   POWER OPTION (TAPE OPTNS<0 / NO/TBL=0 / PT KIN=1 / 1D=2 / 3D=3) =    1
     20   INPUT OPTION NO LONGER USED .................................. =
     21   NONCONDENSABLE GAS FLOW OPTION (NO=0 / YES=1) ................ =    0
     22   NUMBER OF TIME DEP BCS FROM TAPE (IREAD<0 ON 05XXXY DATA) ..... =    0
     23   SLIP OPTION (DYN=1 / Z-L=2 / C-L=3 / Z-L TAUGL=4 / C-L TAUGL=5) =    3
     24   NUMBER OF SPECIFIED HEAT TRAN COEF DESCRIPTIONS (015XXX DATA) . =    0
     25   USE STEADY-STATE SOLUTION (YES=0 / NO=1) ..................... =    1
     26   TWO-REGION NONEQ VOL DESCRIPTIONS (610XXX DATA) .............. =    1
     27   TEMP. TRANSPORT DELAY OPTION (MESH>0 ON 05XXXY DATA) ......... =    0
     28   AUXILIARY DNB MODEL (8001XX DATA INCLUDED) ................... =    1
     29   CONTROL SYSTEM MODEL (702XXX OR 702XXXX DATA) ................ =    1
     30   HEAT TRANSFER MAP OPTION (FORCED=0 / NAT CONV=1) ............. =    0
     31   ACCUMULATOR MODEL DESCRIPTIONS (620XXX DATA) ................. =    0
     32   DYNAMIC GAP CONDUCTANCE MODEL DESCRIPTIONS (225XX0 DATA) ...... =    0
     33   TH MATRIX DIRECT SOLVER OPTION (4-EQ=2 / 6-EQ=3) ............. =    2
     34   NUMBER OF HT CONDUCTOR STACK DESCRIPTIONS (2200XY DATA) ....... =    0
     35   NUMBER OF TURBINE SHAFT DESCRIPTIONS (500XXY DATA) ........... =    0
     36   USE NEUTRON VOID MODEL (YES=1 / NO=0) ........................ =    0
     37   NUMBER OF PROFILE FIT DESCRIPTIONS (061XX1 DATA) ............. =    0
     38   INPUT OPTION NO LONGER USED .................................. =
     39   FIVE-EQUATION OPTION (NO= 0 / YES=1) ......................... =    0
     40   NUMBER OF STEAM-WATER SEPARATOR DESCRIPTIONS (60XXX0 DATA) .... =    1
     41   USE GENERALIZED TRANSPORT MODEL (NO=0 / VAP=1 / LIQ=-1) ....... =    0
     42   TH MATRIX ITERATIVE SOLVER OPTION (NO<=1 / YES=2) ............ =    0


                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * *                                                * * *
                   * * *         SLIP OPTION            =   3           * * *
                   * * *                                                * * *
                   * * *         NUMERICS OPTION        =   2           * * *
                   * * *                                                * * *
                   * * *         HEAT TRANSFER OPTION   =   0           * * *
                   * * *                                                * * *
                   * * *         NEW EQUATIONS OPTION   =   0           * * *
                   * * *                                                * * *
                   * * *        USING THE 4-EQ SOLVER - SOLVE3          * * *
                   * * *                                                * * *
                   * * *                                                * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *


AIR IS THE DEFAULT NONCONDENSABLE GAS.
```


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```
RESTRT-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page    6
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:22
 TTWOB WITH POINT KINETICS  --  RETRAN SAMPLE PROBLEM                                                          CPU TIME =    0.031
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
```

NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	ENERGY BALANCE (BTU)	TOTAL MASS BALANCE (LBM)	NCG MASS BALANCE (LBM)	AVERAGE TIME STEP (SEC)	CURRENT TIME STEP (SEC)	ELAPSED TIME (SEC)	TIME STEP NUM STANDRD/ACTUL
9.74284E-01	2.46825E+03	8.45104E+09	2.36764E+12	2.13941E+09	0.00000E+00	0.00000E+00	8.63179E-04	5.00000E-01	500 501

VOLUME NUMBER		AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	VOID FRAC.	POWR TO H2O (BTU/SEC)
1		1.07399E+03	1.26734E+05	5.26405E+02	4.74195E+01	5.31541E+02	0.00000E+00	0.00000E+00	0.00000E+00
2		1.04289E+03	1.10623E+04	5.48146E+02	4.61930E+01	5.48599E+02	0.00000E+00	0.00000E+00	8.78348E+05
3		1.03989E+03	5.60290E+03	5.81835E+02	2.33961E+01	5.48982E+02	5.16292E-02	5.19340E-01	8.93320E+05
4		1.03580E+03	4.06270E+03	6.06550E+02	1.69647E+01	5.48496E+02	9.09317E-02	6.66153E-01	5.39182E+05
5		1.03602E+03	9.56209E+03	5.32346E+02	4.70761E+01	5.36212E+02	0.00000E+00	0.00000E+00	1.65294E+04
6		1.03471E+03	9.43151E+03	5.43862E+02	4.64332E+01	5.45258E+02	0.00000E+00	0.00000E+00	1.38406E+04
7		1.03345E+03	9.17476E+03	5.48457E+02	4.51692E+01	5.48215E+02	1.21698E-03	2.37980E-02	7.66916E+03
8		1.03299E+03	1.34734E+04	6.14524E+02	1.55298E+01	5.48160E+02	1.03901E-01	6.98897E-01	-1.77842E+02
9	LIQ REG	1.04890E+03	2.63212E+04	5.47839E+02	4.62147E+01	5.48372E+02	0.00000E+00	8.03239E-01	0.00000E+00
	VAP REG		5.49250E+03	1.18794E+03	2.35931E+00	5.50049E+02	9.95103E-01		0.00000E+00
10		1.04950E+03	8.55315E+03	1.18812E+03	2.36007E+00	5.50119E+02	9.95427E-01	9.99766E-01	0.00000E+00
11		1.04131E+03	3.35078E+03	6.14253E+02	1.58346E+01	5.49151E+02	1.01772E-01	6.91811E-01	-5.86062E+03
12		1.05299E+03	1.64954E+05	5.26091E+02	4.74240E+01	5.31257E+02	0.00000E+00	0.00000E+00	2.53946E+03
13		1.07407E+03	9.26391E+03	5.26404E+02	4.74197E+01	5.31540E+02	0.00000E+00	0.00000E+00	0.00000E+00
14		1.05607E+03	1.53804E+03	1.18904E+03	2.37242E+00	5.50892E+02	9.97253E-01	9.99858E-01	0.00000E+00
15		1.06415E+03	1.06161E+03	1.18999E+03	2.38824E+00	5.51838E+02	9.99231E-01	9.99960E-01	0.00000E+00
16		1.08323E+03	5.56979E+03	1.19532E+03	2.39771E+00	5.57524E+02	1.00000E+00	1.00000E+00	0.00000E+00
17		1.07130E+03	2.57459E+02	1.19448E+03	2.37661E+00	5.55336E+02	1.00000E+00	1.00000E+00	0.00000E+00
18		1.13825E+03	2.56837E+04	5.26871E+02	4.74323E+01	5.32014E+02	0.00000E+00	0.00000E+00	7.47244E+03
19		1.19941E+03	2.81549E+04	5.26858E+02	4.74688E+01	5.32098E+02	0.00000E+00	0.00000E+00	0.00000E+00
20		9.57778E+02	2.13894E+09	1.18966E+03	2.13894E+00	5.38913E+02	9.92734E-01	9.99668E-01	0.00000E+00

JUNCTION NUMBER	CONNECTS VOLUMES	CHOK/ PATH	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E D I F F E R E N T I A L S VEL. PSI	ELEV. PSI	FRIC. PSI	ACCL. PSI	PUMP PSI
1	1 TO 2		2.21783E+04	5.26405E+02	2.10884E-02	-4.22499E-01	-3.50320E+00	-2.71151E+01	5.32705E-02	0.00000E+00
2	2 TO 3		2.20552E+04	5.65453E+02	3.20428E-02	-3.07729E-01	-9.66387E-01	-1.70366E+00	2.96107E-02	0.00000E+00
3	3 TO 4		1.96364E+04	5.97703E+02	5.28330E-02	-2.29754E-01	-5.60404E-01	-2.89117E+00	4.14035E-01	0.00000E+00
4	4 TO 8		1.88226E+04	6.15314E+02	6.45468E-02	4.23878E-01	-5.82427E-01	-1.93467E+00	7.29070E-01	0.00000E+00
5	1 TO 5		1.54622E+03	5.26405E+02	2.10884E-02	4.59034E-02	-3.51547E+00	-3.45272E+01	-1.77838E-02	0.00000E+00
6	5 TO 6		1.53450E+03	5.38312E+02	2.13919E-02	4.90026E-06	-1.29874E+00	-1.47821E-02	-1.66734E-02	0.00000E+00
7	6 TO 7		1.52416E+03	5.47557E+02	2.16350E-02	3.22173E-04	-1.27211E+00	-1.61400E-02	-2.28294E-02	0.00000E+00
8	7 TO 8		-8.51401E+02	6.14575E+02	6.44394E-02	-2.10395E-01	-9.74057E-01	1.71798E-01	-5.34493E-01	0.00000E+00
9	11 TO 9		1.54945E+04	6.14244E+02	6.31642E-02	1.68950E+00	-1.94328E+00	-8.37966E-01	-8.64947E+00	0.00000E+00
10	9 TO 10		7.58808E+02	1.18792E+03	4.23918E-01	1.87206E-01	-1.19811E-01	-2.46562E-03	-5.74978E-01	0.00000E+00
11	18 TO 19		9.70022E+03	5.26871E+02	2.10827E-02	1.52540E-01	-2.91786E+00	-1.97586E+01	2.25657E+00	8.59734E+01
12	8 TO 11		1.61828E+04	6.14512E+02	6.43995E-02	-1.27565E+00	-6.47987E-01	-7.36600E-01	-1.09623E+01	0.00000E+00
13	12 TO 13		1.41911E+04	5.26090E+02	2.10864E-02	-1.77588E+00	2.86824E+00	-8.27156E+00	5.00231E+00	3.32815E+01
14	19 TO 13		9.65781E+03	5.26858E+02	2.10665E-02	6.21498E+00	-5.01108E+00	-5.04245E+01	1.97592E+00	-7.41226E+01
15	12 TO 18		9.74533E+03	5.26090E+02	2.10864E-02	-4.13979E+00	1.07843E+01	-5.37794E+00	2.01396E+00	8.59734E+01
16	13 TO 1		2.38370E+04	5.26403E+02	2.10883E-02	6.26282E-01	2.89128E+00	-1.37423E+00	2.18366E+00	0.00000E+00
17	10 TO 14		-3.76776E+02	1.18903E+03	4.21560E-01	-1.48379E-01	5.05288E-01	5.79515E-02	-6.14664E+00	0.00000E+00
18	14 TO 15		-5.87353E+02	1.18998E+03	4.18732E-01	-1.08319E-01	5.12165E-01	2.06442E-01	-7.57213E+00	0.00000E+00
19	15 TO 16		-6.25608E+02	1.19533E+03	4.17028E-01	1.46707E-01	2.46450E-01	1.79295E+00	-1.70486E+01	0.00000E+00
20	16 TO 17		-6.62468E+01	1.19450E+03	4.20673E-01	1.68617E-01	-3.83369E-01	1.42403E-01	1.16666E+01	0.00000E+00
21	9 TO 12		2.10274E+04	5.47837E+02	2.16381E-02	7.55929E-02	6.61941E+00	-2.38264E-01	2.35707E+00	0.00000E+00
22	16 TO 20		0.00000E+00	1.19533E+03	4.17028E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
26	0 TO 14		0.00000E+00	1.18903E+03	4.21560E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
25	0 TO 14		0.00000E+00	1.18903E+03	4.21560E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
24	0 TO 12		3.08926E+03	3.96877E+02	1.89228E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
23	0 TO 14		0.00000E+00	1.18903E+03	4.21560E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

JUNCTION NUMBER	FLOW REG.	SLIP VEL. (FT/SEC)	VOID FRACTION	LIQUID FLOW (LB/SEC)	GAS FLOW (LB/SEC)	SLIP CNVCTN (BTU/SEC)	GAS VEL. (FT/SEC)	LIQ. VEL. (FT/SEC)	VG/VL	SLIP ACCEL. (FT/SEC**2)
2	0	-5.35541E+00	3.40830E-01	2.13319E+04	7.23369E+02	1.03739E+05	2.33915E+01	1.80361E+01	1.29693E+00	1.08170E+01
3	0	-1.14312E+01	6.21281E-01	1.75442E+04	2.09226E+03	3.81063E+05	3.72359E+01	2.58047E+01	1.44299E+00	-1.41179E+01
4	0	-1.54405E+01	6.99702E-01	1.59832E+04	2.83945E+03	5.59399E+05	4.50671E+01	2.96266E+01	1.52117E+00	-5.51480E+01
9	-2	-1.25766E+01	6.91878E-01	1.33221E+04	2.17240E+03	3.83647E+05	4.12242E+01	2.86476E+01	1.43901E+00	7.09693E+01
12	-2	-1.36384E+01	6.98940E-01	1.38565E+04	2.32633E+03	4.16527E+05	4.40898E+01	3.04514E+01	1.44787E+00	7.16715E+01

BUBL SET NUMB.	VOL. NUMB.	BUBBLE GRADIENT PARAMETER	BUBBLE VELOCITY (FT/SEC)	MIXTURE LEVEL (FT)	MIXTURE QUALITY	BUBBLE MASS (LB)
1	9	5.00000E-02	0.00000E+00	4.74101E+00	0.00000E+00	0.00000E+00

PUMP NUMB.	VOL. NUMB.	PUMP SPEED (RPM)	NORM. PUMP TORQUE	NORM. FRIC. TORQUE	NORM. MOT. TORQUE	POWER TO H2O (BTU/HR)
1	18	1.66500E+03	1.00429E+00	1.00000E+00	0.00000E+00	2.69008E+07

HEAT COND. NUMBER		VOL. NUM.	HT TRAN MODE-COR	SURF. FLUX (BTU/HR-FT2)	CRIT. FLUX (BTU/HR-FT2)	H.T. COEF. (BTU/H-F2-F)	SURF. TEMP. (DEG. F)	MASS FLUX (LBM/HR-FT2)	STORD ENRGY (BTU)	POWR TO H20 (BTU/HR)	DRYOUT PNT ()
1	RGHT	2	2-THOM	1.90266E+05	8.00000E+05	1.31668E+04	5.63054E+02	1.32982E+06	1.26491E+07	3.07810E+09	
2	RGHT	3	2-THOM	1.93604E+05	7.48337E+05	1.39482E+04	5.62850E+02	1.25273E+06	1.27863E+07	3.13210E+09	
3	RGHT	4	2-THOM	1.16860E+05	7.09054E+05	1.08014E+04	5.59302E+02	1.15390E+06	9.59183E+06	1.89054E+09	
4	LEFT	2	1-DB-L	6.01370E+02	1.27965E+06	3.48944E+03	5.48776E+02	1.32982E+06		2.40585E+06	
	RGHT	5	1-DB-L	4.01299E+03	1.46838E+05	3.55049E+02	5.47514E+02	1.09236E+05	4.52453E+05	1.60545E+07	
5	LEFT	3	2-THOM	3.43638E+02	1.06576E+06	5.87639E+02	5.49555E+02	1.25273E+06		1.37477E+06	
	RGHT	6	1-DB-L	1.44827E+03	1.43505E+05	3.55563E+02	5.49330E+02	1.08476E+05	4.53503E+05	5.79399E+06	
6	LEFT	4	2-THOM	1.78233E+02	1.05759E+06	4.21835E+02	5.48905E+02	1.15390E+06		7.13045E+05	
	RGHT	7	2-THOM	4.25385E+02	1.01893E+05	6.50476E+02	5.48857E+02	2.52022E+04	4.52955E+05	1.70181E+06	
7	LEFT	11	1-DB-L	-1.25976E+04	3.07217E+05	3.90184E+03	5.45906E+02	1.74782E+06		-2.10982E+07	
	RGHT	12	1-DB-L	4.85013E+03	2.38650E+05	1.15311E+03	5.35462E+02	9.26206E+05	1.40305E+06	8.83937E+06	
8	LEFT	8	1-DB-L	-1.69777E+03	9.00000E+04	9.30884E+02	5.46322E+02	6.86005E+05		-6.40230E+05	
	RGHT	12	1-DB-L	7.85496E+02	2.18399E+05	1.87029E+03	5.31676E+02	9.26206E+05	6.45415E+06	3.02664E+05	

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PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


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   CORE   COND.  DEPTH REAC.  DEPTH REAC.  HEAT GEN.    COND. HEAT-  DIR. MODER-  AVG. METAL   CENTERLINE   FUEL
   NUMB.  NUMB.  EXT. ZR-H2O  INT. ZR-H2O  ZR-H2O       ING RATE     ATOR HT RT   TEMPERATURE  TEMPERATURE  ENTHALPY
                 (FT)         (FT)         (BTU/HR)     (BTU/HR)     (BTU/HR)     (DEG. F)     (DEG. F)     (CAL/GM)
      1      1   0.00000E+00  0.00000E+00  0.00000E+00  3.05355E+09  8.15491E+07  1.70120E+03  2.42604E+03  6.35987E+01
      2      2   0.00000E+00  0.00000E+00  0.00000E+00  3.10793E+09  8.24763E+07  1.71887E+03  2.46193E+03  6.43290E+01
      3      3   0.00000E+00  0.00000E+00  0.00000E+00  1.89294E+09  4.98004E+07  1.29718E+03  1.66662E+03  4.69797E+01
      4      4   0.00000E+00  0.00000E+00  0.00000E+00  1.56609E+07  4.34513E+07  5.48368E+02
      5      5   0.00000E+00  0.00000E+00  0.00000E+00  1.61163E+07  4.40321E+07  5.49552E+02
      6      6   0.00000E+00  0.00000E+00  0.00000E+00  1.07210E+07  2.59072E+07  5.48934E+02
0        AVERAGE CORE           MINIMUM  HEIGHT              HOT  SPOT                   MINUMUM DNBR POSITION
           (RETRAN)               (HOT CHANNEL)              (HOT CHANNEL)                  (HOT CHANNEL)
   LHGR(KW/FT)      DNBR      LHGR(KW/FT)      DNBR      LHGR(KW/FT)      DNBR      POS. (FT)    LHGR(KW/FT)  MDNBR
   7.54188E+00  4.50820E+00  1.25513E+01  1.75077E+00  1.32164E+01  0.00000E+00  7.50000E+00  1.12056E+01  1.65131E+00

  REACTOR      FISSION      DECAY HEAT   TOTAL        CONTROL      COOL. TEMP.  VOID         FUEL TEMP.   DOPPLER
  PERIOD       POWER        POWER        REACTIVITY   REACTIVITY   REACTIVITY   REACTIVITY   REACTIVITY   REACTIVITY
  (SEC)                                  ($)          ($)          ($)          ($)          ($)          ($)
  4.12925E-01  9.74284E-01  0.00000E+00 -2.07381E-03 -2.23813E-01  0.00000E+00  2.19592E-01  0.00000E+00  2.14733E-03


  DATA RECORD NUMBER    11 WAS WRITTEN TO UNIT 14
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PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


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RESTRT-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   11
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:22
 TTWOB WITH POINT KINETICS  --  RETRAN SAMPLE PROBLEM                                                          CPU TIME =    0.296
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	ENERGY BALANCE (BTU)	TOTAL MASS BALANCE (LBM)	NCG MASS BALANCE (LBM)	AVERAGE TIME STEP (SEC)	CURRENT TIME STEP (SEC)	ELAPSED TIME (SEC)	TIME STEP NUM STANDRD/ACTUL
4.93962E-01	1.25140E+03	4.29798E+09	2.36764E+12	2.13942E+09	0.00000E+00	2.00000E-02	1.32235E-02	2.00000E+00	1015 1109

VOLUME NUMBER		AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	VOID FRAC.	POWR TO H2O (BTU/SEC)
1		1.22872E+03	1.26886E+05	5.27043E+02	4.74761E+01	5.32292E+02	0.00000E+00	0.00000E+00	0.00000E+00
2		1.20089E+03	1.10240E+04	5.52737E+02	4.60330E+01	5.52446E+02	0.00000E+00	0.00000E+00	9.96467E+05
3		1.19840E+03	6.42109E+03	5.98420E+02	2.68126E+01	5.66768E+02	4.36765E-02	4.28881E-01	1.00957E+06
4		1.19484E+03	4.39068E+03	6.28545E+02	1.83342E+01	5.66389E+02	9.35149E-02	6.30058E-01	6.06725E+05
5		1.19693E+03	9.55640E+03	5.34651E+02	4.70480E+01	5.38306E+02	0.00000E+00	0.00000E+00	1.10185E+04
6		1.19562E+03	9.41803E+03	5.46868E+02	4.63668E+01	5.47893E+02	0.00000E+00	0.00000E+00	1.17175E+04
7		1.19432E+03	9.35513E+03	5.52245E+02	4.60572E+01	5.52054E+02	0.00000E+00	0.00000E+00	7.78879E+03
8		1.19263E+03	1.43393E+04	6.38741E+02	1.65279E+01	5.66153E+02	1.10553E-01	6.72901E-01	-2.03696E+03
9	LIQ REG	1.18922E+03	2.41513E+04	5.60045E+02	4.55952E+01	5.58018E+02	0.00000E+00	8.17194E-01	0.00000E+00
	VAP REG		6.32432E+03	1.19010E+03	2.67090E+00	5.68511E+02	1.00000E+00		0.00000E+00
10		1.19011E+03	9.49959E+03	1.19735E+03	2.62123E+00	5.72967E+02	1.00000E+00	1.00000E+00	0.00000E+00
11		1.18977E+03	3.52239E+03	6.37460E+02	1.66455E+01	5.65848E+02	1.09027E-01	6.70175E-01	-1.12452E+04
12		1.19675E+03	1.64891E+05	5.28009E+02	4.74060E+01	5.33016E+02	0.00000E+00	0.00000E+00	2.23339E+03
13		1.22654E+03	9.27020E+03	5.27474E+02	4.74519E+01	5.32634E+02	0.00000E+00	0.00000E+00	0.00000E+00
14		1.18707E+03	1.68947E+03	1.19857E+03	2.60600E+00	5.73369E+02	1.00000E+00	1.00000E+00	0.00000E+00
15		1.18792E+03	1.15598E+03	1.19963E+03	2.60053E+00	5.74174E+02	1.00000E+00	1.00000E+00	0.00000E+00
16		1.18833E+03	5.99293E+03	1.20278E+03	2.57987E+00	5.76360E+02	1.00000E+00	1.00000E+00	0.00000E+00
17		1.18829E+03	2.79156E+02	1.20321E+03	2.57690E+00	5.76650E+02	1.00000E+00	1.00000E+00	0.00000E+00
18		1.28577E+03	2.57070E+04	5.27684E+02	4.74754E+01	5.32894E+02	0.00000E+00	0.00000E+00	7.48394E+03
19		1.35093E+03	2.81878E+04	5.27478E+02	4.75241E+01	5.32831E+02	0.00000E+00	0.00000E+00	0.00000E+00
20		9.57778E+02	2.13894E+09	1.18966E+03	2.13894E+00	5.38913E+02	9.92734E-01	9.99668E-01	0.00000E+00

JUNCTION NUMBER	CONNECTS VOLUMES	CHOK/ PATH	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E D I F F E R E N T I A L S VEL. PSI	ELEV. PSI	FRIC. PSI	ACCL. PSI	PUMP PSI
1	1 TO	2	2.08790E+04	5.27043E+02	2.10632E-02	-2.93950E-01	-3.50431E+00	-2.39874E+01	4.03983E-02	0.00000E+00
2	2 TO	3	2.07630E+04	5.78306E+02	2.58199E-02	-2.86295E-01	-1.01074E+00	-1.17838E+00	5.24037E-02	0.00000E+00
3	3 TO	4	1.95640E+04	6.17664E+02	4.80922E-02	-3.47253E-01	-6.25689E-01	-2.62557E+00	-2.05499E-02	0.00000E+00
4	4 TO	8	1.90020E+04	6.40568E+02	6.13118E-02	2.78651E-01	-6.23315E-01	-1.87710E+00	-1.25881E-02	0.00000E+00
5	1 TO	5	1.40131E+03	5.27043E+02	2.10632E-02	4.03011E-02	-3.51849E+00	-2.83574E+01	-4.21498E-04	0.00000E+00
6	5 TO	6	1.39178E+03	5.40714E+02	2.14069E-02	-1.84385E-05	-1.29742E+00	-1.21970E-02	-1.31818E-04	0.00000E+00
7	6 TO	7	1.38860E+03	5.50892E+02	2.16749E-02	-3.54104E-05	-1.28367E+00	-1.34456E-02	-5.73566E-04	0.00000E+00
8	7 TO	8	1.39585E+03	5.52237E+02	2.17119E-02	-5.19399E-01	-1.00879E+00	-1.70901E-01	6.87121E-04	0.00000E+00
9	11 TO	9	2.05285E+04	6.37391E+02	5.99954E-02	2.47758E+00	-1.85652E+00	-1.36865E+00	8.86224E-02	0.00000E+00
10	9 TO	10	2.86525E+03	1.19021E+03	3.74481E-01	2.45406E-01	-1.33044E-01	-3.10586E-02	-1.71620E+00	0.00000E+00
11	18 TO	19	9.57370E+03	5.27680E+02	2.10633E-02	6.18617E-02	-2.92258E+00	-1.92332E+01	3.25064E-01	8.73534E+01
12	8 TO	11	2.01695E+04	6.38757E+02	6.05164E-02	-2.31842E+00	-6.86145E-01	-1.05993E+00	-1.64545E+00	0.00000E+00
13	12 TO	13	1.26790E+04	5.27991E+02	2.10938E-02	-1.54585E+00	2.87006E+00	-6.61496E+00	5.34501E-01	3.51596E+01
14	19 TO	13	9.58045E+03	5.27479E+02	2.10419E-02	6.29637E+00	-5.01823E+00	-4.95618E+01	2.51933E-01	-7.59315E+01
15	12 TO	18	9.55422E+03	5.27991E+02	2.10938E-02	-4.03847E+00	1.07889E+01	-5.17517E+00	6.16905E-02	8.73534E+01
16	13 TO	1	2.22682E+04	5.27466E+02	2.10737E-02	5.35787E-01	2.89338E+00	-1.20173E+00	2.28217E-01	0.00000E+00
17	10 TO	14	3.29266E+03	1.19745E+03	3.81274E-01	-1.57393E-01	5.56688E-01	-4.06206E+00	9.20895E-02	0.00000E+00
18	14 TO	15	6.35022E+02	1.19863E+03	3.83693E-01	-4.32380E-02	5.61432E-01	-2.32971E-01	1.30745E-01	0.00000E+00
19	15 TO	16	6.11337E+02	1.19961E+03	3.84641E-01	1.65420E-01	2.66606E-01	-1.68442E+00	-1.09393E-01	0.00000E+00
20	16 TO	17	2.87234E+01	1.20265E+03	3.88116E-01	1.54654E-01	-4.12157E-01	-2.48639E-02	-1.17916E-01	0.00000E+00
21	9 TO	12	1.90508E+04	5.59945E+02	2.19293E-02	1.81513E-01	6.51501E+00	-1.99375E-01	-1.56550E+00	0.00000E+00
22	16 TO	20	0.00000E+00	1.20265E+03	3.88116E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
26	0 TO	14	-9.70939E+02	1.19863E+03	3.83693E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
25	0 TO	14	-9.70939E+02	1.19863E+03	3.83693E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
24	0 TO	12	2.81825E+03	4.05708E+02	1.89228E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
23	0 TO	14	-7.28204E+02	1.19863E+03	3.83693E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

JUNCTION NUMBER	FLOW REG.	SLIP VEL. (FT/SEC)	VOID FRACTION	LIQUID FLOW (LB/SEC)	GAS FLOW (LB/SEC)	SLIP CNVCTN (BTU/SEC)	GAS VEL. (FT/SEC)	LIQ. VEL. (FT/SEC)	VG/VL	SLIP ACCEL. (FT/SEC**2)
2	0	-2.24651E+00	1.45882E-01	2.05144E+04	2.48588E+02	2.18717E+04	1.60088E+01	1.37623E+01	1.16324E+00	1.15100E+01
3	0	-9.17574E+00	5.71631E-01	1.75803E+04	1.98371E+03	3.17359E+05	3.26809E+01	2.35052E+01	1.39037E+00	6.03522E+00
4	0	-1.36696E+01	6.78021E-01	1.59826E+04	3.01932E+03	5.37246E+05	4.20816E+01	2.84120E+01	1.48112E+00	1.23803E+01
9	-2	-1.40678E+01	6.69635E-01	1.75506E+04	2.97795E+03	4.58882E+05	5.01986E+01	3.61308E+01	1.38936E+00	6.66189E+00
12	-2	-1.41829E+01	6.72984E-01	1.71852E+04	2.98430E+03	4.66237E+05	4.99389E+01	3.57561E+01	1.39666E+00	1.30292E+01

BUBL SET NUMB.	VOL. NUMB.	BUBBLE GRADIENT PARAMETER	BUBBLE VELOCITY (FT/SEC)	MIXTURE LEVEL (FT)	MIXTURE QUALITY	BUBBLE MASS (LB)
1	9	5.00000E-02	0.00000E+00	4.40928E+00	0.00000E+00	0.00000E+00

PUMP NUMB.	VOL. NUMB.	PUMP SPEED (RPM)	NORM. PUMP TORQUE	NORM. FRIC. TORQUE	NORM. MOT. TORQUE	POWER TO H2O (BTU/HR)
1	18	1.66500E+03	1.00584E+00	1.00000E+00	0.00000E+00	2.69422E+07

HEAT COND. NUMBER		VOL. NUM.	HT TRAN MODE-COR	SURF. FLUX (BTU/HR-FT2)	CRIT. FLUX (BTU/HR-FT2)	H.T. COEF. (BTU/HR-F2-F)	SURF. TEMP. (DEG. F)	MASS FLUX (LBM/HR-FT2)	STORD ENRGY (BTU)	POWR TO H20 (BTU/HR)	DRYOUT PNT ()
1	RGHT	2	2-THOM	2.18867E+05	8.00000E+05	7.96176E+03	5.80021E+02	1.25139E+06	1.36711E+07	3.54080E+09	
2	RGHT	3	2-THOM	2.22543E+05	7.56056E+05	1.69602E+04	5.79887E+02	1.21290E+06	1.38174E+07	3.60027E+09	
3	RGHT	4	2-THOM	1.34170E+05	7.06220E+05	1.31316E+04	5.76602E+02	1.16065E+06	1.02583E+07	2.17059E+09	
4	LEFT	2	1-DB-L	1.31995E+03	1.46210E+06	3.33084E+03	5.52927E+02	1.25139E+06		5.28061E+06	
	RGHT	5	1-DB-L	4.41184E+03	1.46598E+05	3.28589E+02	5.51741E+02	9.90853E+04	4.56231E+05	1.76502E+07	
5	LEFT	3	1-DB-L	-3.40749E+03	1.06267E+06	4.02394E+03	5.65919E+02	1.21290E+06		-1.36321E+07	
	RGHT	6	1-DB-L	4.97186E+03	1.43284E+05	3.29871E+02	5.62968E+02	9.86388E+04	4.66810E+05	1.98906E+07	
6	LEFT	4	1-DB-L	-3.40452E+03	1.05820E+06	4.43876E+03	5.65618E+02	1.16065E+06		-1.36202E+07	
	RGHT	7	1-DB-L	3.66026E+03	1.41077E+05	3.31351E+02	5.63094E+02	9.87881E+04	4.66671E+05	1.46434E+07	
7	LEFT	11	1-DB-L	-2.41720E+04	3.06936E+05	4.63325E+03	5.60674E+02	2.24635E+06		-4.04828E+07	
	RGHT	12	1-DB-L	4.85550E+03	2.72228E+05	1.07776E+03	5.37507E+02	8.50775E+05	1.42643E+06	8.84916E+06	
8	LEFT	8	1-DB-L	-1.94459E+04	9.00000E+04	1.03931E+03	5.47439E+02	8.15901E+05		-7.33304E+06	
	RGHT	12	1-DB-L	-2.09947E+03	2.31888E+05	1.74808E+03	5.31801E+02	8.50775E+05	6.46220E+06	-8.08959E+05	

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


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   CORE   COND.  DEPTH REAC.  DEPTH REAC.  HEAT GEN.    COND. HEAT-  DIR. MODER-  AVG. METAL   CENTERLINE   FUEL
   NUMB.  NUMB.  EXT. ZR-H2O  INT. ZR-H2O  ZR-H2O       ING RATE     ATOR HT RT   TEMPERATURE  TEMPERATURE  ENTHALPY
                 (FT)         (FT)         (BTU/HR)     (BTU/HR)     (BTU/HR)     (DEG. F)     (DEG. F)     (CAL/GM)
      1      1   0.00000E+00  0.00000E+00  0.00000E+00  1.54830E+09  4.11969E+07  1.82955E+03  2.59954E+03  6.89131E+01
      2      2   0.00000E+00  0.00000E+00  0.00000E+00  1.56971E+09  4.78213E+07  1.84789E+03  2.63699E+03  6.96838E+01
      3      3   0.00000E+00  0.00000E+00  0.00000E+00  9.57724E+08  2.72457E+07  1.38407E+03  1.77787E+03  5.05459E+01
      4      4   0.00000E+00  0.00000E+00  0.00000E+00  7.95346E+06  2.20164E+07  5.52620E+02
      5      5   0.00000E+00  0.00000E+00  0.00000E+00  8.20293E+06  2.22923E+07  5.64522E+02
      6      6   0.00000E+00  0.00000E+00  0.00000E+00  5.17419E+06  1.33963E+07  5.64366E+02
0        AVERAGE CORE           MINIMUM  HEIGHT              HOT  SPOT                    MINUMUM DNBR POSITION
           (RETRAN)               (HOT CHANNEL)              (HOT CHANNEL)                  (HOT CHANNEL)
   LHGR(KW/FT)      DNBR      LHGR(KW/FT)      DNBR      LHGR(KW/FT)      DNBR      POS. (FT)    LHGR(KW/FT)  MDNBR
   8.66926E+00  3.93042E+00  1.44299E+01  1.56825E+00  1.52000E+01  0.00000E+00  8.00000E+00  1.24228E+01  1.42644E+00

  REACTOR      FISSION      DECAY HEAT   TOTAL        CONTROL      COOL. TEMP.  VOID         FUEL TEMP.   DOPPLER
  PERIOD       POWER        POWER        REACTIVITY   REACTIVITY   REACTIVITY   REACTIVITY   REACTIVITY   REACTIVITY
  (SEC)                                  ($)          ($)          ($)          ($)          ($)          ($)
 -6.60027E+00  4.93962E-01  0.00000E+00 -1.33745E+00 -2.38591E+00  0.00000E+00  1.26025E+00  0.00000E+00 -2.11788E-01


  DATA RECORD NUMBER    31 WAS WRITTEN TO UNIT 14

  TRAILER LABEL WRITTEN ON UNIT 14
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PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


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RESTRT-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   12
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis           11:57:22
 TTWOB WITH POINT KINETICS  --  RETRAN SAMPLE PROBLEM                                                        CPU TIME =    0.296
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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SYSTEM ELAPSED TIME (SEC)	SYSTEM ELAPSED TIME (SEC)	TIME STP ACTUAL	VOL 10 AVG. PRESS. (PSIA)	BUBL 9 MIX. LEVEL (FEET)	SYSTEM NORM. POWER	JUN 1 FLOW (LB/SEC)	JUN 15 FLOW (LB/SEC)	JUN 16 FLOW (LB/SEC)
5.00000E-01	5.00000E-01	5.01000E+02	1.04950E+03	4.74101E+00	9.74284E-01	2.21783E+04	9.74533E+03	2.38370E+04
5.50000E-01	5.50000E-01	5.51000E+02	1.05787E+03	4.65942E+00	1.11071E+00	2.28718E+04	9.78109E+03	2.46190E+04
6.00000E-01	6.00000E-01	6.02000E+02	1.06543E+03	4.54829E+00	1.44852E+00	2.32373E+04	9.86691E+03	2.50616E+04
6.50000E-01	6.50000E-01	6.52000E+02	1.07086E+03	4.42732E+00	2.20245E+00	2.31885E+04	9.85033E+03	2.49633E+04
7.00000E-01	7.00000E-01	7.02000E+02	1.07501E+03	4.30637E+00	4.08568E+00	2.25229E+04	9.79132E+03	2.42520E+04
7.50000E-01	7.50000E-01	7.52000E+02	1.07880E+03	4.19908E+00	9.02292E+00	2.13000E+04	9.70533E+03	2.29745E+04
8.00000E-01	8.00000E-01	8.02000E+02	1.08293E+03	4.11925E+00	1.43446E+01	1.96389E+04	9.57007E+03	2.12308E+04
8.50000E-01	8.50000E-01	8.53000E+02	1.08807E+03	4.08121E+00	7.77486E+00	1.78961E+04	9.41616E+03	1.92518E+04
9.00000E-01	9.00000E-01	9.05000E+02	1.09466E+03	4.09510E+00	2.93175E+00	1.61855E+04	9.27544E+03	1.74134E+04
9.50000E-01	9.50000E-01	9.55000E+02	1.10328E+03	4.15760E+00	1.60019E+00	1.50035E+04	9.19064E+03	1.61131E+04
1.00000E+00	1.00000E+00	1.00700E+03	1.11354E+03	4.25427E+00	1.05971E+00	1.45991E+04	9.16989E+03	1.56677E+04
1.10000E+00	1.10000E+00	1.03400E+03	1.13473E+03	4.47555E+00	6.30582E-01	1.63951E+04	9.30999E+03	1.76370E+04
1.20000E+00	1.20000E+00	1.04600E+03	1.15133E+03	4.60043E+00	5.01019E-01	1.98679E+04	9.55922E+03	2.14108E+04
1.30000E+00	1.30000E+00	1.05000E+03	1.16260E+03	4.57432E+00	4.77171E-01	2.21095E+04	9.73864E+03	2.38144E+04
1.40000E+00	1.40000E+00	1.06300E+03	1.17263E+03	4.47026E+00	5.35168E-01	2.25044E+04	9.77733E+03	2.41936E+04
1.50000E+00	1.50000E+00	1.07300E+03	1.17997E+03	4.36312E+00	6.10127E-01	2.15374E+04	9.67858E+03	2.30914E+04
1.60000E+00	1.60000E+00	1.08700E+03	1.18140E+03	4.32126E+00	7.01333E-01	1.98471E+04	9.50998E+03	2.11828E+04
1.70000E+00	1.70000E+00	1.09000E+03	1.18824E+03	4.35781E+00	6.80563E-01	1.90025E+04	9.43395E+03	2.02590E+04
1.80000E+00	1.80000E+00	1.09700E+03	1.19445E+03	4.40889E+00	6.02447E-01	1.94964E+04	9.46039E+03	2.07985E+04
1.90000E+00	1.90000E+00	1.10400E+03	1.19470E+03	4.42702E+00	5.33798E-01	2.04862E+04	9.52899E+03	2.18662E+04
2.00000E+00	2.00000E+00	1.10900E+03	1.19011E+03	4.40928E+00	4.93962E-01	2.08790E+04	9.55422E+03	2.22682E+04

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RESTRT-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   13
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:22
 TTWOB WITH POINT KINETICS  --  RETRAN SAMPLE PROBLEM                                                           CPU TIME =    0.296
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *
```

SYSTEM ELAPSED TIME (SEC)	JUN 17 FLOW (LB/SEC)	JUN 24 FLOW (LB/SEC)	REAC KIN REACTIVITY ($)	REAC KIN VOID ($)	REAC KIN DOPPLER ($)	REAC KIN CONTROL REAC ($)	VOL 4 VOID FRACTN	VOL 4 AVG. PRESS. (PSIA)
5.00000E-01	-3.76776E+02	3.08926E+03	-2.07381E-03	2.19592E-01	2.14733E-03	-2.23813E-01	6.66153E-01	1.03580E+03
5.50000E-01	-7.36086E+02	3.05273E+03	1.32922E-01	4.06072E-01	1.76230E-03	-2.74912E-01	6.61348E-01	1.04253E+03
6.00000E-01	-7.67175E+02	3.01547E+03	3.67211E-01	6.94319E-01	-1.09710E-03	-3.26011E-01	6.52895E-01	1.05504E+03
6.50000E-01	-5.86238E+02	2.97948E+03	6.20130E-01	1.00592E+00	-8.86609E-03	-3.76926E-01	6.42961E-01	1.06938E+03
7.00000E-01	-2.84704E+02	2.94286E+03	8.61815E-01	1.31689E+00	-2.88894E-02	-4.26182E-01	6.32073E-01	1.08475E+03
7.50000E-01	7.45800E+00	2.90623E+03	9.96787E-01	1.55342E+00	-8.11943E-02	-4.75438E-01	6.21916E-01	1.10054E+03
8.00000E-01	3.55885E+02	2.86961E+03	9.00400E-01	1.61906E+00	-1.93966E-01	-5.24693E-01	6.14215E-01	1.11723E+03
8.50000E-01	8.95723E+02	2.83230E+03	6.20518E-01	1.49587E+00	-3.01408E-01	-5.73949E-01	6.10265E-01	1.13124E+03
9.00000E-01	1.35513E+03	2.79574E+03	3.12849E-01	1.27108E+00	-3.35026E-01	-6.23205E-01	6.11794E-01	1.13948E+03
9.50000E-01	1.64093E+03	2.75973E+03	-8.55436E-02	9.28508E-01	-3.41590E-01	-6.72461E-01	6.19409E-01	1.14250E+03
1.00000E+00	1.80249E+03	2.72272E+03	-5.54447E-01	5.09061E-01	-3.39955E-01	-7.23553E-01	6.32630E-01	1.14118E+03
1.10000E+00	2.02401E+03	2.73629E+03	-1.43604E+00	-2.76534E-01	-3.27775E-01	-8.31728E-01	6.65386E-01	1.13386E+03
1.20000E+00	1.65571E+03	2.80684E+03	-1.88536E+00	-6.33320E-01	-3.12138E-01	-9.39902E-01	6.89995E-01	1.13422E+03
1.30000E+00	1.13580E+03	2.82412E+03	-1.88849E+00	-5.41182E-01	-2.99226E-01	-1.04808E+00	6.97325E-01	1.14946E+03
1.40000E+00	5.86356E+02	2.74842E+03	-1.41685E+00	3.81154E-02	-2.79661E-01	-1.17530E+00	6.91901E-01	1.17142E+03
1.50000E+00	1.40383E+03	2.69045E+03	-1.11475E+00	4.74377E-01	-2.69014E-01	-1.32011E+00	6.78211E-01	1.19225E+03
1.60000E+00	2.17577E+03	2.60832E+03	-7.89838E-01	9.31512E-01	-2.56432E-01	-1.46492E+00	6.63008E-01	1.20393E+03
1.70000E+00	2.21208E+03	2.58014E+03	-8.13391E-01	1.04558E+00	-2.49249E-01	-1.60973E+00	6.51220E-01	1.20351E+03
1.80000E+00	2.76095E+03	2.67259E+03	-1.01423E+00	1.07924E+00	-2.36164E-01	-1.85730E+00	6.42450E-01	1.19857E+03
1.90000E+00	3.18585E+03	2.75172E+03	-1.20954E+00	1.13538E+00	-2.23320E-01	-2.12161E+00	6.35864E-01	1.19513E+03
2.00000E+00	3.29266E+03	2.81825E+03	-1.33745E+00	1.26025E+00	-2.11788E-01	-2.38591E+00	6.30058E-01	1.19484E+03

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2.0 UNCONTROLLED ROD WITHDRAWAL

The Uncontrolled Rod Withdrawal RETRAN Sample Problem is discussed in Section VII.6.0. That problem was terminated at 3.0 seconds and a restart-plot data file was written. The use of the generalized restart option is demonstrated in this example.

The RESTART example restarts the transient at 0.09 seconds and continues to 5.0 seconds. The input listing and selected output are given below.

```
LISTING OF INPUT DATA FOR CASE  1

    1    =UNCONTROLLED ROD WITHDRAWAL  --  RETRAN SAMPLE PROBLEM
    2    *
    3    ********************************************************************************
    4    *
    5    *  PROBLEM DIMENSIONS
    6    *
    7    *10001  REC  EDI  NTC  NTR IRST
    8    010001  41   31   3    1    1
    9    *
   10    020000 TIMX  0 NTTS  0
   11    020001 PRES  4 PRES  5 PRES  6  PRES 7 PRES 20
   12    020002 PNRM  0 TEMP  4 TEMP  5  TEMP 6 TEMP  7 TEMP 20
   13    020003 WP**  3 WP**  4 WP**  5  WP** 6 WP**  7
   14    020004 HP**  3 HP**  4 HP**  5 HP**  6  HP** 7
   15    020005 HTCL  4 HTCL  5 HTCL  6 HTCL  7
   16    020006 HTCR  4 HTCR  5 HTCR  6 HTCR  7
   17    *
   18    * FORMAT FOR TAPE60
   19    *
   20    025000 1
   21    025001 '(5(1X,1P,E15.7))'
   22    *
   23    *3XXX0  RTG  MIN  RST  MAJ  DMP NCHK  DTMAX  TLAST
   24    030010  0.   0.01 0.01 0.1  0.1   0    0.01    0.1
   25    030020  0.   0.05 0.05 0.4  0.4   0    0.05    0.5
   26    030030  0.   0.05 0.1  1.   3.    0    0.05   70.0
   27    *
   28    *      IDTRP IDSIG IX1 IX2    SETPT    DELAY  DESCRIPTION
   29    040010   1     1    0   0        5.0    0.0   "PROBLEM END TIME              "
   30    *
   31    / END
```

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GENRST-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page    1
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis             11:57:29
 UNCONTROLLED ROD WITHDRAWAL  --  RETRAN SAMPLE PROBLEM                                                         CPU TIME =    0.000
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *




 ************************************************************************************************************************
0********* GENERALIZED RESTART OPTION IS BEING USED *********

 THE FOLLOWING DATA IS BEING MERGED WITH THE ORIGINAL PROBLEM INPUT DATA FOR THIS RUN ONLY.
 THE ORIGINAL PROBLEM INPUT DATA IS SAVED ON THE RESTART FILE SAVED WITH THIS RUN. SUBSEQUENT
 RESTART RUNS WILL REQUIRE THE GENERALIZED INPUT BELOW IF THE MODIFICATIONS ARE DESIRED.


1LISTING OF INPUT DATA FOR CASE  1

     1    =UNCONTROLLED ROD WITHDRAWAL  --  RETRAN SAMPLE PROBLEM
     2    *
     3    *  CHANGE HTMAP FROM 1 TO  0
     4    *
     5    *        1     2     3     4     5     6     7     8     9    10    11    12
     6    *      TAPE PRNPLT  POW    SS  NVOID GENTRN HTMAP SLIP  5EQ  NCOND  NSOL  PNMTH
     7    *010001  -1     0     1     0     0     0     0     0     0     0     2     0
     8    *
     9    *
    10    *5XXXY B V   PRES  ENTH  QUAL VOLUM  ZVOL  FL     FLOWA    DIA    ELEV
    11    050041 0 0   0.0   0.0   0.0  607.5 14.87  13.25  45.84   .055    6.66   * SG T
+                                                                                                   *** THIS CARD IS A REPLACEMENT CARD. ***
    12    050051 0 0   0.0   0.0   0.0  607.5 14.87  13.25  45.84   .055   21.53   * SG TU
+                                                                                                   *** THIS CARD IS A REPLACEMENT CARD. ***
    13    050061 0 0   0.0   0.0   0.0  607.5 14.87  13.25  45.84   .055   21.53   * SG TU
+                                                                                                   *** THIS CARD IS A REPLACEMENT CARD. ***
    14    050071 0 0   0.0   0.0   0.0  607.5 14.87  13.25  45.84   .055    6.66   * SG TU
+                                                                                                   *** THIS CARD IS A REPLACEMENT CARD. ***
    15    *
    16    *5XXXY  EOVRD   MESH  IHTLG  IMAP  IVFIT  IFRIC
    17    050042  0.05
    18    050052  0.05
    19    050062  0.05
    20    050072  0.05
    21    *
    22    *8XXX1  JVT C  CL M  HDI      CON    IFRJ   JTPMJ  IHQCOR  ISP  ANGL1  ANGL2
    23    080032  0   0  0  3   0.055   0.95      0      0      1
+                                                                                                   *** THIS CARD IS A REPLACEMENT CARD. ***
    24    080042  0   0  0  3   0.055   0.95      0      0      1
+                                                                                                   *** THIS CARD IS A REPLACEMENT CARD. ***
    25    080052  0   0  0  3   0.055   0.95      0      0      1
+                                                                                                   *** THIS CARD IS A REPLACEMENT CARD. ***
    26    080062  0   0  0  3   0.055   0.95      0      0      1
+                                                                                                   *** THIS CARD IS A REPLACEMENT CARD. ***
    27    080072  0   0  0  3   0.055   0.95      0      0      1
+                                                                                                   *** THIS CARD IS A REPLACEMENT CARD. ***
    28    *
    29    *  HEAT CONDUCTOR DATA
    30    *      IVSL IVSR IGOM CELEV IMCL IMCR   ASUL    ASUR    VOLS    HDML
    31    *
    32    150041  4    20   2     6.66  1    1   29514.  33322.  131.    0.0746
+                                                                                                   *** THIS CARD IS A REPLACEMENT CARD. ***
    33    150051  5    20   2     6.66  1    1   29514.  33322.  131.    0.0746
+                                                                                                   *** THIS CARD IS A REPLACEMENT CARD. ***
    34    150061  7    20   2     6.66  1    1   29514.  33322.  131.    0.0746
+                                                                                                   *** THIS CARD IS A REPLACEMENT CARD. ***
    35    150071  6    20   2     6.66  1    1   29514.  33322.  131.    0.0746
+                                                                                                   *** THIS CARD IS A REPLACEMENT CARD. ***
    36    *
    37    *       HDMR    DHEL    DHER    CHNL    CHNR    IHXQF
    38    150042  .112    .0746   .132    14.87   14.87     1
+                                                                                                   *** THIS CARD IS A REPLACEMENT CARD. ***
    39    150052  .112    .0746   .132    29.75   29.75     1
+                                                                                                   *** THIS CARD IS A REPLACEMENT CARD. ***
    40    150062  .112    .0746   .132    59.5    29.75     1
+                                                                                                   *** THIS CARD IS A REPLACEMENT CARD. ***
    41    150072  .112    .0746   .132    44.62   14.87     1
+                                                                                                   *** THIS CARD IS A REPLACEMENT CARD. ***
    42    . END
```


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GENRST-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page    2
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis             11:57:29
 UNCONTROLLED ROD WITHDRAWAL  --  RETRAN SAMPLE PROBLEM                                                          CPU TIME =     0.000
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *

RESTRT PROBLEM CONTROL AND DESCRIPTION DATA.

    WORD  DESCRIPTION
    ====  ======================================================================
      1   RECORD TO RESTART FROM (>=1).................................. =   41
      2   NUMBER OF MINOR EDIT PAIRS (<0 = PRINTER PLOTS) .............. =   31
      3   NUMBER OF TIME-STEP CONTROL SETS (03XXX0 DATA )............... =    3
      4   NUMBER OF TRIP CONTROL SETS (04XXX0 DATA )..................... =    1
      5   RESTART TYPE (NORMAL=0 / GENERALIZED=1) ...................... =    1
      6   SAVE NEW RESTART FILE (YES=0 / NO=-1).......................... =    0


RETRAN PROBLEM CONTROL AND DESCRIPTION DATA FOR THE INITIAL RETRAN RUN.

    WORD  DESCRIPTION
    ====  ======================================================================
      1   RESTART FILE OPTION (SAVE=-1 / NO SAVE=0) .................... =   -1
      2   NUMBER OF MINOR EDIT PAIRS (<0 = PRINTER PLOTS) .............. =   20
      3   NUMBER OF TIME-STEP CONTROL SETS (03XXX0 DATA )............... =    3
      4   NUMBER OF TRIP CONTROL SETS (04XXX0 DATA )..................... =   43
      5   NUMBER OF CONTROL VOLUME DESCRIPTIONS (05XXXY DATA )........... =   20
      6   NUMBER OF BUBBLE RISE DESCRIPTIONS (060XXY DATA) ............. =    2
      7   NUMBER OF TIME DEPENDENT VOLUMES FORM CARDS (07XXYY DATA) ..... =    0
      8   NUMBER OF JUNCTION DESCRIPTIONS (08XXXY DATA) ................ =   31
      9   NUMBER OF CENTRIFUGAL PUMP DESCRIPTIONS (090XXY DATA )......... =    1
     10   NUMBER OF VALVE DESCRIPTIONS (11XXXY DATA) ................... =   11
     11   NUMBER OF GENERAL DATA TABLE DESCRIPTIONS (12XXYY DATA) ....... =    8
     12   NUMBER OF FILL DESCRIPTIONS (13XXYY DATA )..................... =    7
     13   NUMBER OF HEAT CONDUCTOR DESCRIPTIONS (15XXXY DATA) ........... =    7
     14   NUMBER OF HEAT CONDUCTOR GEOMETRY DESCRIPTIONS (17XXYY DATA) .. =    2
     15   NUMBER OF HEAT CONDUCTOR MATERIAL DESCRIPTIONS (18XXYY DATA) .. =    4
     16   NUMBER OF CORE SECTION DESCRIPTIONS (16XXXY DATA) ............ =    3
     17   NUMBER OF NON-CONDUCTNG HEAT EXCHNGR DESCRIPTIONS (21XXYY DATA) =    3
     18   INPUT OPTION NO LONGER USED .................................. =
     19   POWER OPTION (TAPE OPTNS<0 / NO/TBL=0 / PT KIN=1 / 1D=2 / 3D=3) =    1
     20   INPUT OPTION NO LONGER USED .................................. =
     21   NONCONDENSABLE GAS FLOW OPTION (NO=0 / YES=1) ................ =    0
     22   NUMBER OF TIME DEP BCS FROM TAPE (IREAD<0 ON 05XXXY DATA) ..... =    0
     23   SLIP OPTION (DYN=1 / Z-L=2 / C-L=3 / Z-L TAUGL=4 / C-L TAUGL=5) =    0
     24   NUMBER OF SPECIFIED HEAT TRAN COEF DESCRIPTIONS (015XXX DATA) . =    0
     25   USE STEADY-STATE SOLUTION (YES=0 / NO=1) ..................... =    0
     26   TWO-REGION NONEQ VOL DESCRIPTIONS (610XXX DATA) .............. =    1
     27   TEMP. TRANSPORT DELAY OPTION (MESH>0 ON 05XXXY DATA) ......... =    0
     28   AUXILIARY DNB MODEL (8001XX DATA INCLUDED) ................... =    1
     29   CONTROL SYSTEM MODEL (702XXX OR 702XXXX DATA) ................ =    1
     30   HEAT TRANSFER MAP OPTION (FORCED=0 / NAT CONV=1) ............. =    1
     31   ACCUMULATOR MODEL DESCRIPTIONS (620XXX DATA) ................. =    0
     32   DYNAMIC GAP CONDUCTANCE MODEL DESCRIPTIONS (225XX0 DATA) ...... =    0
     33   TH MATRIX DIRECT SOLVER OPTION (4-EQ=2 / 6-EQ=3) ............. =    3
     34   NUMBER OF HT CONDUCTOR STACK DESCRIPTIONS (2200XY DATA) ....... =    0
     35   NUMBER OF TURBINE SHAFT DESCRIPTIONS (500XXY DATA) ........... =    0
     36   USE NEUTRON VOID MODEL (YES=1 / NO=0) ........................ =    0
     37   NUMBER OF PROFILE FIT DESCRIPTIONS (061XX1 DATA) ............. =    0
     38   INPUT OPTION NO LONGER USED .................................. =
     39   FIVE-EQUATION OPTION (NO= 0 / YES=1) ......................... =    0
     40   NUMBER OF STEAM-WATER SEPARATOR DESCRIPTIONS (60XXX0 DATA) .... =    0
     41   USE GENERALIZED TRANSPORT MODEL (NO=0 / VAP=1 / LIQ=-1) ....... =    0
     42   TH MATRIX ITERATIVE SOLVER OPTION (NO<=1 / YES=2) ............ =    0


                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * *                                                * * *
                   * * *          SLIP OPTION            =   0          * * *
                   * * *                                                * * *
                   * * *          NUMERICS OPTION        =   3          * * *
                   * * *                                                * * *
                   * * *          HEAT TRANSFER OPTION   =   1          * * *
                   * * *                                                * * *
                   * * *          NEW EQUATIONS OPTION   =   0          * * *
                   * * *                                                * * *
                   * * *         USING THE 6-EQ SOLVER - SOLVE4         * * *
                   * * *                                                * * *
                   * * *                                                * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *


AIR IS THE DEFAULT NONCONDENSABLE GAS.
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LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis           11:57:30
 UNCONTROLLED ROD WITHDRAWAL  --  RETRAN SAMPLE PROBLEM                                                       CPU TIME =    0.062
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	ENERGY BALANCE (BTU)	TOTAL MASS BALANCE (LBM)	NCG MASS BALANCE (LBM)	AVERAGE TIME STEP (SEC)	CURRENT TIME STEP (SEC)	ELAPSED TIME (SEC)	TIME STEP NUM STANDRD/ACTUL
8.09849E-01	1.81730E+03	6.23618E+09	2.84359E+08	4.88511E+05	0.00000E+00	0.00000E+00	1.94230E-02	3.00000E+00	120 131

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	VOID FRAC.	POWR TO H2O (BTU/SEC)
1	2.26364E+03	4.16898E+04	6.25086E+02	4.23548E+01	6.07618E+02	0.00000E+00	0.00000E+00	0.00000E+00
2001	2.24970E+03	3.12534E+03	6.24972E+02	4.23488E+01	6.07501E+02	0.00000E+00	0.00000E+00	0.00000E+00
2002	2.24975E+03	3.12628E+03	6.24784E+02	4.23616E+01	6.07374E+02	0.00000E+00	0.00000E+00	0.00000E+00
2003	2.24962E+03	3.12733E+03	6.24571E+02	4.23757E+01	6.07229E+02	0.00000E+00	0.00000E+00	0.00000E+00
2	2.24949E+03	3.12826E+03	6.24382E+02	4.23883E+01	6.07100E+02	0.00000E+00	0.00000E+00	0.00000E+00
3	2.25056E+03	1.72266E+04	6.23619E+02	4.24405E+01	6.06585E+02	0.00000E+00	0.00000E+00	0.00000E+00
4	2.24256E+03	2.64171E+04	6.07543E+02	4.34850E+01	5.95419E+02	0.00000E+00	0.00000E+00	-8.50011E+05
5	2.23321E+03	2.74217E+04	5.80479E+02	4.51386E+01	5.75728E+02	0.00000E+00	0.00000E+00	-5.71742E+05
6	2.22830E+03	2.80575E+04	5.62156E+02	4.61851E+01	5.61793E+02	0.00000E+00	0.00000E+00	-3.80985E+05
7	2.22860E+03	2.84702E+04	5.49737E+02	4.68645E+01	5.52092E+02	0.00000E+00	0.00000E+00	-2.52472E+05
8	2.22307E+03	3.77919E+04	5.44396E+02	4.71456E+01	5.47847E+02	0.00000E+00	0.00000E+00	0.00000E+00
9	2.27227E+03	2.71643E+04	5.44677E+02	4.71602E+01	5.48161E+02	0.00000E+00	0.00000E+00	9.36825E+03
10001	2.29313E+03	2.33788E+03	5.44677E+02	4.71726E+01	5.48199E+02	0.00000E+00	0.00000E+00	0.00000E+00
10002	2.29301E+03	2.33787E+03	5.44678E+02	4.71725E+01	5.48200E+02	0.00000E+00	0.00000E+00	0.00000E+00
10003	2.29289E+03	2.33787E+03	5.44679E+02	4.71724E+01	5.48200E+02	0.00000E+00	0.00000E+00	0.00000E+00
10004	2.29276E+03	2.33786E+03	5.44680E+02	4.71723E+01	5.48200E+02	0.00000E+00	0.00000E+00	0.00000E+00
10	2.29264E+03	2.33785E+03	5.44681E+02	4.71722E+01	5.48201E+02	0.00000E+00	0.00000E+00	0.00000E+00
11	2.29095E+03	3.72604E+04	5.44682E+02	4.71711E+01	5.48199E+02	0.00000E+00	0.00000E+00	0.00000E+00
12	2.29372E+03	3.80308E+04	5.44679E+02	4.71729E+01	5.48202E+02	0.00000E+00	0.00000E+00	0.00000E+00
13	2.27676E+03	2.01384E+03	5.44682E+02	4.71626E+01	5.48173E+02	0.00000E+00	0.00000E+00	0.00000E+00
14	2.28266E+03	7.78728E+03	5.56745E+02	4.65190E+01	5.57701E+02	0.00000E+00	0.00000E+00	6.31025E+05
15	2.27776E+03	7.49031E+03	5.87663E+02	4.47450E+01	5.81163E+02	0.00000E+00	0.00000E+00	9.77174E+05
16	2.27282E+03	7.16357E+03	6.18628E+02	4.27931E+01	6.03231E+02	0.00000E+00	0.00000E+00	6.28146E+05
17	2.24714E+03	2.39310E+02	5.44495E+02	4.71548E+01	5.47970E+02	0.00000E+00	0.00000E+00	0.00000E+00
19	2.24797E+03	1.09238E+03	6.81893E+02	3.81951E+01	6.43275E+02	0.00000E+00	0.00000E+00	0.00000E+00
20	8.86796E+02	9.49338E+04	6.18895E+02	1.11125E+01	5.29743E+02	1.40381E-01	7.98517E-01	2.05434E+06
110001	2.24553E+03	4.79903E+03	6.97800E+02	3.69156E+01	6.52198E+02	0.00000E+00	0.00000E+00	0.00000E+00
110002	2.24467E+03	4.79573E+03	6.98094E+02	3.68902E+01	6.52357E+02	0.00000E+00	0.00000E+00	0.00000E+00
110003	2.24380E+03	4.79560E+03	6.98090E+02	3.68893E+01	6.52351E+02	0.00000E+00	0.00000E+00	0.00000E+00
110004	2.24294E+03	4.79548E+03	6.98085E+02	3.68883E+01	6.52346E+02	0.00000E+00	0.00000E+00	0.00000E+00
110005	2.24207E+03	4.79536E+03	6.98080E+02	3.68874E+01	6.52341E+02	0.00000E+00	0.00000E+00	0.00000E+00
110006	2.24121E+03	4.79524E+03	6.98075E+02	3.68864E+01	6.52336E+02	0.00000E+00	0.00000E+00	0.00000E+00
110 LIQ REG	2.24031E+03	2.49804E+03	6.98065E+02	3.68858E+01	6.52328E+02	0.00000E+00	8.69763E-01	0.00000E+00
VAP REG		2.78972E+03	1.12112E+03	6.16818E+00	6.54024E+02	1.00000E+00		0.00000E+00

JUNCTION NUMBER	CONNECTS VOLUMES	CHOK/ PATH	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E VEL. PSI	ELEV. PSI	D I F F E R E N T I A L S FRIC. PSI	ACCL. PSI	PUMP PSI
1	1 TO 2001		2.72899E+04	6.25051E+02	2.36088E-02	-1.00150E+01	2.58857E-01	-4.25892E+00	-7.01277E-02	0.00000E+00
2001	2001 TO 2002		2.72986E+04	6.24877E+02	2.36099E-02	1.68322E-01	-1.25150E-04	-1.36217E-01	-5.74650E-03	0.00000E+00
2002	2002 TO 2003		2.70638E+04	6.24662E+02	2.36018E-02	-6.10330E-03	-1.37044E-04	-1.33992E-01	-2.04707E-03	0.00000E+00
2003	2003 TO 2		2.70720E+04	6.24461E+02	2.35944E-02	-4.89166E-03	-1.20779E-04	-1.34025E-01	-7.09209E-03	0.00000E+00
2	2 TO 3		2.70793E+04	6.24279E+02	2.35877E-02	9.69749E+00	-1.15928E+00	-7.48511E+00	-3.14679E-02	0.00000E+00
3	3 TO 4		2.71055E+04	6.23619E+02	2.35617E-02	-9.26328E-01	-2.98947E+00	-4.08880E+00	-4.46128E-03	0.00000E+00
4	4 TO 5		2.71374E+04	5.91409E+02	2.24764E-02	7.69838E-02	-4.57590E+00	-4.85579E+00	-6.02607E-03	0.00000E+00
5	5 TO 6		2.71646E+04	5.69519E+02	2.18467E-02	4.45318E-02	5.32997E-02	-5.01165E+00	-4.39241E-03	0.00000E+00
6	6 TO 7		2.71878E+04	5.54732E+02	2.14619E-02	2.67181E-02	4.80441E+00	-4.53716E+00	-3.76286E-03	0.00000E+00
7	7 TO 8		2.72099E+04	5.44682E+02	2.12163E-02	-5.83511E+00	5.11426E+00	-4.81115E+00	-1.01440E-02	0.00000E+00
8	8 TO 9		2.72183E+04	5.44333E+02	2.12095E-02	6.86002E+00	-4.11838E-02	-1.21921E+00	1.58634E-02	4.36132E+01
9	9 TO 10001		2.72167E+04	5.44677E+02	2.12044E-02	-1.10921E+01	-4.73239E-01	-1.11651E+01	1.37930E-02	4.36132E+01
10001	10001 TO 10002		2.72166E+04	5.44677E+02	2.11988E-02	3.18020E-03	8.53274E-07	-1.20983E-01	3.53920E-03	0.00000E+00
10002	10002 TO 10003		2.72164E+04	5.44678E+02	2.11988E-02	2.41456E-04	8.48575E-07	-1.20982E-01	3.72771E-03	0.00000E+00
10003	10003 TO 10004		2.72163E+04	5.44678E+02	2.11988E-02	2.78702E-04	1.21010E-06	-1.20981E-01	3.92425E-03	0.00000E+00
10004	10004 TO 10		2.72161E+04	5.44679E+02	2.11989E-02	4.22522E-04	1.16197E-06	-1.20979E-01	3.77617E-03	0.00000E+00
10	10 TO 11		2.72158E+04	5.44682E+02	2.11990E-02	9.14617E+00	2.13416E+00	-1.29512E+01	1.97895E-02	0.00000E+00
11	11 TO 12		2.72136E+04	5.44680E+02	2.11994E-02	1.94575E+00	4.94971E+00	-4.11246E+00	1.00543E-02	0.00000E+00
12	12 TO 13		8.57516E+02	5.44678E+02	2.11986E-02	-1.35761E-01	-3.57848E+00	-1.32447E+01	-3.04172E-04	0.00000E+00
13	12 TO 14		2.63540E+04	5.44679E+02	2.11986E-02	-8.53589E-01	-2.25946E+00	-7.93769E+00	4.25666E-03	0.00000E+00
14	14 TO 15		2.63462E+04	5.68863E+02	2.18127E-02	-6.67264E-02	-1.26751E+00	-3.57022E+00	1.31341E-03	0.00000E+00
15	15 TO 16		2.63271E+04	6.06490E+02	2.29450E-02	-7.65438E-02	-1.21576E+00	-3.64187E+00	5.91889E-04	0.00000E+00
16	16 TO 1		2.63172E+04	6.30580E+02	2.38141E-02	8.96718E-01	-2.29450E+00	-7.78711E+00	-2.10807E-03	0.00000E+00
17	13 TO 1		8.57398E+02	5.44681E+02	2.12033E-02	1.35778E-01	-3.66527E+00	-9.59055E+00	-3.36826E-04	0.00000E+00
18	10 TO 17		1.65878E-01	5.44682E+02	2.11990E-02	1.10916E+01	-7.46627E+00	-4.95835E+01	-3.11599E-03	0.00000E+00
19	17 TO 110		1.05223E-01	5.44418E+02	2.12051E-02	-7.79367E-06	-6.79659E+00	-1.70603E-02	1.61083E-02	0.00000E+00
20	19 TO 110001		2.14496E+02	6.82140E+02	2.61950E-02	7.41435E-05	-1.59665E+00	-1.06069E+00	-6.42857E-03	0.00000E+00
21	2002 TO 19		2.43824E+02	6.24662E+02	2.36018E-02	0.00000E+00	-1.10497E+00	-1.02618E+00	-1.24593E-01	0.00000E+00
110001	110001 TO 110002		2.02369E+02	6.98011E+02	2.71021E-02	1.05480E-05	-8.65396E-01	-4.83671E-07	1.39847E-04	0.00000E+00
110002	110002 TO 110003		1.97880E+02	6.98010E+02	2.71031E-02	7.09036E-06	-8.65100E-01	-4.64228E-07	-2.03429E-04	0.00000E+00
110003	110003 TO 110004		1.93387E+02	6.98010E+02	2.71040E-02	6.93590E-06	-8.65077E-01	-4.45126E-07	-2.01379E-04	0.00000E+00
110004	110004 TO 110005		1.88890E+02	6.98007E+02	2.71049E-02	6.78109E-06	-8.65055E-01	-4.26374E-07	-1.99608E-04	0.00000E+00
110005	110005 TO 110006		1.84389E+02	6.98007E+02	2.71058E-02	6.62593E-06	-8.65033E-01	-4.07971E-07	-1.98095E-04	0.00000E+00
110009	110006 TO 110		1.79884E+02	6.98007E+02	2.71068E-02	6.77359E-05	-8.82515E-01	-9.74806E-07	1.68242E-02	0.00000E+00
31	0 TO 20		0.00000E+00	6.17307E+02	8.88171E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
30	0 TO 20		0.00000E+00	6.17307E+02	8.88171E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
29	0 TO 20		0.00000E+00	6.17307E+02	8.88171E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
28	0 TO 20		0.00000E+00	6.17307E+02	8.88171E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
27	0 TO 20		0.00000E+00	6.17307E+02	8.88171E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
26	0 TO 110		0.00000E+00	1.12110E+03	1.62156E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
25	0 TO 110		0.00000E+00	1.12110E+03	1.62156E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
24	0 TO 10002		0.00000E+00	5.44678E+02	2.11988E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
23	0 TO 20		-2.73979E+03	1.19682E+03	5.11832E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
22	0 TO 20		2.73979E+03	4.17089E+02	1.91099E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

BUBL SET	VOL.	BUBBLE GRADIENT	BUBBLE VELOCITY	MIXTURE LEVEL	MIXTURE QUALITY	BUBBLE MASS

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NUMB.	NUMB.	PARAMETER	(FT/SEC)	(FT)		(LB)
1	110	1.00000E+00	1.00000E+00	1.75925E+00	0.00000E+00	0.00000E+00
2	20	0.00000E+00	1.41808E+01	6.19890E+01	0.00000E+00	1.30591E+04

PUMP NUMB.	VOL. NUMB.	PUMP SPEED (RPM)	NORM. PUMP TORQUE	NORM. FRIC. TORQUE	NORM. MOT. TORQUE	POWER TO H2O (BTU/HR)
1	9	1.18000E+03	9.94337E-01	0.00000E+00	0.00000E+00	3.37257E+07

HEAT COND. NUMBER	VOL. HT TRAN NUM.	MODE-COR	SURF. FLUX (BTU/HR-FT2)	CRIT. FLUX (BTU/HR-FT2)	H.T. COEF. (BTU/H-F2-F)	SURF. TEMP. (DEG. F)	MASS FLUX (LBM/HR-FT2)	STORD ENRGY (BTU)	POWR TO H20 (BTU/HR)	DRYOUT PNT ()
1 RGHT	14	1-DB-L	1.60504E+05	9.11599E+05	5.34107E+03	5.87764E+02	2.16808E+06	6.25935E+06	2.27169E+09	
2 RGHT	15	1-DB-L	2.48549E+05	9.12722E+05	5.44979E+03	6.26796E+02	2.16706E+06	8.21940E+06	3.51783E+09	
3 RGHT	16	1-DB-L	1.59772E+05	9.13857E+05	5.56603E+03	6.31946E+02	2.16605E+06	6.51631E+06	2.26132E+09	
4 LEFT	4	1-DB-L	-9.97020E+04	8.25021E+05	5.42992E+03	5.77045E+02	2.39076E+06		-3.06004E+09	
RGHT	20	2-THOM	8.82971E+04	2.54639E+05	8.34298E+03	5.40336E+02	2.90951E+05	4.50938E+06	3.05987E+09	
5 LEFT	5	1-DB-L	-6.70625E+04	8.27033E+05	5.33594E+03	5.63147E+02	2.39336E+06		-2.05827E+09	
RGHT	20	2-THOM	5.93822E+04	1.40568E+05	6.84188E+03	5.38432E+02	2.90951E+05	4.44231E+06	2.05785E+09	
6 LEFT	7	1-DB-L	-2.96137E+04	8.28257E+05	5.23663E+03	5.46425E+02	2.39758E+06		-9.08899E+08	
RGHT	20	2-THOM	2.61767E+04	1.40568E+05	4.54257E+03	5.35515E+02	2.90951E+05	4.35868E+06	9.07135E+08	
7 LEFT	6	1-DB-L	-4.46876E+04	8.28156E+05	5.27590E+03	5.53311E+02	2.39558E+06		-1.37155E+09	
RGHT	20	2-THOM	3.95554E+04	2.54639E+05	5.58404E+03	5.36837E+02	2.90951E+05	4.39372E+06	1.37076E+09	

CORE NUMB.	COND. NUMB.	DEPTH REAC. EXT. ZR-H2O (FT)	DEPTH REAC. INT. ZR-H2O (FT)	HEAT GEN. ZR-H2O (BTU/HR)	COND. HEAT-ING RATE (BTU/HR)	DIR. MODER-ATOR HT RT (BTU/HR)	AVG. METAL TEMPERATURE (DEG. F)	CENTERLINE TEMPERATURE (DEG. F)	FUEL ENTHALPY (CAL/GM)
1	1	0.00000E+00	0.00000E+00	0.00000E+00	1.74909E+09	0.00000E+00	1.27484E+03	1.63271E+03	0.00000E+00
2	2	0.00000E+00	0.00000E+00	0.00000E+00	2.70427E+09	0.00000E+00	1.66099E+03	2.31756E+03	0.00000E+00
3	3	0.00000E+00	0.00000E+00	0.00000E+00	1.74909E+09	0.00000E+00	1.31963E+03	1.68433E+03	0.00000E+00

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AVERAGE CORE (RETRAN)		MINIMUM HEIGHT (HOT CHANNEL)		HOT SPOT (HOT CHANNEL)		MINUMUM DNBR POSITION (HOT CHANNEL)		
LHGR(KW/FT)	DNBR	LHGR(KW/FT)	DNBR	LHGR(KW/FT)	DNBR	POS. (FT)	LHGR(KW/FT)	MDNBR
6.38641E+00	4.75600E+00	1.53658E+01	2.68786E+00	1.95004E+01	1.46471E+00	9.00000E+00	1.39638E+01	1.27071E+00

REACTOR PERIOD (SEC)	FISSION POWER	DECAY HEAT POWER	TOTAL REACTIVITY ($)	CONTROL REACTIVITY ($)	COOL. TEMP. REACTIVITY ($)	VOID REACTIVITY ($)	FUEL TEMP. REACTIVITY ($)	DOPPLER REACTIVITY ($)
-1.14316E+00	8.09849E-01	0.00000E+00	-2.94725E-01	-2.70785E-01	0.00000E+00	0.00000E+00	0.00000E+00	-2.39405E-02

HEAT EXCGR. NUMBER	VOLUME NUMBER	POWR TO H2O (BTU/HR)
1	110	0.00000E+00
2	110	0.00000E+00
3	110	0.00000E+00

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GENRST-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page    9
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis           11:57:30
 UNCONTROLLED ROD WITHDRAWAL  --  RETRAN SAMPLE PROBLEM                                                       CPU TIME =    0.343
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	ENERGY BALANCE (BTU)	TOTAL MASS BALANCE (LBM)	NCG MASS BALANCE (LBM)	AVERAGE TIME STEP (SEC)	CURRENT TIME STEP (SEC)	ELAPSED TIME (SEC)	TIME STEP NUM STANDRD/ACTUL
7.60959E-02	1.70759E+02	6.12904E+08	2.82546E+08	4.85345E+05	0.00000E+00	5.00000E-02	5.00000E-02	5.00000E+00	160 / 282

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	VOID FRAC.	POWR TO H2O (BTU/SEC)
1	2.41230E+03	4.06283E+04	6.43066E+02	4.12763E+01	6.19969E+02	0.00000E+00	0.00000E+00	0.00000E+00
2001	2.41057E+03	3.05775E+03	6.40787E+02	4.14329E+01	6.18482E+02	0.00000E+00	0.00000E+00	0.00000E+00
2002	2.41063E+03	3.07670E+03	6.37061E+02	4.16897E+01	6.16040E+02	0.00000E+00	0.00000E+00	0.00000E+00
2003	2.41054E+03	3.09514E+03	6.33396E+02	4.19396E+01	6.13614E+02	0.00000E+00	0.00000E+00	0.00000E+00
2	2.41059E+03	3.11102E+03	6.30213E+02	4.21547E+01	6.11489E+02	0.00000E+00	0.00000E+00	0.00000E+00
3	2.40981E+03	1.72320E+04	6.25724E+02	4.24538E+01	6.08460E+02	0.00000E+00	0.00000E+00	0.00000E+00
4	2.39081E+03	2.68479E+04	5.98210E+02	4.41941E+01	5.89139E+02	0.00000E+00	0.00000E+00	-5.65850E+05
5	2.35737E+03	2.78906E+04	5.68603E+02	4.59105E+01	5.67027E+02	0.00000E+00	0.00000E+00	-3.51179E+05
6	2.33044E+03	2.83531E+04	5.54490E+02	4.66718E+01	5.56031E+02	0.00000E+00	0.00000E+00	-2.48718E+05
7	2.30963E+03	2.86684E+04	5.44518E+02	4.71909E+01	5.48103E+02	0.00000E+00	0.00000E+00	-1.77660E+05
8	2.30202E+03	3.78524E+04	5.43857E+02	4.72211E+01	5.47561E+02	0.00000E+00	0.00000E+00	0.00000E+00
9	2.36073E+03	2.71779E+04	5.45232E+02	4.71838E+01	5.48766E+02	0.00000E+00	0.00000E+00	8.36186E+03
10001	2.41572E+03	2.34007E+03	5.45224E+02	4.72170E+01	5.48860E+02	0.00000E+00	0.00000E+00	0.00000E+00
10002	2.41569E+03	2.34011E+03	5.45210E+02	4.72177E+01	5.48849E+02	0.00000E+00	0.00000E+00	0.00000E+00
10003	2.41567E+03	2.34017E+03	5.45187E+02	4.72189E+01	5.48831E+02	0.00000E+00	0.00000E+00	0.00000E+00
10004	2.41564E+03	2.34024E+03	5.45158E+02	4.72203E+01	5.48808E+02	0.00000E+00	0.00000E+00	0.00000E+00
10	2.41561E+03	2.34031E+03	5.45129E+02	4.72218E+01	5.48785E+02	0.00000E+00	0.00000E+00	0.00000E+00
11	2.41724E+03	3.73013E+04	5.45129E+02	4.72228E+01	5.48787E+02	0.00000E+00	0.00000E+00	0.00000E+00
12	2.42191E+03	3.80717E+04	5.45167E+02	4.72236E+01	5.48826E+02	0.00000E+00	0.00000E+00	0.00000E+00
13	2.41684E+03	2.01619E+03	5.45226E+02	4.72175E+01	5.48864E+02	0.00000E+00	0.00000E+00	0.00000E+00
14	2.41863E+03	7.67238E+03	5.70724E+02	4.58326E+01	5.68783E+02	0.00000E+00	0.00000E+00	4.29351E+05
15	2.41697E+03	6.98240E+03	6.36848E+02	4.17109E+01	6.15918E+02	0.00000E+00	0.00000E+00	6.16417E+05
16	2.41533E+03	6.22701E+03	6.97510E+02	3.71984E+01	6.52555E+02	0.00000E+00	0.00000E+00	4.06914E+05
17	2.40915E+03	2.39439E+02	5.45854E+02	4.71800E+01	5.49351E+02	0.00000E+00	0.00000E+00	0.00000E+00
19	2.40259E+03	1.17166E+03	6.47320E+02	4.09672E+01	6.22683E+02	0.00000E+00	0.00000E+00	0.00000E+00
20	8.44237E+02	9.17821E+04	6.12107E+02	1.07435E+01	5.24000E+02	1.39074E-01	8.06342E-01	1.43911E+06
110001	2.39349E+03	4.91172E+03	6.89762E+02	3.77824E+01	6.48197E+02	0.00000E+00	0.00000E+00	0.00000E+00
110002	2.39260E+03	4.81748E+03	6.98833E+02	3.70575E+01	6.53207E+02	0.00000E+00	0.00000E+00	0.00000E+00
110003	2.39172E+03	4.81735E+03	6.98828E+02	3.70566E+01	6.53201E+02	0.00000E+00	0.00000E+00	0.00000E+00
110004	2.39085E+03	4.81723E+03	6.98824E+02	3.70556E+01	6.53196E+02	0.00000E+00	0.00000E+00	0.00000E+00
110005	2.38997E+03	4.81711E+03	6.98818E+02	3.70547E+01	6.53191E+02	0.00000E+00	0.00000E+00	0.00000E+00
110006	2.38909E+03	4.81699E+03	6.98813E+02	3.70538E+01	6.53185E+02	0.00000E+00	0.00000E+00	0.00000E+00
110 LIQ REG	2.38809E+03	3.41724E+03	6.98589E+02	3.70703E+01	6.53060E+02	0.00000E+00	8.22726E-01	0.00000E+00
VAP REG		2.77330E+03	1.12558E+03	6.48244E+00	6.68813E+02	1.00000E+00		0.00000E+00

JUNCTION NUMBER	CONNECTS VOLUMES	CHOK/ PATH	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E D I F F E R E N T I A L S VEL. PSI	ELEV. PSI	FRIC. PSI	ACCL. PSI	PUMP PSI
1	1 TO 2001		1.02717E+04	6.42318E+02	2.41975E-02	-1.46296E+00	2.52334E-01	-6.20782E-01	-1.69761E-01	0.00000E+00
2001	2001 TO 2002		1.03466E+04	6.38606E+02	2.40490E-02	1.09037E-01	-2.46715E-03	-2.25296E-02	-2.10180E-02	0.00000E+00
2002	2002 TO 2003		9.93088E+03	6.34536E+02	2.38888E-02	-1.62596E-02	-2.26229E-03	-2.08093E-02	-6.61757E-02	0.00000E+00
2003	2003 TO 2		9.97087E+03	6.31958E+02	2.37894E-02	-1.33233E-02	-2.15096E-03	-2.09881E-02	4.89056E-02	0.00000E+00
2	2 TO 3		1.00176E+04	6.28923E+02	2.36744E-02	1.33194E+00	-1.15758E+00	-1.03523E+00	-3.59268E-02	0.00000E+00
3	3 TO 4		1.00590E+04	6.25724E+02	2.35522E-02	0.00000E+00	-3.02588E+00	-1.60583E+01	-3.72584E-02	0.00000E+00
4	4 TO 5		9.95367E+03	5.75990E+02	2.19721E-02	0.00000E+00	-4.65079E+00	-2.88916E+01	-4.26189E-02	0.00000E+00
5	5 TO 6		9.70916E+03	5.59734E+02	2.15507E-02	0.00000E+00	3.91078E-02	-2.69708E+01	2.70642E-02	0.00000E+00
6	6 TO 7		9.54252E+03	5.48037E+02	2.12691E-02	0.00000E+00	4.84509E+00	-2.56484E+01	1.74151E-02	0.00000E+00
7	7 TO 8		9.42047E+03	5.40066E+02	2.10871E-02	0.00000E+00	5.13465E+00	-1.26977E+01	3.76299E-02	0.00000E+00
8	8 TO 9		9.36261E+03	5.44568E+02	2.11942E-02	8.17036E-01	-4.03729E-02	-1.51725E-01	3.14937E-02	5.81373E+01
9	9 TO 10001		9.35734E+03	5.45221E+02	2.11939E-02	-1.30791E+00	-4.73472E-01	-1.31831E+00	2.61688E-02	5.81373E+01
10001	10001 TO 10002		9.35680E+03	5.45222E+02	2.11792E-02	1.32898E-03	-6.05725E-06	-1.64176E-02	6.94935E-03	0.00000E+00
10002	10002 TO 10003		9.35631E+03	5.45207E+02	2.11789E-02	4.25563E-04	-1.01043E-05	-1.64151E-02	7.31638E-03	0.00000E+00
10003	10003 TO 10004		9.35590E+03	5.45184E+02	2.11784E-02	4.03560E-04	-1.26319E-05	-1.64128E-02	7.15857E-03	0.00000E+00
10004	10004 TO 10		9.35558E+03	5.45153E+02	2.11776E-02	9.07155E-04	-1.15837E-05	-1.64106E-02	7.46806E-03	0.00000E+00
10	10 TO 11		9.35312E+03	5.45127E+02	2.11770E-02	1.07825E+00	2.13648E+00	-1.52931E+00	3.58846E-02	0.00000E+00
11	11 TO 12		9.34278E+03	5.45151E+02	2.11772E-02	2.29213E-01	4.95506E+00	-4.85636E-01	2.07627E-02	0.00000E+00
12	12 TO 13		2.84711E+02	5.45161E+02	2.11761E-02	-1.48476E-02	-3.58246E+00	-1.47340E+00	1.14844E-05	0.00000E+00
13	12 TO 14		9.04766E+03	5.45167E+02	2.11761E-02	-1.02702E-01	-2.25142E+00	-9.46199E-01	-2.38706E-02	0.00000E+00
14	14 TO 15		8.99111E+03	5.97639E+02	2.25991E-02	-1.64040E-02	-1.21518E+00	-4.58101E-01	-1.95586E-02	0.00000E+00
15	15 TO 16		8.87936E+03	6.73947E+02	2.56182E-02	-2.47505E-02	-1.09599E+00	-4.90546E-01	-1.69094E-02	0.00000E+00
16	16 TO 1		8.99705E+03	7.13098E+02	2.78362E-02	1.13437E-01	-2.17594E+00	-1.08482E+00	-7.71499E-02	0.00000E+00
17	13 TO 1		2.84161E+02	5.45197E+02	2.11783E-02	1.49253E-02	-3.62618E+00	-1.06634E+00	-1.37186E-01	0.00000E+00
18	10 TO 17		2.07959E+00	5.45127E+02	2.11770E-02	1.30610E+00	-7.47039E+00	-6.06611E-03	4.66431E-01	0.00000E+00
19	17 TO 110		2.00598E+00	5.45432E+02	2.11860E-02	8.04137E-04	-6.79699E+00	-1.05610E+01	-3.00573E-01	0.00000E+00
20	19 TO 110001		4.73029E+02	6.47587E+02	2.44207E-02	1.11129E-04	-1.69120E+00	-4.31820E+01	1.30797E+00	0.00000E+00
21	2002 TO 19		4.83503E+02	6.34536E+02	2.38888E-02	0.00000E+00	-1.19041E+00	-3.65823E+00	1.22389E+00	0.00000E+00
110001	110001 TO 110002		4.29809E+02	6.98011E+02	2.69335E-02	1.93036E-05	-8.77385E-01	-1.74401E-06	1.47098E-02	0.00000E+00
110002	110002 TO 110003		4.36326E+02	6.98010E+02	2.69345E-02	-2.33522E-05	-8.69098E-01	-1.80022E-06	9.62971E-03	0.00000E+00
110003	110003 TO 110004		4.42836E+02	6.98010E+02	2.69354E-02	-2.38093E-05	-8.69075E-01	-1.85702E-06	1.27256E-02	0.00000E+00
110004	110004 TO 110005		4.49331E+02	6.98007E+02	2.69362E-02	-2.42669E-05	-8.69053E-01	-1.91478E-06	1.58139E-02	0.00000E+00
110005	110005 TO 110006		4.55797E+02	6.98007E+02	2.69372E-02	-2.47241E-05	-8.69031E-01	-1.97348E-06	1.88910E-02	0.00000E+00
110009	110006 TO 110		4.62227E+02	6.98007E+02	2.69381E-02	5.43599E-04	-1.04677E+00	-5.08280E-06	-8.41167E-03	0.00000E+00
31	0 TO 20		0.00000E+00	6.08312E+02	8.99687E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
30	0 TO 20		0.00000E+00	6.08312E+02	8.99687E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
29	0 TO 20		0.00000E+00	6.08312E+02	8.99687E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
28	0 TO 20		0.00000E+00	6.08312E+02	8.99687E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
27	0 TO 20		0.00000E+00	6.08312E+02	8.99687E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
26	0 TO 110		0.00000E+00	1.12564E+03	1.54156E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
25	0 TO 110		-1.19987E+02	1.12564E+03	1.54156E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
24	0 TO 10002		0.00000E+00	5.45201E+02	2.11787E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
23	0 TO 20		-2.73979E+03	1.19810E+03	5.38906E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
22	0 TO 20		0.00000E+00	6.08312E+02	8.99687E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

BUBL SET	VOL.	BUBBLE GRADIENT	BUBBLE VELOCITY	MIXTURE LEVEL	MIXTURE QUALITY	BUBBLE MASS

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   NUMB.  NUMB.  PARAMETER    (FT/SEC)     (FT)                    (LB)
      1    110   1.00000E+00  1.00000E+00  2.39462E+00  0.00000E+00  0.00000E+00
      2     20   0.00000E+00  1.41808E+01  6.05570E+01  1.33277E-01  1.21507E+04

   PUMP   VOL.   PUMP SPEED   NORM. PUMP   NORM. FRIC.  NORM. MOT.   POWER TO H2O
   NUMB.  NUMB.  (RPM)        TORQUE       TORQUE       TORQUE       (BTU/HR)
      1      9   1.18000E+03  8.87520E-01  0.00000E+00  0.00000E+00  3.01027E+07

  HEAT COND.   VOL. HT TRAN   SURF. FLUX   CRIT. FLUX   H.T. COEF.   SURF. TEMP.  MASS FLUX    STORD ENRGY  POWR TO H20  DRYOUT PNT
  NUMBER       NUM. MODE-COR  (BTU/HR-FT2) (BTU/HR-FT2) (BTU/H-F2-F) (DEG. F)     (LBM/HR-FT2) (BTU)        (BTU/HR)     ()
      1 RGHT     14   1-DB-L  1.09208E+05  6.30507E+05  2.28262E+03  6.16836E+02  7.40889E+05  5.53731E+06  1.54566E+09
      2 RGHT     15   2-THOM  1.56789E+05  6.29585E+05  2.96903E+03  6.69026E+02  7.34432E+05  7.10976E+06  2.21910E+09
      3 RGHT     16   2-THOM  1.03501E+05  6.30865E+05  6.53064E+03  6.68142E+02  7.36470E+05  5.80144E+06  1.46489E+09
      4 LEFT      4   1-DB-L -6.63714E+04  5.73084E+05  2.15400E+03  5.58409E+02  7.86725E+05              -2.03706E+09
        RGHT     20  17-T-SG  6.09158E+04  1.28761E+05  6.53252E+03  5.33478E+02  1.45475E+05  4.40058E+06  2.11099E+09
      5 LEFT      5   1-DB-L -4.11916E+04  5.83827E+05  2.08116E+03  5.47488E+02  7.72476E+05              -1.26424E+09
        RGHT     20  17-T-SG  3.93958E+04  9.00000E+04  5.26211E+03  5.31640E+02  1.45475E+05  4.34646E+06  1.36523E+09
      6 LEFT      7   1-DB-L -2.08387E+04  5.98295E+05  1.98901E+03  5.37759E+02  7.44532E+05              -6.39577E+08
        RGHT     20  17-T-SG  2.07971E+04  9.00000E+04  3.83140E+03  5.29581E+02  1.45475E+05  4.29594E+06  7.20707E+08
      7 LEFT      6   1-DB-L -2.91733E+04  5.91734E+05  2.02677E+03  5.41817E+02  7.56058E+05              -8.95384E+08
        RGHT     20  17-T-SG  2.83909E+04  1.28761E+05  4.47145E+03  5.30503E+02  1.45475E+05  4.31727E+06  9.83864E+08

   CORE   COND.  DEPTH REAC.  DEPTH REAC.  HEAT GEN.    COND. HEAT-  DIR. MODER-  AVG. METAL   CENTERLINE   FUEL
   NUMB.  NUMB.  EXT. ZR-H2O  INT. ZR-H2O  ZR-H2O       ING RATE     ATOR HT RT   TEMPERATURE  TEMPERATURE  ENTHALPY
                 (FT)         (FT)         (BTU/HR)     (BTU/HR)     (BTU/HR)     (DEG. F)     (DEG. F)     (CAL/GM)
      1      1   0.00000E+00  0.00000E+00  0.00000E+00  1.64350E+08  0.00000E+00  1.12051E+03  1.42653E+03  0.00000E+00
      2      2   0.00000E+00  0.00000E+00  0.00000E+00  2.54101E+08  0.00000E+00  1.43241E+03  2.00642E+03  0.00000E+00
      3      3   0.00000E+00  0.00000E+00  0.00000E+00  1.64350E+08  0.00000E+00  1.16620E+03  1.47910E+03  0.00000E+00
0         AVERAGE CORE            MINIMUM  HEIGHT              HOT  SPOT                    MINUMUM DNBR POSITION
            (RETRAN)               (HOT CHANNEL)               (HOT CHANNEL)                (HOT CHANNEL)
   LHGR(KW/FT)      DNBR      LHGR(KW/FT)      DNBR      LHGR(KW/FT)      DNBR      POS. (FT)    LHGR(KW/FT)  MDNBR
   4.09435E+00  5.11765E+00  9.55242E+00  2.36056E+00  1.20283E+01  1.00396E+00  1.20000E+01  2.00373E+00 -1.56476E+00

  REACTOR       FISSION       DECAY HEAT   TOTAL        CONTROL      COOL. TEMP.  VOID         FUEL TEMP.   DOPPLER
  PERIOD        POWER         POWER        REACTIVITY   REACTIVITY   REACTIVITY   REACTIVITY   REACTIVITY   REACTIVITY
  (SEC)                                    ($)          ($)          ($)          ($)          ($)          ($)
 -6.34489E+00  7.60959E-02  0.00000E+00 -8.30723E+00 -8.39922E+00  0.00000E+00  0.00000E+00  0.00000E+00  9.19900E-02

  HEAT EXCGR.   VOLUME   POWR TO H2O
  NUMBER        NUMBER   (BTU/HR)
      1         110001   0.00000E+00
      2         110001   0.00000E+00
      3         110001   0.00000E+00


  DATA RECORD NUMBER    61 WAS WRITTEN TO UNIT 14

  TRAILER LABEL WRITTEN ON UNIT 14
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GENRST-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   10
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis           11:57:30
 UNCONTROLLED ROD WITHDRAWAL  --  RETRAN SAMPLE PROBLEM                                                       CPU TIME =    0.343
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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SYSTEM ELAPSED TIME (SEC)	SYSTEM ELAPSED TIME (SEC)	TIME STP ACTUAL	VOL 4 AVG. PRESS. (PSIA)	VOL 5 AVG. PRESS. (PSIA)	VOL 6 AVG. PRESS. (PSIA)	VOL 7 AVG. PRESS. (PSIA)	VOL 20 AVG. PRESS. (PSIA)	SYSTEM NORM. POWER
3.00000E+00	3.00000E+00	1.31000E+02	2.24256E+03	2.23321E+03	2.22830E+03	2.22860E+03	8.86796E+02	8.09849E-01
3.05000E+00	3.05000E+00	1.46000E+02	2.39599E+03	2.26282E+03	2.13156E+03	2.00470E+03	8.86586E+02	7.75955E-01
3.10000E+00	3.10000E+00	1.54000E+02	2.28053E+03	2.19825E+03	2.12762E+03	2.07065E+03	8.86255E+02	7.44067E-01
3.15000E+00	3.15000E+00	1.58000E+02	2.28741E+03	2.23047E+03	2.18076E+03	2.13702E+03	8.85769E+02	6.89079E-01
3.20000E+00	3.20000E+00	1.62000E+02	2.26832E+03	2.21941E+03	2.17640E+03	2.13913E+03	8.85122E+02	6.40042E-01
3.25000E+00	3.25000E+00	1.66000E+02	2.25192E+03	2.20802E+03	2.17134E+03	2.14118E+03	8.84315E+02	5.96717E-01
3.30000E+00	3.30000E+00	1.70000E+02	2.25249E+03	2.21166E+03	2.17783E+03	2.15037E+03	8.83366E+02	5.58166E-01
3.35000E+00	3.35000E+00	1.75000E+02	2.25273E+03	2.21439E+03	2.18284E+03	2.15747E+03	8.82307E+02	5.08930E-01
3.40000E+00	3.40000E+00	1.80000E+02	2.25447E+03	2.21736E+03	2.18721E+03	2.16335E+03	8.81150E+02	4.66517E-01
3.45000E+00	3.45000E+00	1.85000E+02	2.26004E+03	2.22382E+03	2.19461E+03	2.17173E+03	8.79915E+02	4.29876E-01
3.50000E+00	3.50000E+00	1.89000E+02	2.26737E+03	2.23188E+03	2.20337E+03	2.18117E+03	8.78624E+02	3.97975E-01
3.55000E+00	3.55000E+00	1.95000E+02	2.27521E+03	2.24025E+03	2.21225E+03	2.19055E+03	8.77295E+02	3.58102E-01
3.60000E+00	3.60000E+00	2.00000E+02	2.28355E+03	2.24895E+03	2.22131E+03	2.19999E+03	8.75930E+02	3.24557E-01
3.65000E+00	3.65000E+00	2.05000E+02	2.29208E+03	2.25778E+03	2.23043E+03	2.20937E+03	8.74542E+02	2.96230E-01
3.70000E+00	3.70000E+00	2.10000E+02	2.30017E+03	2.26613E+03	2.23900E+03	2.21813E+03	8.73135E+02	2.71968E-01
3.75000E+00	3.75000E+00	2.16000E+02	2.30769E+03	2.27384E+03	2.24687E+03	2.22615E+03	8.71720E+02	2.41019E-01
3.80000E+00	3.80000E+00	2.22000E+02	2.31449E+03	2.28080E+03	2.25396E+03	2.23333E+03	8.70296E+02	2.15792E-01
3.85000E+00	3.85000E+00	2.28000E+02	2.32048E+03	2.28690E+03	2.26015E+03	2.23958E+03	8.68865E+02	1.94911E-01
3.90000E+00	3.90000E+00	2.33000E+02	2.32563E+03	2.29213E+03	2.26543E+03	2.24490E+03	8.67889E+02	1.77376E-01
3.95000E+00	3.95000E+00	2.40000E+02	2.33007E+03	2.29663E+03	2.26995E+03	2.24943E+03	8.66893E+02	1.54500E-01
4.00000E+00	4.00000E+00	2.47000E+02	2.33386E+03	2.30044E+03	2.27377E+03	2.25324E+03	8.65881E+02	1.36433E-01
4.05000E+00	4.05000E+00	2.55000E+02	2.33721E+03	2.30379E+03	2.27711E+03	2.25656E+03	8.64859E+02	1.16426E-01
4.10000E+00	4.10000E+00	2.62000E+02	2.34018E+03	2.30675E+03	2.28005E+03	2.25947E+03	8.63826E+02	1.01206E-01
4.15000E+00	4.15000E+00	2.64000E+02	2.34284E+03	2.30939E+03	2.28266E+03	2.26206E+03	8.62765E+02	9.32705E-02
4.20000E+00	4.20000E+00	2.65000E+02	2.34540E+03	2.31193E+03	2.28515E+03	2.26452E+03	8.61684E+02	9.00260E-02
4.25000E+00	4.25000E+00	2.66000E+02	2.34805E+03	2.31455E+03	2.28773E+03	2.26707E+03	8.60609E+02	8.82149E-02
4.30000E+00	4.30000E+00	2.67000E+02	2.35079E+03	2.31727E+03	2.29042E+03	2.26972E+03	8.59535E+02	8.71372E-02
4.35000E+00	4.35000E+00	2.69000E+02	2.35368E+03	2.32013E+03	2.29327E+03	2.27256E+03	8.58478E+02	8.61089E-02
4.40000E+00	4.40000E+00	2.70000E+02	2.35653E+03	2.32297E+03	2.29608E+03	2.27535E+03	8.57393E+02	8.50908E-02
4.45000E+00	4.45000E+00	2.71000E+02	2.35955E+03	2.32597E+03	2.29905E+03	2.27830E+03	8.56309E+02	8.41136E-02
4.50000E+00	4.50000E+00	2.72000E+02	2.36263E+03	2.32904E+03	2.30211E+03	2.28135E+03	8.55225E+02	8.31644E-02
4.55000E+00	4.55000E+00	2.73000E+02	2.36576E+03	2.33217E+03	2.30523E+03	2.28445E+03	8.54139E+02	8.22415E-02
4.60000E+00	4.60000E+00	2.74000E+02	2.36893E+03	2.33533E+03	2.30837E+03	2.28759E+03	8.53050E+02	8.13432E-02
4.65000E+00	4.65000E+00	2.75000E+02	2.37209E+03	2.33849E+03	2.31152E+03	2.29072E+03	8.51959E+02	8.06271E-02
4.70000E+00	4.70000E+00	2.76000E+02	2.37521E+03	2.34162E+03	2.31465E+03	2.29384E+03	8.50865E+02	7.99303E-02
4.75000E+00	4.75000E+00	2.77000E+02	2.37832E+03	2.34473E+03	2.31775E+03	2.29693E+03	8.49768E+02	7.92515E-02
4.80000E+00	4.80000E+00	2.78000E+02	2.38135E+03	2.34777E+03	2.32078E+03	2.29996E+03	8.48668E+02	7.85898E-02
4.85000E+00	4.85000E+00	2.79000E+02	2.38428E+03	2.35070E+03	2.32371E+03	2.30288E+03	8.47565E+02	7.79441E-02
4.90000E+00	4.90000E+00	2.80000E+02	2.38698E+03	2.35342E+03	2.32643E+03	2.30560E+03	8.46459E+02	7.73138E-02
4.95000E+00	4.95000E+00	2.81000E+02	2.38918E+03	2.35568E+03	2.32872E+03	2.30790E+03	8.45349E+02	7.66979E-02
5.00000E+00	5.00000E+00	2.82000E+02	2.39081E+03	2.35737E+03	2.33044E+03	2.30963E+03	8.44237E+02	7.60959E-02

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


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GENRST-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   11
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:30
 UNCONTROLLED ROD WITHDRAWAL  --  RETRAN SAMPLE PROBLEM                                                         CPU TIME =     0.343
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *
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SYSTEM ELAPSED TIME (SEC)	VOL 4 AVG. TEMP. (DEG F)	VOL 5 AVG. TEMP. (DEG F)	VOL 6 AVG. TEMP. (DEG F)	VOL 7 AVG. TEMP. (DEG F)	VOL 20 AVG. TEMP. (DEG F)	JUN 3 FLOW (LB/SEC)	JUN 4 FLOW (LB/SEC)	JUN 5 FLOW (LB/SEC)
3.00000E+00	5.95419E+02	5.75728E+02	5.61793E+02	5.52092E+02	5.29743E+02	2.71055E+04	2.71374E+04	2.71646E+04
3.05000E+00	5.96284E+02	5.75881E+02	5.61311E+02	5.51015E+02	5.29716E+02	2.07510E+04	2.13759E+04	2.13667E+04
3.10000E+00	5.95539E+02	5.75476E+02	5.61272E+02	5.51355E+02	5.29672E+02	1.72412E+04	1.75955E+04	1.75829E+04
3.15000E+00	5.95404E+02	5.75523E+02	5.61469E+02	5.51644E+02	5.29608E+02	1.44881E+04	1.41755E+04	1.39043E+04
3.20000E+00	5.95087E+02	5.75310E+02	5.61350E+02	5.51596E+02	5.29522E+02	1.27714E+04	1.27519E+04	1.27258E+04
3.25000E+00	5.94766E+02	5.75075E+02	5.61211E+02	5.51536E+02	5.29415E+02	1.20427E+04	1.18346E+04	1.16817E+04
3.30000E+00	5.94527E+02	5.74906E+02	5.61122E+02	5.51505E+02	5.29289E+02	1.15686E+04	1.12900E+04	1.10768E+04
3.35000E+00	5.94278E+02	5.74720E+02	5.61017E+02	5.51457E+02	5.29149E+02	1.11247E+04	1.08517E+04	1.06466E+04
3.40000E+00	5.94033E+02	5.74526E+02	5.60902E+02	5.51397E+02	5.28995E+02	1.08815E+04	1.05796E+04	1.03502E+04
3.45000E+00	5.93808E+02	5.74343E+02	5.60797E+02	5.51345E+02	5.28831E+02	1.07324E+04	1.04071E+04	1.01525E+04
3.50000E+00	5.93594E+02	5.74160E+02	5.60693E+02	5.51294E+02	5.28659E+02	1.06045E+04	1.02744E+04	1.00094E+04
3.55000E+00	5.93385E+02	5.73975E+02	5.60586E+02	5.51240E+02	5.28482E+02	1.05019E+04	1.01731E+04	9.90258E+03
3.60000E+00	5.93182E+02	5.73786E+02	5.60477E+02	5.51182E+02	5.28300E+02	1.04311E+04	1.01035E+04	9.82665E+03
3.65000E+00	5.92984E+02	5.73592E+02	5.60364E+02	5.51121E+02	5.28115E+02	1.03703E+04	1.00491E+04	9.76947E+03
3.70000E+00	5.92789E+02	5.73393E+02	5.60245E+02	5.51053E+02	5.27927E+02	1.03154E+04	1.00041E+04	9.72522E+03
3.75000E+00	5.92596E+02	5.73186E+02	5.60120E+02	5.50980E+02	5.27738E+02	1.02691E+04	9.96898E+03	9.69190E+03
3.80000E+00	5.92404E+02	5.72973E+02	5.59989E+02	5.50900E+02	5.27546E+02	1.02303E+04	9.94227E+03	9.66763E+03
3.85000E+00	5.92214E+02	5.72752E+02	5.59851E+02	5.50813E+02	5.27354E+02	1.01972E+04	9.92172E+03	9.65021E+03
3.90000E+00	5.92024E+02	5.72524E+02	5.59706E+02	5.50719E+02	5.27223E+02	1.01702E+04	9.90749E+03	9.63933E+03
3.95000E+00	5.91837E+02	5.72290E+02	5.59556E+02	5.50619E+02	5.27089E+02	1.01492E+04	9.89869E+03	9.63367E+03
4.00000E+00	5.91653E+02	5.72050E+02	5.59401E+02	5.50515E+02	5.26953E+02	1.01349E+04	9.89526E+03	9.63237E+03
4.05000E+00	5.91473E+02	5.71807E+02	5.59242E+02	5.50406E+02	5.26815E+02	1.01247E+04	9.89532E+03	9.63432E+03
4.10000E+00	5.91296E+02	5.71560E+02	5.59081E+02	5.50294E+02	5.26676E+02	1.01186E+04	9.89837E+03	9.63848E+03
4.15000E+00	5.91125E+02	5.71308E+02	5.58915E+02	5.50179E+02	5.26532E+02	1.01173E+04	9.90453E+03	9.64413E+03
4.20000E+00	5.90960E+02	5.71053E+02	5.58747E+02	5.50060E+02	5.26386E+02	1.01190E+04	9.91249E+03	9.65051E+03
4.25000E+00	5.90802E+02	5.70799E+02	5.58580E+02	5.49942E+02	5.26240E+02	1.01195E+04	9.91974E+03	9.65790E+03
4.30000E+00	5.90651E+02	5.70545E+02	5.58412E+02	5.49824E+02	5.26095E+02	1.01201E+04	9.92683E+03	9.66502E+03
4.35000E+00	5.90507E+02	5.70295E+02	5.58247E+02	5.49707E+02	5.25951E+02	1.01186E+04	9.93250E+03	9.67195E+03
4.40000E+00	5.90369E+02	5.70041E+02	5.58079E+02	5.49588E+02	5.25803E+02	1.01196E+04	9.93904E+03	9.67711E+03
4.45000E+00	5.90238E+02	5.69789E+02	5.57912E+02	5.49469E+02	5.25656E+02	1.01202E+04	9.94506E+03	9.68292E+03
4.50000E+00	5.90113E+02	5.69537E+02	5.57745E+02	5.49349E+02	5.25508E+02	1.01191E+04	9.94977E+03	9.68788E+03
4.55000E+00	5.89994E+02	5.69285E+02	5.57578E+02	5.49230E+02	5.25360E+02	1.01173E+04	9.95376E+03	9.69226E+03
4.60000E+00	5.89881E+02	5.69034E+02	5.57410E+02	5.49109E+02	5.25211E+02	1.01150E+04	9.95722E+03	9.69630E+03
4.65000E+00	5.89773E+02	5.68784E+02	5.57242E+02	5.48988E+02	5.25061E+02	1.01119E+04	9.96006E+03	9.69996E+03
4.70000E+00	5.89670E+02	5.68533E+02	5.57073E+02	5.48866E+02	5.24911E+02	1.01079E+04	9.96185E+03	9.70279E+03
4.75000E+00	5.89572E+02	5.68283E+02	5.56903E+02	5.48743E+02	5.24761E+02	1.01044E+04	9.96397E+03	9.70596E+03
4.80000E+00	5.89479E+02	5.68033E+02	5.56732E+02	5.48619E+02	5.24610E+02	1.01003E+04	9.96570E+03	9.70908E+03
4.85000E+00	5.89391E+02	5.67783E+02	5.56561E+02	5.48493E+02	5.24458E+02	1.00954E+04	9.96685E+03	9.71189E+03
4.90000E+00	5.89305E+02	5.67533E+02	5.56387E+02	5.48366E+02	5.24306E+02	1.00878E+04	9.96593E+03	9.71330E+03
4.95000E+00	5.89222E+02	5.67281E+02	5.56211E+02	5.48236E+02	5.24153E+02	1.00746E+04	9.96066E+03	9.71174E+03
5.00000E+00	5.89139E+02	5.67027E+02	5.56031E+02	5.48103E+02	5.24000E+02	1.00590E+04	9.95367E+03	9.70916E+03

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


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GENRST-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   12
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:30
 UNCONTROLLED ROD WITHDRAWAL  --  RETRAN SAMPLE PROBLEM                                                         CPU TIME =     0.343
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *
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SYSTEM ELAPSED TIME (SEC)	JUN 6 FLOW (LB/SEC)	JUN 7 FLOW (LB/SEC)	JUN 3 ENTHALPY (BTU/LB)	JUN 4 ENTHALPY (BTU/LB)	JUN 5 ENTHALPY (BTU/LB)	JUN 6 ENTHALPY (BTU/LB)	JUN 7 ENTHALPY (BTU/LB)	COND 4 LEFT HTC B/H-F-F2
3.00000E+00	2.71878E+04	2.72099E+04	6.23619E+02	5.91409E+02	5.69519E+02	5.54732E+02	5.44682E+02	5.42992E+03
3.05000E+00	2.11486E+04	2.09790E+04	6.24541E+02	5.91373E+02	5.69505E+02	5.54715E+02	5.44652E+02	3.97923E+03
3.10000E+00	1.72214E+04	1.65334E+04	6.24003E+02	5.91241E+02	5.69416E+02	5.54628E+02	5.44555E+02	3.43695E+03
3.15000E+00	1.36982E+04	1.35498E+04	6.24010E+02	5.90908E+02	5.69193E+02	5.54473E+02	5.44448E+02	2.96872E+03
3.20000E+00	1.26971E+04	1.26506E+04	6.23934E+02	5.90562E+02	5.68988E+02	5.54342E+02	5.44362E+02	2.66924E+03
3.25000E+00	1.15746E+04	1.14871E+04	6.23884E+02	5.90183E+02	5.68759E+02	5.54192E+02	5.44266E+02	2.50790E+03
3.30000E+00	1.09271E+04	1.08130E+04	6.23903E+02	5.89777E+02	5.68517E+02	5.54035E+02	5.44165E+02	2.41564E+03
3.35000E+00	1.05103E+04	1.04117E+04	6.23923E+02	5.89355E+02	5.68271E+02	5.53876E+02	5.44065E+02	2.34033E+03
3.40000E+00	1.01981E+04	1.00892E+04	6.23953E+02	5.88918E+02	5.68018E+02	5.53712E+02	5.43961E+02	2.29031E+03
3.45000E+00	9.98140E+03	9.85773E+03	6.24000E+02	5.88470E+02	5.67760E+02	5.53544E+02	5.43855E+02	2.26002E+03
3.50000E+00	9.83111E+03	9.70221E+03	6.24056E+02	5.88014E+02	5.67500E+02	5.53374E+02	5.43747E+02	2.24154E+03
3.55000E+00	9.72118E+03	9.59039E+03	6.24108E+02	5.87554E+02	5.67239E+02	5.53204E+02	5.43638E+02	2.21953E+03
3.60000E+00	9.64080E+03	9.50654E+03	6.24166E+02	5.87091E+02	5.66978E+02	5.53031E+02	5.43528E+02	2.20837E+03
3.65000E+00	9.58203E+03	9.44676E+03	6.24228E+02	5.86627E+02	5.66717E+02	5.52858E+02	5.43418E+02	2.19709E+03
3.70000E+00	9.53930E+03	9.40563E+03	6.24289E+02	5.86163E+02	5.66457E+02	5.52685E+02	5.43306E+02	2.18726E+03
3.75000E+00	9.50821E+03	9.37663E+03	6.24347E+02	5.85699E+02	5.66196E+02	5.52510E+02	5.43193E+02	2.18039E+03
3.80000E+00	9.48652E+03	9.35728E+03	6.24402E+02	5.85238E+02	5.65937E+02	5.52335E+02	5.43079E+02	2.17367E+03
3.85000E+00	9.47244E+03	9.34629E+03	6.24453E+02	5.84779E+02	5.65677E+02	5.52160E+02	5.42964E+02	2.16811E+03
3.90000E+00	9.46479E+03	9.34141E+03	6.24500E+02	5.84324E+02	5.65418E+02	5.51983E+02	5.42848E+02	2.16464E+03
3.95000E+00	9.46213E+03	9.34132E+03	6.24546E+02	5.83871E+02	5.65158E+02	5.51805E+02	5.42730E+02	2.16143E+03
4.00000E+00	9.46300E+03	9.34397E+03	6.24589E+02	5.83422E+02	5.64898E+02	5.51627E+02	5.42611E+02	2.15918E+03
4.05000E+00	9.46672E+03	9.34904E+03	6.24629E+02	5.82978E+02	5.64638E+02	5.51448E+02	5.42491E+02	2.15796E+03
4.10000E+00	9.47195E+03	9.35500E+03	6.24667E+02	5.82539E+02	5.64377E+02	5.51268E+02	5.42370E+02	2.15725E+03
4.15000E+00	9.47742E+03	9.36020E+03	6.24701E+02	5.82114E+02	5.64122E+02	5.51090E+02	5.42248E+02	2.15726E+03
4.20000E+00	9.48299E+03	9.36499E+03	6.24731E+02	5.81706E+02	5.63871E+02	5.50916E+02	5.42128E+02	2.15723E+03
4.25000E+00	9.49003E+03	9.37129E+03	6.24766E+02	5.81306E+02	5.63624E+02	5.50743E+02	5.42009E+02	2.15769E+03
4.30000E+00	9.49668E+03	9.37706E+03	6.24806E+02	5.80912E+02	5.63376E+02	5.50569E+02	5.41888E+02	2.15801E+03
4.35000E+00	9.50377E+03	9.38361E+03	6.24848E+02	5.80512E+02	5.63118E+02	5.50389E+02	5.41763E+02	2.15814E+03
4.40000E+00	9.50766E+03	9.38625E+03	6.24889E+02	5.80128E+02	5.62865E+02	5.50212E+02	5.41639E+02	2.15836E+03
4.45000E+00	9.51258E+03	9.39002E+03	6.24938E+02	5.79751E+02	5.62613E+02	5.50035E+02	5.41514E+02	2.15870E+03
4.50000E+00	9.51699E+03	9.39353E+03	6.24989E+02	5.79379E+02	5.62359E+02	5.49858E+02	5.41388E+02	2.15897E+03
4.55000E+00	9.52090E+03	9.39666E+03	6.25044E+02	5.79013E+02	5.62104E+02	5.49680E+02	5.41262E+02	2.15898E+03
4.60000E+00	9.52457E+03	9.39968E+03	6.25103E+02	5.78654E+02	5.61847E+02	5.49500E+02	5.41133E+02	2.15890E+03
4.65000E+00	9.52802E+03	9.40263E+03	6.25168E+02	5.78300E+02	5.61588E+02	5.49320E+02	5.41004E+02	2.15873E+03
4.70000E+00	9.53073E+03	9.40493E+03	6.25230E+02	5.77952E+02	5.61328E+02	5.49139E+02	5.40873E+02	2.15846E+03
4.75000E+00	9.53377E+03	9.40761E+03	6.25296E+02	5.77610E+02	5.61066E+02	5.48958E+02	5.40742E+02	2.15803E+03
4.80000E+00	9.53697E+03	9.41064E+03	6.25372E+02	5.77275E+02	5.60803E+02	5.48775E+02	5.40609E+02	2.15768E+03
4.85000E+00	9.54001E+03	9.41366E+03	6.25453E+02	5.76945E+02	5.60539E+02	5.48592E+02	5.40475E+02	2.15725E+03
4.90000E+00	9.54219E+03	9.41632E+03	6.25541E+02	5.76621E+02	5.60272E+02	5.48408E+02	5.40340E+02	2.15672E+03
4.95000E+00	9.54253E+03	9.41822E+03	6.25624E+02	5.76303E+02	5.60004E+02	5.48223E+02	5.40203E+02	2.15578E+03
5.00000E+00	9.54252E+03	9.42047E+03	6.25724E+02	5.75990E+02	5.59734E+02	5.48037E+02	5.40066E+02	2.15400E+03

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GENRST-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   13
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis             11:57:30
 UNCONTROLLED ROD WITHDRAWAL  --  RETRAN SAMPLE PROBLEM                                                          CPU TIME =     0.343
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *
```

SYSTEM ELAPSED TIME (SEC)	COND 5 LEFT HTC B/H-F-F2	COND 6 LEFT HTC B/H-F-F2	COND 7 LEFT HTC B/H-F-F2	COND 4 RIGHT HTC B/H-F-F2	COND 5 RIGHT HTC B/H-F-F2	COND 6 RIGHT HTC B/H-F-F2	COND 7 RIGHT HTC B/H-F-F2
3.00000E+00	5.33594E+03	5.23663E+03	5.27590E+03	8.34298E+03	6.84188E+03	4.54257E+03	5.58404E+03
3.05000E+00	3.92091E+03	3.75959E+03	3.83329E+03	8.28466E+03	6.79145E+03	4.51737E+03	5.54750E+03
3.10000E+00	3.42381E+03	3.28444E+03	3.37577E+03	8.16450E+03	6.69158E+03	4.43607E+03	5.46005E+03
3.15000E+00	2.85989E+03	2.71070E+03	2.77551E+03	8.01585E+03	6.57698E+03	4.35604E+03	5.36665E+03
3.20000E+00	2.61552E+03	2.55234E+03	2.57913E+03	7.84745E+03	6.44488E+03	4.28350E+03	5.26657E+03
3.25000E+00	2.43715E+03	2.35749E+03	2.39026E+03	7.68276E+03	6.31899E+03	4.22423E+03	5.17614E+03
3.30000E+00	2.33168E+03	2.23545E+03	2.27479E+03	7.53960E+03	6.20852E+03	4.17541E+03	5.09784E+03
3.35000E+00	2.25872E+03	2.16750E+03	2.20420E+03	7.40966E+03	6.10379E+03	4.12373E+03	5.02011E+03
3.40000E+00	2.20541E+03	2.11048E+03	2.14854E+03	7.31223E+03	6.02737E+03	4.09350E+03	4.96706E+03
3.45000E+00	2.17120E+03	2.06989E+03	2.11073E+03	7.24058E+03	5.97189E+03	4.07639E+03	4.93080E+03
3.50000E+00	2.15181E+03	2.04867E+03	2.09028E+03	7.15178E+03	5.89486E+03	4.03088E+03	4.86932E+03
3.55000E+00	2.12968E+03	2.02566E+03	2.06759E+03	7.11198E+03	5.86599E+03	4.03203E+03	4.85531E+03
3.60000E+00	2.11829E+03	2.01319E+03	2.05559E+03	7.05443E+03	5.81553E+03	4.00474E+03	4.81625E+03
3.65000E+00	2.10733E+03	2.00177E+03	2.04435E+03	7.02610E+03	5.79408E+03	4.00583E+03	4.80603E+03
3.70000E+00	2.09860E+03	1.99382E+03	2.03602E+03	7.00674E+03	5.78016E+03	4.01181E+03	4.80211E+03
3.75000E+00	2.09284E+03	1.98896E+03	2.03074E+03	6.96541E+03	5.74263E+03	3.99190E+03	4.77342E+03
3.80000E+00	2.08747E+03	1.98477E+03	2.02601E+03	6.95261E+03	5.73398E+03	4.00126E+03	4.77405E+03
3.85000E+00	2.08341E+03	1.98218E+03	2.02273E+03	6.94928E+03	5.73343E+03	4.01663E+03	4.78178E+03
3.90000E+00	2.08111E+03	1.98102E+03	2.02106E+03	6.89930E+03	5.68315E+03	3.97737E+03	4.73730E+03
3.95000E+00	2.07924E+03	1.98046E+03	2.01991E+03	6.87641E+03	5.65982E+03	3.96502E+03	4.71993E+03
4.00000E+00	2.07819E+03	1.98051E+03	2.01947E+03	6.86871E+03	5.65158E+03	3.96810E+03	4.71793E+03
4.05000E+00	2.07787E+03	1.98096E+03	2.01960E+03	6.84373E+03	5.62530E+03	3.95286E+03	4.69776E+03
4.10000E+00	2.07795E+03	1.98165E+03	2.02004E+03	6.82467E+03	5.60536E+03	3.94511E+03	4.68462E+03
4.15000E+00	2.07827E+03	1.98207E+03	2.02041E+03	6.80058E+03	5.57945E+03	3.92861E+03	4.66410E+03
4.20000E+00	2.07851E+03	1.98243E+03	2.02075E+03	6.77634E+03	5.55235E+03	3.90666E+03	4.64003E+03
4.25000E+00	2.07924E+03	1.98308E+03	2.02144E+03	6.76566E+03	5.54284E+03	3.91115E+03	4.63830E+03
4.30000E+00	2.07999E+03	1.98398E+03	2.02235E+03	6.75042E+03	5.52773E+03	3.91006E+03	4.63098E+03
4.35000E+00	2.08087E+03	1.98527E+03	2.02362E+03	6.73130E+03	5.50913E+03	3.91131E+03	4.62335E+03
4.40000E+00	2.08128E+03	1.98571E+03	2.02406E+03	6.71108E+03	5.48518E+03	3.89518E+03	4.60397E+03
4.45000E+00	2.08178E+03	1.98603E+03	2.02450E+03	6.69842E+03	5.47103E+03	3.89470E+03	4.59756E+03
4.50000E+00	2.08229E+03	1.98653E+03	2.02509E+03	6.68317E+03	5.45365E+03	3.89099E+03	4.58790E+03
4.55000E+00	2.08262E+03	1.98696E+03	2.02555E+03	6.66754E+03	5.43537E+03	3.88626E+03	4.57730E+03
4.60000E+00	2.08283E+03	1.98731E+03	2.02593E+03	6.65190E+03	5.41665E+03	3.88101E+03	4.56623E+03
4.65000E+00	2.08298E+03	1.98764E+03	2.02625E+03	6.63635E+03	5.39765E+03	3.87541E+03	4.55487E+03
4.70000E+00	2.08303E+03	1.98794E+03	2.02652E+03	6.62096E+03	5.37848E+03	3.86958E+03	4.54329E+03
4.75000E+00	2.08294E+03	1.98812E+03	2.02667E+03	6.60576E+03	5.35920E+03	3.86355E+03	4.53158E+03
4.80000E+00	2.08289E+03	1.98836E+03	2.02686E+03	6.59072E+03	5.33983E+03	3.85737E+03	4.51972E+03
4.85000E+00	2.08281E+03	1.98864E+03	2.02706E+03	6.57588E+03	5.32041E+03	3.85103E+03	4.50776E+03
4.90000E+00	2.08266E+03	1.98890E+03	2.02723E+03	6.56126E+03	5.30099E+03	3.84459E+03	4.49573E+03
4.95000E+00	2.08222E+03	1.98906E+03	2.02720E+03	6.54684E+03	5.28157E+03	3.83805E+03	4.48364E+03
5.00000E+00	2.08116E+03	1.98901E+03	2.02677E+03	6.53252E+03	5.26211E+03	3.83140E+03	4.47145E+03

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IX

REEDIT SAMPLE PROBLEMS

The use of the REEDIT program module is briefly discussed in Section II.3.0. As examples which illustrate the use of REEDIT, the Turbine Trip Without Bypass With Point Kinetics and the Uncontrolled Rod Withdrawal models have been used. These examples correspond to previous RETRAN sample problems (Sections VII.5.0 and VII.6.0) and to the previous RESTRT sample problems (Section VIII).

1.0 TURBINE TRIP WITHOUT BYPASS WITH POINT KINETICS

The Turbine Trip Without Bypass With Point Kinetics REEDIT example employs the restart-plot data file created by the RESTRT example (Section VIII.1.0). The input listing and selected output are given below.

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```
LISTING OF INPUT DATA FOR CASE  1

    1    =TTWOB WITH POINT KINETICS -- RETRAN SAMPLE PROBLEM
    2    *
    3    *10001 LDMP NEDI NEDF NPLOT
    4    010001  -2    7    1     0
    5    *
    6    * MINOR EDIT CARDS
    7    *
    8    020000 TIMX 0, WP**, 24 WP**, 17 MIXL, 9 RD**, 0 RF**, 0 RV**, 0
    9    *
   10    * EDIT FREQUENCY CARD
   11    *
   12    *3XXX0 NRTG NMIN NMAJ TLAST
   13    030010   0    1    5   2.0
   14    *
   15    * FORMAT FOR TAPE60
   16    *
   17    025000 1
   18    025001 '(5(1X,1P,E15.7))'
   19    *
   20    . END
```


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```
REEDIT-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page    1
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:24
 TTWOB WITH POINT KINETICS -- RETRAN SAMPLE PROBLEM                                                             CPU TIME =    0.000
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *

REEDIT PROBLEM CONTROL AND DESCRIPTION DATA.

    WORD  DESCRIPTION
    ====  ======================================================================
      1   REEDIT REQUEST FLAG (=-2) ..................................... =   11
      2   NUMBER OF MINOR EDIT PAIRS (<0 = PRINTER PLOTS) .............. =    7
      3   NUMBER OF EDIT FREQUENCY SETS (03XXX0 DATA) .................. =    1
      4   RESTART RECORD WHERE REEDIT (>=1) ............................ =    1

0DATA FOR  1 EDIT FREQUENCY SETS.
0 SET DATA DATA  MIN  END
  NUM  PER  PER  PER  OF
       VBC  MIN  MAJ  INTERVAL

   1    0    1    5   2.000000E+00


 AIR IS THE DEFAULT NONCONDENSABLE GAS.
```


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REEDIT-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page    5
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis           11:57:24
 TTWOB WITH POINT KINETICS -- RETRAN SAMPLE PROBLEM                                                          CPU TIME =    0.000
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
```

NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	ENERGY BALANCE (BTU)	TOTAL MASS BALANCE (LBM)	NCG MASS BALANCE (LBM)	AVERAGE TIME STEP (SEC)	CURRENT TIME STEP (SEC)	ELAPSED TIME (SEC)	TIME STEP NUM STANDRD/ACTUL
1.00000E+00	2.53340E+03	8.67334E+09	2.36764E+12	2.13941E+09	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0 0

VOLUME NUMBER		AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	VOID FRAC.	POWR TO H2O (BTU/SEC)
1		1.05977E+03	1.26720E+05	5.26350E+02	4.74142E+01	5.31475E+02	0.00000E+00	0.00000E+00	0.00000E+00
2		1.03384E+03	1.08182E+04	5.48511E+02	4.51739E+01	5.48261E+02	1.20833E-03	2.36212E-02	8.94189E+05
3		1.03103E+03	5.51125E+03	5.81407E+02	2.30134E+01	5.47926E+02	5.29153E-02	5.28575E-01	9.11590E+05
4		1.02704E+03	4.03092E+03	6.05560E+02	1.68320E+01	5.47448E+02	9.12273E-02	6.69380E-01	5.55446E+05
5		1.02890E+03	9.56124E+03	5.32344E+02	4.70719E+01	5.36198E+02	0.00000E+00	0.00000E+00	1.65122E+04
6		1.02759E+03	9.43075E+03	5.43846E+02	4.64295E+01	5.45233E+02	0.00000E+00	0.00000E+00	1.51753E+04
7		1.02632E+03	8.96130E+03	5.48231E+02	4.41183E+01	5.47361E+02	2.54401E-03	4.89653E-02	8.89185E+03
8		1.02457E+03	1.34178E+04	6.13230E+02	1.54657E+01	5.47151E+02	1.03623E-01	7.00489E-01	-9.71613E+01
9	LIQ REG	1.01936E+03	2.69705E+04	5.47482E+02	4.37641E+01	5.46523E+02	3.02561E-03	7.99303E-01	0.00000E+00
	VAP REG		5.23962E+03	1.18574E+03	2.29679E+00	5.46523E+02	9.90000E-01		0.00000E+00
10		1.01948E+03	8.32486E+03	1.18574E+03	2.29708E+00	5.46538E+02	9.90007E-01	9.99505E-01	0.00000E+00
11		1.01992E+03	3.25469E+03	6.12838E+02	1.53805E+01	5.46592E+02	1.03972E-01	7.02498E-01	-2.30398E+03
12		1.02604E+03	1.64916E+05	5.26001E+02	4.74130E+01	5.31144E+02	0.00000E+00	0.00000E+00	2.40114E+03
13		1.05750E+03	9.26257E+03	5.26350E+02	4.74128E+01	5.31471E+02	0.00000E+00	0.00000E+00	0.00000E+00
14		1.01175E+03	1.47732E+03	1.18574E+03	2.27876E+00	5.45603E+02	9.89583E-01	9.99488E-01	0.00000E+00
15		1.00644E+03	1.00734E+03	1.18574E+03	2.26617E+00	5.44957E+02	9.89294E-01	9.99478E-01	0.00000E+00
16		9.60100E+02	5.00999E+03	1.18574E+03	2.15673E+00	5.39207E+02	9.86894E-01	9.99396E-01	0.00000E+00
17		9.64096E+02	2.34657E+02	1.18574E+03	2.16614E+00	5.39710E+02	9.87093E-01	9.99402E-01	0.00000E+00
18		1.11532E+03	2.56788E+04	5.26786E+02	4.74234E+01	5.31910E+02	0.00000E+00	0.00000E+00	7.45813E+03
19		1.18112E+03	2.81509E+04	5.26786E+02	4.74619E+01	5.32012E+02	0.00000E+00	0.00000E+00	0.00000E+00
20		9.57778E+02	2.13894E+09	1.18966E+03	2.13894E+00	5.38913E+02	9.92734E-01	9.99668E-01	0.00000E+00

JUNCTION NUMBER	CONNECTS VOLUMES	CHOK/ PATH	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E VEL. PSI	ELEV. PSI	D I F F E R E N T I A L S FRIC. PSI	ACCL. PSI	PUMP PSI
1	1 TO	2	2.00115E+04	5.26350E+02	2.10907E-02	-3.60807E-01	-3.48873E+00	-2.20841E+01	-7.32034E-09	0.00000E+00
2	2 TO	3	2.00115E+04	5.65602E+02	3.30487E-02	-3.97154E-01	-9.47046E-01	-1.46724E+00	-2.46072E-08	0.00000E+00
3	3 TO	4	2.00115E+04	5.96830E+02	5.33228E-02	-4.02603E-01	-5.53408E-01	-3.03080E+00	-1.44930E-08	0.00000E+00
4	4 TO	8	2.00115E+04	6.14301E+02	6.50233E-02	3.07020E-01	-5.79233E-01	-2.20202E+00	2.89706E-08	0.00000E+00
5	1 TO	5	1.37744E+03	5.26350E+02	2.10907E-02	3.70285E-02	-3.51509E+00	-2.73928E+01	-4.38081E-11	0.00000E+00
6	5 TO	6	1.37744E+03	5.38338E+02	2.13946E-02	-9.16953E-05	-1.29863E+00	-1.19231E-02	-5.18724E-10	0.00000E+00
7	6 TO	7	1.37744E+03	5.47518E+02	2.20882E-02	-1.95430E-04	-1.25761E+00	-1.35396E-02	-1.19132E-09	0.00000E+00
8	7 TO	8	1.37744E+03	5.49012E+02	2.31686E-02	-6.17734E-01	-9.58209E-01	-1.77330E-01	-1.50285E-09	0.00000E+00
9	11 TO	9	2.13889E+04	6.12838E+02	6.50175E-02	2.99433E+00	-1.96250E+00	-1.60150E+00	8.83940E-09	0.00000E+00
10	9 TO	10	3.05410E+03	1.18574E+03	4.35391E-01	2.77250E-01	-1.16626E-01	-3.61521E-02	-4.14932E-11	0.00000E+00
11	18 TO	19	9.50000E+03	5.26786E+02	2.10866E-02	7.53022E-02	-2.91766E+00	-1.89627E+01	1.06780E-08	8.76006E+01
12	8 TO	11	2.13889E+04	6.13230E+02	6.46591E-02	-2.73750E+00	-6.38003E-01	-1.26472E+00	-5.14690E-09	0.00000E+00
13	12 TO	13	1.18889E+04	5.26001E+02	2.10913E-02	-1.42094E+00	2.86782E+00	-5.81919E+00	-6.24615E-10	3.58358E+01
14	19 TO	13	9.50000E+03	5.26786E+02	2.10695E-02	6.31313E+00	-5.01036E+00	-4.88114E+01	2.25292E-09	-7.61103E+01
15	12 TO	18	9.50000E+03	5.26001E+02	2.10913E-02	-3.98059E+00	1.07821E+01	-5.11517E+00	1.70960E-08	8.76006E+01
16	13 TO	1	2.13889E+04	5.26350E+02	2.10913E-02	4.91656E-01	2.89087E+00	-1.11134E+00	-9.84730E-10	0.00000E+00
17	10 TO	14	3.05410E+03	1.18574E+03	4.35335E-01	-4.29100E+00	4.86934E-01	-3.92105E+00	1.79944E-10	0.00000E+00
18	14 TO	15	3.05410E+03	1.18574E+03	4.38835E-01	-5.81603E-02	4.90513E-01	-5.74679E+00	5.24639E-11	0.00000E+00
19	15 TO	16	3.05410E+03	1.18574E+03	4.41274E-01	-2.43152E-01	2.27953E-01	-4.63248E+01	4.41881E-10	0.00000E+00
20	16 TO	17	0.00000E+00	1.18574E+03	4.61652E-01	4.34084E+00	-3.45144E-01	0.00000E+00	-1.34037E-10	0.00000E+00
21	9 TO	12	1.83348E+04	5.47379E+02	2.27832E-02	2.28122E-01	6.64616E+00	-1.92960E-01	-1.87637E-09	0.00000E+00
22	16 TO	20	3.05410E+03	1.18574E+03	4.63666E-01	4.32111E+00	-3.05783E-01	-6.33774E+00	-6.62295E-11	0.00000E+00
26	0 TO	14	0.00000E+00	1.18574E+03	4.38835E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
25	0 TO	14	0.00000E+00	1.18574E+03	4.38835E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
24	0 TO	12	3.20872E+03	3.96877E+02	1.89228E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
23	0 TO	14	0.00000E+00	1.18574E+03	4.38835E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

JUNCTION NUMBER	FLOW REG.	SLIP VEL. (FT/SEC)	VOID FRACTION	LIQUID FLOW (LB/SEC)	GAS FLOW (LB/SEC)	SLIP CNVCTN (BTU/SEC)	GAS VEL. (FT/SEC)	LIQ. VEL. (FT/SEC)	VG/VL	SLIP ACCEL. (FT/SEC**2)
2	0	-5.31646E+00	3.63383E-01	1.92873E+04	7.24145E+02	1.08691E+05	2.21751E+01	1.68587E+01	1.31535E+00	2.34327E-07
3	0	-1.18577E+01	6.25542E-01	1.78601E+04	2.15131E+03	3.95373E+05	3.83853E+01	2.65276E+01	1.44700E+00	3.37938E-07
4	0	-1.66101E+01	7.02421E-01	1.69830E+04	3.02847E+03	6.01202E+05	4.83294E+01	3.17194E+01	1.52366E+00	-1.32017E-06
7	0	-1.49818E+00	2.24829E-02	1.37195E+03	5.49169E+00	2.52985E+03	2.09563E+00	5.97449E-01	3.50762E+00	3.25727E-07
8	0	-1.76941E+00	7.07117E-02	1.35776E+03	1.96813E+01	9.36323E+03	2.39122E+00	6.21817E-01	3.84554E+00	7.39444E-07
9	-2	-1.81379E+01	7.02498E-01	1.83151E+04	3.07375E+03	5.49522E+05	5.87771E+01	4.06392E+01	1.44632E+00	-1.21910E-08
12	-2	-1.79160E+01	7.00489E-01	1.83309E+04	3.05804E+03	5.43446E+05	5.83501E+01	4.04340E+01	1.44309E+00	-8.67002E-09

BUBL SET NUMB.	VOL. NUMB.	BUBBLE GRADIENT PARAMETER	BUBBLE VELOCITY (FT/SEC)	MIXTURE LEVEL (FT)	MIXTURE QUALITY	BUBBLE MASS (LB)
1	9	5.00000E-02	0.00000E+00	5.13000E+00	3.02561E-03	8.16022E+01

PUMP NUMB.	VOL. NUMB.	PUMP SPEED (RPM)	NORM. PUMP TORQUE	NORM. FRIC. TORQUE	NORM. MOT. TORQUE	POWER TO H2O (BTU/HR)
1	18	1.66500E+03	1.00237E+00	1.00000E+00	1.00000E+00	2.68493E+07

HEAT COND. NUMBER		VOL. NUM.	HT TRAN MODE-COR	SURF. FLUX (BTU/HR-FT2)	CRIT. FLUX (BTU/HR-FT2)	H.T. COEF. (BTU/H-F2-F)	SURF. TEMP. (DEG. F)	MASS FLUX (LBM/HR-FT2)	STORD ENRGY (BTU)	POWR TO H20 (BTU/HR)	DRYOUT PNT ()
1	RGHT	2	2-THOM	1.93845E+05	7.98792E+05	1.38911E+04	5.62216E+02	1.20331E+06	1.26583E+07	3.13600E+09	
2	RGHT	3	2-THOM	1.97265E+05	7.47085E+05	1.39818E+04	5.62034E+02	1.20331E+06	1.27957E+07	3.19132E+09	
3	RGHT	4	2-THOM	1.20121E+05	7.08773E+05	1.08761E+04	5.58492E+02	1.20331E+06	9.59717E+06	1.94330E+09	
4	LEFT	2	2-THOM	3.07076E+02	1.24553E+06	5.52881E+02	5.48817E+02	1.20331E+06		1.22849E+06	
	RGHT	5	1-DB-L	3.71184E+03	1.40590E+05	3.24606E+02	5.47633E+02	9.76521E+04	4.52510E+05	1.48497E+07	
5	LEFT	3	2-THOM	1.77592E+03	1.06188E+06	1.32663E+03	5.49264E+02	1.20331E+06		7.10479E+06	
	RGHT	6	2-THOM	2.35974E+03	1.37927E+05	6.16336E+02	5.49061E+02	9.76521E+04	4.53347E+05	9.44045E+06	
6	LEFT	4	2-THOM	1.39585E+03	1.06188E+06	1.17243E+03	5.48639E+02	1.20331E+06		5.58429E+06	
	RGHT	7	2-THOM	1.50790E+03	1.36082E+05	1.21788E+03	5.48600E+02	9.76521E+04	4.52808E+05	6.03255E+06	
7	LEFT	11	1-DB-L	-4.95249E+03	3.06876E+05	4.94470E+03	5.45591E+02	2.35460E+06		-8.29434E+06	
	RGHT	12	1-DB-L	4.55107E+03	2.26174E+05	1.05119E+03	5.35473E+02	8.24941E+05	1.40263E+06	8.29434E+06	
8	LEFT	8	1-DB-L	-9.27555E+02	9.00000E+04	1.11582E+03	5.46320E+02	8.58704E+05		-3.49781E+05	

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      RGHT     12   1-DB-L  9.07777E+02  2.11828E+05  1.70499E+03  5.31676E+02  8.24941E+05  6.45414E+06  3.49781E+05

   CORE   COND.  DEPTH REAC.  DEPTH REAC.  HEAT GEN.    COND. HEAT-  DIR. MODER-  AVG. METAL   CENTERLINE   FUEL
   NUMB.  NUMB.  EXT. ZR-H2O  INT. ZR-H2O  ZR-H2O       ING RATE     ATOR HT RT   TEMPERATURE  TEMPERATURE  ENTHALPY
                 (FT)         (FT)         (BTU/HR)     (BTU/HR)     (BTU/HR)     (DEG. F)     (DEG. F)     (CAL/GM)
      1      1   0.00000E+00  0.00000E+00  0.00000E+00  3.13600E+09  8.18558E+07  1.70250E+03  2.42734E+03  6.36524E+01
      2      2   0.00000E+00  0.00000E+00  0.00000E+00  3.19132E+09  8.32997E+07  1.72020E+03  2.46325E+03  6.43836E+01
      3      3   0.00000E+00  0.00000E+00  0.00000E+00  1.94330E+09  5.07239E+07  1.29801E+03  1.66745E+03  4.70135E+01
      4      4   0.00000E+00  0.00000E+00  0.00000E+00  1.60782E+07  4.45943E+07  5.48432E+02
      5      5   0.00000E+00  0.00000E+00  0.00000E+00  1.65452E+07  4.51907E+07  5.49376E+02
      6      6   0.00000E+00  0.00000E+00  0.00000E+00  1.16168E+07  2.59781E+07  5.48769E+02
0        AVERAGE CORE            MINIMUM  HEIGHT              HOT  SPOT                    MINUMUM DNBR POSITION
           (RETRAN)                (HOT CHANNEL)               (HOT CHANNEL)                (HOT CHANNEL)
   LHGR(KW/FT)      DNBR       LHGR(KW/FT)      DNBR       LHGR(KW/FT)      DNBR       POS. (FT)    LHGR(KW/FT)  MDNBR
   7.70004E+00  4.41024E+00  1.27784E+01  1.67871E+00  1.34549E+01  0.00000E+00  8.00000E+00  1.10390E+01  1.53909E+00

  REACTOR       FISSION       DECAY HEAT    TOTAL         CONTROL       COOL. TEMP.   VOID          FUEL TEMP.    DOPPLER
  PERIOD        POWER         POWER         REACTIVITY    REACTIVITY    REACTIVITY    REACTIVITY    REACTIVITY    REACTIVITY
  (SEC)                                     ($)           ($)           ($)           ($)           ($)           ($)
  0.00000E+00  1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
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REEDIT-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   11
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:24
 TTWOB WITH POINT KINETICS -- RETRAN SAMPLE PROBLEM                                                           CPU TIME =    0.016
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	ENERGY BALANCE (BTU)	TOTAL MASS BALANCE (LBM)	NCG MASS BALANCE (LBM)	AVERAGE TIME STEP (SEC)	CURRENT TIME STEP (SEC)	ELAPSED TIME (SEC)	TIME STEP NUM STANDRD/ACTUL
4.93962E-01	1.25140E+03	4.29798E+09	2.36764E+12	2.13942E+09	0.00000E+00	2.00000E-02	1.32235E-02	2.00000E+00	1015 1109

VOLUME NUMBER		AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	VOID FRAC.	POWR TO H2O (BTU/SEC)
1		1.22872E+03	1.26886E+05	5.27043E+02	4.74761E+01	5.32292E+02	0.00000E+00	0.00000E+00	0.00000E+00
2		1.20089E+03	1.10240E+04	5.52737E+02	4.60330E+01	5.52446E+02	0.00000E+00	0.00000E+00	9.96467E+05
3		1.19840E+03	6.42109E+03	5.98420E+02	2.68126E+01	5.66768E+02	4.36765E-02	4.28881E-01	1.00957E+06
4		1.19484E+03	4.39068E+03	6.28545E+02	1.83342E+01	5.66389E+02	9.35149E-02	6.30058E-01	6.06725E+05
5		1.19693E+03	9.55640E+03	5.34651E+02	4.70480E+01	5.38306E+02	0.00000E+00	0.00000E+00	1.10185E+04
6		1.19562E+03	9.41803E+03	5.46868E+02	4.63668E+01	5.47893E+02	0.00000E+00	0.00000E+00	1.17175E+04
7		1.19432E+03	9.35513E+03	5.52245E+02	4.60572E+01	5.52054E+02	0.00000E+00	0.00000E+00	7.78879E+03
8		1.19263E+03	1.43393E+04	6.38741E+02	1.65279E+01	5.66153E+02	1.10553E-01	6.72901E-01	-2.03696E+03
9	LIQ REG	1.18922E+03	2.41513E+04	5.60045E+02	4.55952E+01	5.58018E+02	0.00000E+00	8.17194E-01	0.00000E+00
	VAP REG		6.32432E+03	1.19010E+03	2.67090E+00	5.68511E+02	1.00000E+00		0.00000E+00
10		1.19011E+03	9.49959E+03	1.19735E+03	2.62123E+00	5.72967E+02	1.00000E+00	1.00000E+00	0.00000E+00
11		1.18977E+03	3.52239E+03	6.37460E+02	1.66455E+01	5.65848E+02	1.09027E-01	6.70175E-01	-1.12452E+04
12		1.19675E+03	1.64891E+05	5.28009E+02	4.74060E+01	5.33016E+02	0.00000E+00	0.00000E+00	2.23339E+03
13		1.22654E+03	9.27020E+03	5.27474E+02	4.74519E+01	5.32634E+02	0.00000E+00	0.00000E+00	0.00000E+00
14		1.18707E+03	1.68947E+03	1.19857E+03	2.60600E+00	5.73369E+02	1.00000E+00	1.00000E+00	0.00000E+00
15		1.18792E+03	1.15598E+03	1.19963E+03	2.60053E+00	5.74174E+02	1.00000E+00	1.00000E+00	0.00000E+00
16		1.18833E+03	5.99293E+03	1.20278E+03	2.57987E+00	5.76360E+02	1.00000E+00	1.00000E+00	0.00000E+00
17		1.18829E+03	2.79156E+02	1.20321E+03	2.57690E+00	5.76650E+02	1.00000E+00	1.00000E+00	0.00000E+00
18		1.28577E+03	2.57070E+04	5.27684E+02	4.74754E+01	5.32894E+02	0.00000E+00	0.00000E+00	7.48394E+03
19		1.35093E+03	2.81878E+04	5.27478E+02	4.75241E+01	5.32831E+02	0.00000E+00	0.00000E+00	0.00000E+00
20		9.57778E+02	2.13894E+09	1.18966E+03	2.13894E+00	5.38913E+02	9.92734E-01	9.99668E-01	0.00000E+00

JUNCTION NUMBER	CONNECTS VOLUMES	CHOK/ PATH	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E D I F F E R E N T I A L S VEL. PSI	ELEV. PSI	FRIC. PSI	ACCL. PSI	PUMP PSI
1	1 TO 2		2.08790E+04	5.27043E+02	2.10632E-02	-2.93950E-01	-3.50431E+00	-2.39874E+01	4.03983E-02	0.00000E+00
2	2 TO 3		2.07630E+04	5.78306E+02	2.58199E-02	-2.86295E-01	-1.01074E+00	-1.17838E+00	5.24037E-02	0.00000E+00
3	3 TO 4		1.95640E+04	6.17664E+02	4.80922E-02	-3.47253E-01	-6.25689E-01	-2.62557E+00	-2.05499E-02	0.00000E+00
4	4 TO 8		1.90020E+04	6.40568E+02	6.13118E-02	2.78651E-01	-6.23315E-01	-1.87710E+00	-1.25881E-02	0.00000E+00
5	1 TO 5		1.40131E+03	5.27043E+02	2.10632E-02	4.03011E-02	-3.51849E+00	-2.83574E+01	-4.21498E-04	0.00000E+00
6	5 TO 6		1.39178E+03	5.40714E+02	2.14069E-02	-1.84385E-05	-1.29742E+00	-1.21970E-02	-1.31818E-04	0.00000E+00
7	6 TO 7		1.38860E+03	5.50892E+02	2.16749E-02	-3.54104E-05	-1.28367E+00	-1.34456E-02	-5.73566E-04	0.00000E+00
8	7 TO 8		1.39585E+03	5.52237E+02	2.17119E-02	-5.19399E-01	-1.00879E+00	-1.70901E-01	6.87121E-04	0.00000E+00
9	11 TO 9		2.05285E+04	6.37391E+02	5.99954E-02	2.47758E+00	-1.85652E+00	-1.36865E+00	8.86224E-02	0.00000E+00
10	9 TO 10		2.86525E+03	1.19021E+03	3.74481E-01	2.45406E-01	-1.33044E-01	-3.10586E-02	-1.71620E+00	0.00000E+00
11	18 TO 19		9.57370E+03	5.27680E+02	2.10633E-02	6.18617E-02	-2.92258E+00	-1.92332E+01	3.25064E-01	8.73534E+01
12	8 TO 11		2.01695E+04	6.38757E+02	6.05164E-02	-2.31842E+00	-6.86145E-01	-1.05993E+00	-1.64545E+00	0.00000E+00
13	12 TO 13		1.26790E+04	5.27991E+02	2.10938E-02	-1.54585E+00	2.87006E+00	-6.61496E+00	5.34501E-01	3.51596E+01
14	19 TO 13		9.58045E+03	5.27479E+02	2.10419E-02	6.29637E+00	-5.01823E+00	-4.95618E+01	2.51933E-01	-7.59315E+01
15	12 TO 18		9.55422E+03	5.27991E+02	2.10938E-02	-4.03847E+00	1.07889E+01	-5.17517E+00	6.16905E-02	8.73534E+01
16	13 TO 1		2.22682E+04	5.27466E+02	2.10737E-02	5.35787E-01	2.89338E+00	-1.20173E+00	2.28217E-01	0.00000E+00
17	10 TO 14		3.29266E+03	1.19745E+03	3.81274E-01	-1.57393E-01	5.56688E-01	-4.06206E+00	9.20895E-02	0.00000E+00
18	14 TO 15		6.35022E+02	1.19863E+03	3.83693E-01	-4.32380E-02	5.61432E-01	-2.32971E-01	1.30745E-01	0.00000E+00
19	15 TO 16		6.11337E+02	1.19961E+03	3.84641E-01	1.65420E-01	2.66606E-01	-1.68442E+00	-1.09393E-01	0.00000E+00
20	16 TO 17		2.87234E+01	1.20265E+03	3.88116E-01	1.54654E-01	-4.12157E-01	-2.48639E-02	-1.17916E-01	0.00000E+00
21	9 TO 12		1.90508E+04	5.59945E+02	2.19293E-02	1.81513E-01	6.51501E+00	-1.99375E-01	-1.56550E+00	0.00000E+00
22	16 TO 20		0.00000E+00	1.20265E+03	3.88116E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
26	0 TO 14		-9.70939E+02	1.19863E+03	3.83693E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
25	0 TO 14		-9.70939E+02	1.19863E+03	3.83693E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
24	0 TO 12		2.81825E+03	4.05708E+02	1.89228E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
23	0 TO 14		-7.28204E+02	1.19863E+03	3.83693E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

JUNCTION NUMBER	FLOW REG.	SLIP VEL. (FT/SEC)	VOID FRACTION	LIQUID FLOW (LB/SEC)	GAS FLOW (LB/SEC)	SLIP CNVCTN (BTU/SEC)	GAS VEL. (FT/SEC)	LIQ. VEL. (FT/SEC)	VG/VL	SLIP ACCEL. (FT/SEC**2)
2	0	-2.24651E+00	1.45882E-01	2.05144E+04	2.48588E+02	2.18717E+04	1.60088E+01	1.37623E+01	1.16324E+00	1.15100E+01
3	0	-9.17574E+00	5.71631E-01	1.75803E+04	1.98371E+03	3.17359E+05	3.26809E+01	2.35052E+01	1.39037E+00	6.03522E+00
4	0	-1.36696E+01	6.78021E-01	1.59826E+04	3.01932E+03	5.37246E+05	4.20816E+01	2.84120E+01	1.48112E+00	1.23803E+01
9	-2	-1.40678E+01	6.69635E-01	1.75506E+04	2.97795E+03	4.58882E+05	5.01986E+01	3.61308E+01	1.38936E+00	6.66189E+00
12	-2	-1.41829E+01	6.72984E-01	1.71852E+04	2.98430E+03	4.66237E+05	4.99389E+01	3.57561E+01	1.39666E+00	1.30292E+01

BUBL SET NUMB.	VOL. NUMB.	BUBBLE GRADIENT PARAMETER	BUBBLE VELOCITY (FT/SEC)	MIXTURE LEVEL (FT)	MIXTURE QUALITY	BUBBLE MASS (LB)
1	9	5.00000E-02	0.00000E+00	4.40928E+00	0.00000E+00	0.00000E+00

PUMP NUMB.	VOL. NUMB.	PUMP SPEED (RPM)	NORM. PUMP TORQUE	NORM. FRIC. TORQUE	NORM. MOT. TORQUE	POWER TO H2O (BTU/HR)
1	18	1.66500E+03	1.00584E+00	1.00000E+00	0.00000E+00	2.69422E+07

HEAT COND. NUMBER		VOL. NUM.	HT TRAN MODE-COR	SURF. FLUX (BTU/HR-FT2)	CRIT. FLUX (BTU/HR-FT2)	H.T. COEF. (BTU/H-F2-F)	SURF. TEMP. (DEG. F)	MASS FLUX (LBM/HR-FT2)	STORD ENRGY (BTU)	POWR TO H20 (BTU/HR)	DRYOUT PNT ()
1	RGHT	2	2-THOM	2.18867E+05	8.00000E+05	7.96176E+03	5.80021E+02	1.25139E+06	1.36711E+07	3.54080E+09	
2	RGHT	3	2-THOM	2.22543E+05	7.56056E+05	1.69602E+04	5.79887E+02	1.21290E+06	1.38174E+07	3.60027E+09	
3	RGHT	4	2-THOM	1.34170E+05	7.06220E+05	1.31316E+04	5.76602E+02	1.16065E+06	1.02583E+07	2.17059E+09	
4	LEFT	2	1-DB-L	1.31995E+03	1.46210E+06	3.33084E+03	5.52927E+02	1.25139E+06		5.28061E+06	
	RGHT	5	1-DB-L	4.41184E+03	1.46598E+05	3.28589E+02	5.51741E+02	9.90853E+04	4.56231E+05	1.76502E+07	
5	LEFT	3	1-DB-L	-3.40749E+03	1.06267E+06	4.02394E+03	5.65919E+02	1.21290E+06		-1.36321E+07	
	RGHT	6	1-DB-L	4.97186E+03	1.43284E+05	3.29871E+02	5.62968E+02	9.86388E+04	4.66810E+05	1.98906E+07	
6	LEFT	4	1-DB-L	-3.40452E+03	1.05820E+06	4.43876E+03	5.65618E+02	1.16065E+06		-1.36202E+07	
	RGHT	7	1-DB-L	3.66026E+03	1.41077E+05	3.31351E+02	5.63094E+02	9.87881E+04	4.66671E+05	1.46434E+07	
7	LEFT	11	1-DB-L	-2.41720E+04	3.06936E+05	4.63325E+03	5.60674E+02	2.24635E+06		-4.04828E+07	
	RGHT	12	1-DB-L	4.85550E+03	2.72228E+05	1.07776E+03	5.37507E+02	8.50775E+05	1.42643E+06	8.84916E+06	
8	LEFT	8	1-DB-L	-1.94459E+04	9.00000E+04	1.03931E+03	5.47439E+02	8.15901E+05		-7.33304E+06	
	RGHT	12	1-DB-L	-2.09947E+03	2.31888E+05	1.74808E+03	5.31801E+02	8.50775E+05	6.46220E+06	-8.08959E+05	

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CORE NUMB.	COND. NUMB.	DEPTH REAC. EXT. ZR-H2O (FT)	DEPTH REAC. INT. ZR-H2O (FT)	HEAT GEN. ZR-H2O (BTU/HR)	COND. HEAT-ING RATE (BTU/HR)	DIR. MODER-ATOR HT RT (BTU/HR)	AVG. METAL TEMPERATURE (DEG. F)	CENTERLINE TEMPERATURE (DEG. F)	FUEL ENTHALPY (CAL/GM)
1	1	0.00000E+00	0.00000E+00	0.00000E+00	1.54830E+09	4.11969E+07	1.82955E+03	2.59954E+03	6.89131E+01
2	2	0.00000E+00	0.00000E+00	0.00000E+00	1.56971E+09	4.78213E+07	1.84789E+03	2.63699E+03	6.96838E+01
3	3	0.00000E+00	0.00000E+00	0.00000E+00	9.57724E+08	2.72457E+07	1.38407E+03	1.77787E+03	5.05459E+01
4	4	0.00000E+00	0.00000E+00	0.00000E+00	7.95346E+06	2.20164E+07	5.52620E+02		
5	5	0.00000E+00	0.00000E+00	0.00000E+00	8.20293E+06	2.22923E+07	5.64522E+02		
6	6	0.00000E+00	0.00000E+00	0.00000E+00	5.17419E+06	1.33963E+07	5.64366E+02		

0 AVERAGE CORE (RETRAN)		MINIMUM HEIGHT (HOT CHANNEL)		HOT SPOT (HOT CHANNEL)		MINUMUM DNBR POSITION (HOT CHANNEL)		
LHGR(KW/FT)	DNBR	LHGR(KW/FT)	DNBR	LHGR(KW/FT)	DNBR	POS. (FT)	LHGR(KW/FT)	MDNBR
8.66926E+00	3.93042E+00	1.44299E+01	1.56825E+00	1.52000E+01	0.00000E+00	8.00000E+00	1.24228E+01	1.42644E+00

REACTOR PERIOD (SEC)	FISSION POWER	DECAY HEAT POWER	TOTAL REACTIVITY ($)	CONTROL REACTIVITY ($)	COOL. TEMP. REACTIVITY ($)	VOID REACTIVITY ($)	FUEL TEMP. REACTIVITY ($)	DOPPLER REACTIVITY ($)
-6.60027E+00	4.93962E-01	0.00000E+00	-1.33745E+00	-2.38591E+00	0.00000E+00	1.26025E+00	0.00000E+00	-2.11788E-01

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REEDIT-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page   12
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis              11:57:24
 TTWOB WITH POINT KINETICS -- RETRAN SAMPLE PROBLEM                                                              CPU TIME =     0.016
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *
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SYSTEM ELAPSED TIME (SEC)	SYSTEM ELAPSED TIME (SEC)	JUN 24 FLOW (LB/SEC)	JUN 17 FLOW (LB/SEC)	BUBL 9 MIX. LEVEL (FEET)	REAC KIN DOPPLER ($)	REAC KIN FUEL TEMP ($)	REAC KIN VOID ($)
0.00000E+00	0.00000E+00	3.20872E+03	3.05410E+03	5.13000E+00	0.00000E+00	0.00000E+00	0.00000E+00
5.00000E-02	5.00000E-02	3.20872E+03	3.05431E+03	5.13064E+00	-9.68197E-07	0.00000E+00	6.10527E-04
1.00000E-01	1.00000E-01	3.20872E+03	3.05507E+03	5.13130E+00	-9.98916E-06	0.00000E+00	1.26869E-03
1.50000E-01	1.50000E-01	3.20872E+03	3.04955E+03	5.13213E+00	-2.42784E-05	0.00000E+00	1.66797E-03
2.00000E-01	2.00000E-01	3.20872E+03	2.91861E+03	5.13076E+00	-4.33344E-05	0.00000E+00	2.25212E-03
2.50000E-01	2.50000E-01	3.18543E+03	2.40140E+03	5.11178E+00	-6.78739E-05	0.00000E+00	2.78587E-03
3.00000E-01	3.00000E-01	3.18395E+03	1.69615E+03	5.05540E+00	-8.50491E-05	0.00000E+00	5.29115E-03
3.50000E-01	3.50000E-01	3.18150E+03	1.13016E+03	4.96474E+00	1.96753E-04	0.00000E+00	1.61755E-02
4.00000E-01	4.00000E-01	3.16252E+03	5.89948E+02	4.84758E+00	8.05819E-04	0.00000E+00	4.48046E-02
4.50000E-01	4.50000E-01	3.12598E+03	8.71354E+01	4.79933E+00	1.53894E-03	0.00000E+00	9.90920E-02
5.00000E-01	5.00000E-01	3.08926E+03	-3.76776E+02	4.74101E+00	2.14733E-03	0.00000E+00	2.19592E-01
5.50000E-01	5.50000E-01	3.05273E+03	-7.36086E+02	4.65942E+00	1.76230E-03	0.00000E+00	4.06072E-01
6.00000E-01	6.00000E-01	3.01547E+03	-7.67175E+02	4.54829E+00	-1.09710E-03	0.00000E+00	6.94319E-01
6.50000E-01	6.50000E-01	2.97948E+03	-5.86238E+02	4.42732E+00	-8.86609E-03	0.00000E+00	1.00592E+00
7.00000E-01	7.00000E-01	2.94286E+03	-2.84704E+02	4.30637E+00	-2.88894E-02	0.00000E+00	1.31689E+00
7.50000E-01	7.50000E-01	2.90623E+03	7.45800E+00	4.19908E+00	-8.11943E-02	0.00000E+00	1.55342E+00
8.00000E-01	8.00000E-01	2.86961E+03	3.55885E+02	4.11925E+00	-1.93966E-01	0.00000E+00	1.61906E+00
8.50000E-01	8.50000E-01	2.83230E+03	8.95723E+02	4.08121E+00	-3.01408E-01	0.00000E+00	1.49587E+00
9.00000E-01	9.00000E-01	2.79574E+03	1.35513E+03	4.09510E+00	-3.35026E-01	0.00000E+00	1.27108E+00
9.50000E-01	9.50000E-01	2.75973E+03	1.64093E+03	4.15760E+00	-3.41590E-01	0.00000E+00	9.28508E-01
1.00000E+00	1.00000E+00	2.72272E+03	1.80249E+03	4.25427E+00	-3.39955E-01	0.00000E+00	5.09061E-01
1.10000E+00	1.10000E+00	2.73629E+03	2.02401E+03	4.47555E+00	-3.27775E-01	0.00000E+00	-2.76534E-01
1.20000E+00	1.20000E+00	2.80684E+03	1.65571E+03	4.60043E+00	-3.12138E-01	0.00000E+00	-6.33320E-01
1.30000E+00	1.30000E+00	2.82412E+03	1.13580E+03	4.57432E+00	-2.99226E-01	0.00000E+00	-5.41182E-01
1.40000E+00	1.40000E+00	2.74842E+03	5.86356E+02	4.47026E+00	-2.79661E-01	0.00000E+00	3.81154E-02
1.50000E+00	1.50000E+00	2.69045E+03	1.40383E+03	4.36312E+00	-2.69014E-01	0.00000E+00	4.74377E-01
1.60000E+00	1.60000E+00	2.60832E+03	2.17577E+03	4.32126E+00	-2.56432E-01	0.00000E+00	9.31512E-01
1.70000E+00	1.70000E+00	2.58014E+03	2.21208E+03	4.35781E+00	-2.49249E-01	0.00000E+00	1.04558E+00
1.80000E+00	1.80000E+00	2.67259E+03	2.76095E+03	4.40889E+00	-2.36164E-01	0.00000E+00	1.07924E+00
1.90000E+00	1.90000E+00	2.75172E+03	3.18585E+03	4.42702E+00	-2.23320E-01	0.00000E+00	1.13538E+00
2.00000E+00	2.00000E+00	2.81825E+03	3.29266E+03	4.40928E+00	-2.11788E-01	0.00000E+00	1.26025E+00

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2.0 UNCONTROLLED ROD WITHDRAWAL

The restart-plot data file created by the RESTRT example of Section VII.6.0 was used to obtain the REEDIT example. The input listing is given below. The minor edit printout from the example is also given. Note that this is different from the RESTRT minor edit printout given in Section VII.6.0.

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LISTING OF INPUT DATA FOR CASE  1

    1    =UNCONTROLLED ROD WITHDRAWAL  --  RETRAN SAMPLE PROBLEM
    2    *
    3    *10001 LDMP NEDI NEDF NPLOT
    4    010001  -2  -11   1     0
    5    *
    6    *
    7    *  EDIT FREQUENCY CARD
    8    *
    9    *3XXX0 NRTG NMIN  NMAJ  TLAST
   10    030010    0    2    10    3.0
   11    *
   12    *
   13    *   EDIT VARIABLES
   14    *
   15    020000 TIMX  0 NTTS  0
   16    020001 PRES  1 PRES 110 PRES 20
   17    020002 PNRM  0 TEMP  2 TEMP 10
   18    020003 WP** 13 WP** 19 WP** 21
   19    *
   20    *
   21    * FORMAT FOR TAPE60
   22    *
   23    025000 1
   24    025001 '(5(1X,1P,E15.7))'
   25    *
   26    *
   27    . END
```


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REEDIT-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page    1
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:33
 UNCONTROLLED ROD WITHDRAWAL  --  RETRAN SAMPLE PROBLEM                                                         CPU TIME =     0.000
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

REEDIT PROBLEM CONTROL AND DESCRIPTION DATA.

    WORD  DESCRIPTION
    ====  ======================================================================
      1   REEDIT REQUEST FLAG (=-2) ..................................... =   41
      2   NUMBER OF MINOR EDIT PAIRS (<0 = PRINTER PLOTS) ............... =  -11
      3   NUMBER OF EDIT FREQUENCY SETS (03XXX0 DATA) ................... =    1
      4   RESTART RECORD WHERE REEDIT (>=1) ............................. =    1

0DATA FOR  1 EDIT FREQUENCY SETS.
0 SET DATA DATA  MIN  END
  NUM  PER  PER  PER  OF
       VBC  MIN  MAJ  INTERVAL

   1    0    2   10   3.000000E+00


 AIR IS THE DEFAULT NONCONDENSABLE GAS.
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REEDIT-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page    5
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis           11:57:33
 UNCONTROLLED ROD WITHDRAWAL  --  RETRAN SAMPLE PROBLEM                                                        CPU TIME =    0.016
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	ENERGY BALANCE (BTU)	TOTAL MASS BALANCE (LBM)	NCG MASS BALANCE (LBM)	AVERAGE TIME STEP (SEC)	CURRENT TIME STEP (SEC)	ELAPSED TIME (SEC)	TIME STEP NUM STANDRD/ACTUL
1.00000E+00	2.24400E+03	7.69557E+09	2.83773E+08	4.88511E+05	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0 0

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	VOID FRAC.	POWR TO H2O (BTU/SEC)
1	2.24180E+03	4.18180E+04	6.22827E+02	4.24851E+01	6.06021E+02	0.00000E+00	0.00000E+00	0.00000E+00
2001	2.22793E+03	3.13441E+03	6.22827E+02	4.24717E+01	6.05982E+02	0.00000E+00	0.00000E+00	0.00000E+00
2002	2.22779E+03	3.13433E+03	6.22842E+02	4.24705E+01	6.05992E+02	0.00000E+00	0.00000E+00	0.00000E+00
2003	2.22765E+03	3.13432E+03	6.22842E+02	4.24704E+01	6.05992E+02	0.00000E+00	0.00000E+00	0.00000E+00
2	2.22751E+03	3.13431E+03	6.22842E+02	4.24703E+01	6.05991E+02	0.00000E+00	0.00000E+00	0.00000E+00
3	2.22858E+03	1.72391E+04	6.22842E+02	4.24713E+01	6.05994E+02	0.00000E+00	0.00000E+00	0.00000E+00
4	2.22055E+03	2.64324E+04	6.06849E+02	4.35102E+01	5.94870E+02	0.00000E+00	0.00000E+00	-8.70014E+05
5	2.21118E+03	2.74305E+04	5.79958E+02	4.51531E+01	5.75287E+02	0.00000E+00	0.00000E+00	-5.92821E+05
6	2.20626E+03	2.80650E+04	5.61673E+02	4.61975E+01	5.61373E+02	0.00000E+00	0.00000E+00	-4.01897E+05
7	2.20655E+03	2.84772E+04	5.49268E+02	4.68761E+01	5.51679E+02	0.00000E+00	0.00000E+00	-2.72925E+05
8	2.20103E+03	3.77875E+04	5.44250E+02	4.71400E+01	5.47691E+02	0.00000E+00	0.00000E+00	0.00000E+00
9	2.25025E+03	2.71592E+04	5.44595E+02	4.71513E+01	5.48055E+02	0.00000E+00	0.00000E+00	9.36731E+03
10001	2.27117E+03	2.33744E+03	5.44595E+02	4.71639E+01	5.48093E+02	0.00000E+00	0.00000E+00	0.00000E+00
10002	2.27105E+03	2.33744E+03	5.44595E+02	4.71638E+01	5.48093E+02	0.00000E+00	0.00000E+00	0.00000E+00
10003	2.27093E+03	2.33743E+03	5.44595E+02	4.71637E+01	5.48093E+02	0.00000E+00	0.00000E+00	0.00000E+00
10004	2.27081E+03	2.33743E+03	5.44595E+02	4.71637E+01	5.48093E+02	0.00000E+00	0.00000E+00	0.00000E+00
10	2.27069E+03	2.33743E+03	5.44595E+02	4.71636E+01	5.48092E+02	0.00000E+00	0.00000E+00	0.00000E+00
11	2.26902E+03	3.72537E+04	5.44595E+02	4.71626E+01	5.48089E+02	0.00000E+00	0.00000E+00	0.00000E+00
12	2.27181E+03	3.80238E+04	5.44595E+02	4.71643E+01	5.48094E+02	0.00000E+00	0.00000E+00	0.00000E+00
13	2.25490E+03	2.01348E+03	5.44595E+02	4.71541E+01	5.48063E+02	0.00000E+00	0.00000E+00	0.00000E+00
14	2.26077E+03	7.79190E+03	5.55984E+02	4.65466E+01	5.57062E+02	0.00000E+00	0.00000E+00	5.99937E+05
15	2.25587E+03	7.51436E+03	5.84982E+02	4.48887E+01	5.79130E+02	0.00000E+00	0.00000E+00	9.27562E+05
16	2.25095E+03	7.21114E+03	6.13980E+02	4.30773E+01	5.99953E+02	0.00000E+00	0.00000E+00	5.99937E+05
17	2.27425E+03	2.39366E+02	5.44595E+02	4.71657E+01	5.48099E+02	0.00000E+00	0.00000E+00	0.00000E+00
19	2.22673E+03	1.05516E+03	6.97712E+02	3.68938E+01	6.52093E+02	0.00000E+00	0.00000E+00	0.00000E+00
20	8.71120E+02	9.49338E+04	6.14934E+02	1.11125E+01	5.27657E+02	1.37694E-01	7.98434E-01	2.13766E+06
110 LIQ REG	2.22000E+03	3.10545E+04	6.98013E+02	3.67517E+01	6.52073E+02	7.13060E-04	3.52796E-01	0.00000E+00
VAP REG		2.78679E+03	1.12050E+03	6.12455E+00	6.52073E+02	1.00000E+00		0.00000E+00

JUNCTION NUMBER	CONNECTS VOLUMES	CHOK/ PATH	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E VEL. PSI	ELEV. PSI	D I F F E R E N T I A L S FRIC. PSI	ACCL. PSI	PUMP PSI
1	1 TO 2001		2.71940E+04	6.22827E+02	2.35377E-02	-9.91017E+00	2.59650E-01	-4.21552E+00	-4.75192E-12	0.00000E+00
2001	2001 TO 2002		2.71940E+04	6.22827E+02	2.35451E-02	-7.45088E-03	1.14016E-05	-1.34904E-01	-6.85590E-13	0.00000E+00
2002	2002 TO 2003		2.71996E+04	6.22842E+02	2.35457E-02	-8.42693E-03	1.35469E-06	-1.34959E-01	5.77094E-13	0.00000E+00
2003	2003 TO 2		2.71996E+04	6.22842E+02	2.35458E-02	-6.27117E-05	1.27569E-06	-1.34959E-01	2.36500E-12	0.00000E+00
2	2 TO 3		2.71996E+04	6.22842E+02	2.35459E-02	9.76886E+00	-1.16058E+00	-7.53743E+00	1.98463E-12	0.00000E+00
3	3 TO 4		2.71996E+04	6.22842E+02	2.35453E-02	-9.29851E-01	-2.99124E+00	-4.11326E+00	7.50808E-08	0.00000E+00
4	4 TO 5		2.71996E+04	5.90856E+02	2.24681E-02	8.15621E-02	-4.57785E+00	-4.87483E+00	8.40893E-08	0.00000E+00
5	5 TO 6		2.71996E+04	5.69060E+02	2.18415E-02	4.83949E-02	5.32016E-02	-5.02258E+00	-1.33765E-07	0.00000E+00
6	6 TO 7		2.71996E+04	5.54285E+02	2.14571E-02	3.01361E-02	4.80557E+00	-4.53994E+00	-1.84363E-07	0.00000E+00
7	7 TO 8		2.71996E+04	5.44250E+02	2.12119E-02	-5.82667E+00	5.11449E+00	-4.80671E+00	-7.57764E-08	0.00000E+00
8	8 TO 9		2.71996E+04	5.44250E+02	2.12134E-02	6.85332E+00	-4.11241E-02	-1.21783E+00	9.16668E-08	4.36235E+01
9	9 TO 10001		2.71996E+04	5.44595E+02	2.12083E-02	-1.10810E+01	-4.73151E-01	-1.11538E+01	2.49717E-11	4.36235E+01
10001	10001 TO 10002		2.71996E+04	5.44595E+02	2.12027E-02	2.92548E-03	5.63335E-07	-1.20867E-01	-3.73876E-10	0.00000E+00
10002	10002 TO 10003		2.71996E+04	5.44595E+02	2.12027E-02	-3.35622E-05	5.77475E-07	-1.20868E-01	5.63022E-13	0.00000E+00
10003	10003 TO 10004		2.71996E+04	5.44595E+02	2.12027E-02	-3.39785E-05	5.77482E-07	-1.20868E-01	-3.10030E-13	0.00000E+00
10004	10004 TO 10		2.71996E+04	5.44595E+02	2.12028E-02	4.50509E-03	5.55807E-07	-1.20868E-01	-1.59428E-13	0.00000E+00
10	10 TO 11		2.71940E+04	5.44595E+02	2.12028E-02	9.13337E+00	2.13378E+00	-1.29339E+01	5.10081E-12	0.00000E+00
11	11 TO 12		2.71940E+04	5.44595E+02	2.12032E-02	1.94314E+00	4.94882E+00	-4.10774E+00	2.00284E-12	0.00000E+00
12	12 TO 13		8.56000E+02	5.44595E+02	2.12025E-02	-1.35346E-01	-3.57784E+00	-1.32000E+01	4.78728E-13	0.00000E+00
13	12 TO 14		2.63380E+04	5.44595E+02	2.12025E-02	-8.51854E-01	-2.25956E+00	-7.93077E+00	-6.21725E-14	0.00000E+00
14	14 TO 15		2.63380E+04	5.67373E+02	2.17798E-02	-6.34856E-02	-1.26993E+00	-3.56361E+00	1.88294E-13	0.00000E+00
15	15 TO 16		2.63380E+04	6.02591E+02	2.28257E-02	-7.22735E-02	-1.22175E+00	-3.62743E+00	2.31370E-13	0.00000E+00
16	16 TO 1		2.63380E+04	6.25369E+02	2.36276E-02	8.92761E-01	-2.30360E+00	-7.73780E+00	1.07647E-12	0.00000E+00
17	13 TO 1		8.56000E+02	5.44595E+02	2.12071E-02	1.35317E-01	-3.67006E+00	-9.56141E+00	6.11955E-13	0.00000E+00
18	10 TO 17		5.57113E+00	5.44595E+02	2.12028E-02	1.10697E+01	-7.46789E+00	-4.14894E-02	3.94706E-12	0.00000E+00
19	17 TO 110		5.57113E+00	5.44595E+02	2.12018E-02	6.89376E-03	-6.79770E+00	-4.74609E+01	2.93650E-11	0.00000E+00
21	2002 TO 19		-5.57113E+00	6.97712E+02	2.71049E-02	0.00000E+00	-1.06576E+00	7.63311E-04	-1.53211E-14	0.00000E+00
110009	19 TO 110		-5.57113E+00	6.97712E+02	2.71125E-02	1.36035E-07	-6.72684E+00	6.37925E-04	2.27374E-13	0.00000E+00
31	0 TO 20		0.00000E+00	1.19732E+03	5.21811E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
30	0 TO 20		0.00000E+00	1.19732E+03	5.21811E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
29	0 TO 20		0.00000E+00	1.19732E+03	5.21811E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
28	0 TO 20		0.00000E+00	1.19732E+03	5.21811E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
27	0 TO 20		0.00000E+00	1.19732E+03	5.21811E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
26	0 TO 110		0.00000E+00	1.12050E+03	1.63277E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
25	0 TO 110		0.00000E+00	1.12050E+03	1.63277E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
24	0 TO 10002		0.00000E+00	5.44595E+02	2.12027E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
23	0 TO 20		-2.73979E+03	1.19732E+03	5.21811E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
22	0 TO 20		2.73979E+03	4.17089E+02	1.91099E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

BUBL SET NUMB.	VOL. NUMB.	BUBBLE GRADIENT PARAMETER	BUBBLE VELOCITY (FT/SEC)	MIXTURE LEVEL (FT)	MIXTURE QUALITY	BUBBLE MASS (LB)
1	110	1.00000E+00	1.00000E+00	2.19500E+01	7.13060E-04	2.21437E+01
2	20	0.00000E+00	1.41808E+01	4.95000E+01	1.04605E-01	9.56357E+03

PUMP NUMB.	VOL. NUMB.	PUMP SPEED (RPM)	NORM. PUMP TORQUE	NORM. FRIC. TORQUE	NORM. MOT. TORQUE	POWER TO H2O (BTU/HR)
1	9	1.18000E+03	9.94238E-01	0.00000E+00	1.00000E+00	3.37223E+07

HEAT COND. NUMBER	VOL. HT TRAN NUM. MODE-COR	SURF. FLUX (BTU/HR-FT2)	CRIT. FLUX (BTU/HR-FT2)	H.T. COEF. (BTU/H-F2-F)	SURF. TEMP. (DEG. F)	MASS FLUX (LBM/HR-FT2)	STORD ENRGY (BTU)	POWR TO H20 (BTU/HR)	DRYOUT PNT ()
1 RGHT	14 1-DB-L	1.52597E+05	9.16986E+05	5.33720E+03	5.85654E+02	2.16724E+06	6.10875E+06	2.15977E+09	
2 RGHT	15 1-DB-L	2.35930E+05	9.18223E+05	5.44056E+03	6.22495E+02	2.16724E+06	7.99299E+06	3.33922E+09	

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      3 RGHT     16   1-DB-L  1.52597E+05  9.19467E+05  5.55000E+03  6.27448E+02  2.16724E+06  6.36107E+06  2.15977E+09
      4 LEFT      4   1-DB-L -1.02048E+05  8.29783E+05  5.43996E+03  5.76111E+02  2.39761E+06               -3.13205E+09
        RGHT     20   2-THOM  9.03800E+04  2.51851E+05  8.33604E+03  5.38499E+02  2.90951E+05  4.49714E+06  3.13205E+09
      5 LEFT      5   1-DB-L -6.95349E+04  8.31594E+05  5.34210E+03  5.62271E+02  2.39761E+06               -2.13416E+09
        RGHT     20   2-THOM  6.15843E+04  1.38458E+05  6.88111E+03  5.36607E+02  2.90951E+05  4.43034E+06  2.13416E+09
      6 LEFT      7   1-DB-L -3.20127E+04  8.32489E+05  5.23567E+03  5.45565E+02  2.39761E+06               -9.82529E+08
        RGHT     20   2-THOM  2.83523E+04  1.38458E+05  4.66894E+03  5.33730E+02  2.90951E+05  4.34694E+06  9.82529E+08
      7 LEFT      6   1-DB-L -4.71406E+04  8.32546E+05  5.27834E+03  5.52442E+02  2.39761E+06               -1.44683E+09
        RGHT     20   2-THOM  4.17505E+04  2.51851E+05  5.66571E+03  5.35026E+02  2.90951E+05  4.38183E+06  1.44683E+09

   CORE   COND.  DEPTH REAC.  DEPTH REAC.  HEAT GEN.    COND. HEAT-  DIR. MODER-  AVG. METAL   CENTERLINE   FUEL
   NUMB.  NUMB.  EXT. ZR-H2O  INT. ZR-H2O  ZR-H2O       ING RATE     ATOR HT RT   TEMPERATURE  TEMPERATURE  ENTHALPY
                 (FT)         (FT)         (BTU/HR)     (BTU/HR)     (BTU/HR)     (DEG. F)     (DEG. F)     (CAL/GM)
      1      1   0.00000E+00  0.00000E+00  0.00000E+00  2.15977E+09  0.00000E+00  1.24439E+03  1.58917E+03  0.00000E+00
      2      2   0.00000E+00  0.00000E+00  0.00000E+00  3.33922E+09  0.00000E+00  1.61721E+03  2.25170E+03  0.00000E+00
      3      3   0.00000E+00  0.00000E+00  0.00000E+00  2.15977E+09  0.00000E+00  1.28877E+03  1.64093E+03  0.00000E+00
0        AVERAGE CORE            MINIMUM  HEIGHT              HOT  SPOT                    MINUMUM DNBR POSITION
          (RETRAN)               (HOT CHANNEL)              (HOT CHANNEL)                  (HOT CHANNEL)
   LHGR(KW/FT)      DNBR      LHGR(KW/FT)      DNBR      LHGR(KW/FT)      DNBR      POS. (FT)    LHGR(KW/FT)  MDNBR
   5.99613E+00  5.09065E+00  1.43439E+01  2.91240E+00  1.82291E+01  1.63188E+00  8.50000E+00  1.49336E+01  1.46116E+00

  REACTOR      FISSION      DECAY HEAT   TOTAL        CONTROL      COOL. TEMP.  VOID         FUEL TEMP.   DOPPLER
  PERIOD       POWER        POWER        REACTIVITY   REACTIVITY   REACTIVITY   REACTIVITY   REACTIVITY   REACTIVITY
  (SEC)                                  ($)          ($)          ($)          ($)          ($)          ($)
  0.00000E+00  1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00

  HEAT EXCGR.   VOLUME   POWR TO H2O
  NUMBER        NUMBER   (BTU/HR)
      1           110    0.00000E+00
      2           110    3.07093E+06
      3           110    0.00000E+00
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REEDIT-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page    7
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis           11:57:33
 UNCONTROLLED ROD WITHDRAWAL  --  RETRAN SAMPLE PROBLEM                                                       CPU TIME =    0.016
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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NORMALIZED CORE POWER	CORE POWER (MW)	THERMAL POWER (BTU/HR)	ENERGY BALANCE (BTU)	TOTAL MASS BALANCE (LBM)	NCG MASS BALANCE (LBM)	AVERAGE TIME STEP (SEC)	CURRENT TIME STEP (SEC)	ELAPSED TIME (SEC)	TIME STEP NUM STANDRD/ACTUL
8.09849E-01	1.81730E+03	6.23618E+09	2.84359E+08	4.88511E+05	0.00000E+00	2.08333E-02	1.94230E-02	3.00000E+00	120 / 131

VOLUME NUMBER	AVG. PRES. (PSIA)	TOT. MASS (LB)	AVG. ENTH. (BTU/LB)	AVG. DEN. (LB/FT3)	AVG. TEMP. (DEG. F)	AVG. QUAL.	VOID FRAC.	POWR TO H2O (BTU/SEC)
1	2.26364E+03	4.16898E+04	6.25086E+02	4.23548E+01	6.07618E+02	0.00000E+00	0.00000E+00	0.00000E+00
2001	2.24970E+03	3.12534E+03	6.24972E+02	4.23488E+01	6.07501E+02	0.00000E+00	0.00000E+00	0.00000E+00
2002	2.24975E+03	3.12628E+03	6.24784E+02	4.23616E+01	6.07374E+02	0.00000E+00	0.00000E+00	0.00000E+00
2003	2.24962E+03	3.12733E+03	6.24571E+02	4.23757E+01	6.07229E+02	0.00000E+00	0.00000E+00	0.00000E+00
2	2.24949E+03	3.12826E+03	6.24382E+02	4.23883E+01	6.07100E+02	0.00000E+00	0.00000E+00	0.00000E+00
3	2.25056E+03	1.72266E+04	6.23619E+02	4.24405E+01	6.06585E+02	0.00000E+00	0.00000E+00	0.00000E+00
4	2.24256E+03	2.64171E+04	6.07543E+02	4.34850E+01	5.95419E+02	0.00000E+00	0.00000E+00	-8.50011E+05
5	2.23321E+03	2.74217E+04	5.80479E+02	4.51386E+01	5.75728E+02	0.00000E+00	0.00000E+00	-5.71742E+05
6	2.22830E+03	2.80575E+04	5.62156E+02	4.61851E+01	5.61793E+02	0.00000E+00	0.00000E+00	-3.80985E+05
7	2.22860E+03	2.84702E+04	5.49737E+02	4.68645E+01	5.52092E+02	0.00000E+00	0.00000E+00	-2.52472E+05
8	2.22307E+03	3.77919E+04	5.44396E+02	4.71456E+01	5.47847E+02	0.00000E+00	0.00000E+00	0.00000E+00
9	2.27227E+03	2.71643E+04	5.44677E+02	4.71602E+01	5.48161E+02	0.00000E+00	0.00000E+00	9.36825E+03
10001	2.29313E+03	2.33788E+03	5.44677E+02	4.71726E+01	5.48199E+02	0.00000E+00	0.00000E+00	0.00000E+00
10002	2.29301E+03	2.33787E+03	5.44678E+02	4.71725E+01	5.48200E+02	0.00000E+00	0.00000E+00	0.00000E+00
10003	2.29289E+03	2.33787E+03	5.44679E+02	4.71724E+01	5.48200E+02	0.00000E+00	0.00000E+00	0.00000E+00
10004	2.29276E+03	2.33786E+03	5.44680E+02	4.71723E+01	5.48200E+02	0.00000E+00	0.00000E+00	0.00000E+00
10	2.29264E+03	2.33785E+03	5.44681E+02	4.71722E+01	5.48201E+02	0.00000E+00	0.00000E+00	0.00000E+00
11	2.29095E+03	3.72604E+04	5.44682E+02	4.71711E+01	5.48199E+02	0.00000E+00	0.00000E+00	0.00000E+00
12	2.29372E+03	3.80308E+04	5.44679E+02	4.71729E+01	5.48202E+02	0.00000E+00	0.00000E+00	0.00000E+00
13	2.27676E+03	2.01384E+03	5.44682E+02	4.71626E+01	5.48173E+02	0.00000E+00	0.00000E+00	0.00000E+00
14	2.28266E+03	7.78728E+03	5.56745E+02	4.65190E+01	5.57701E+02	0.00000E+00	0.00000E+00	6.31025E+05
15	2.27776E+03	7.49031E+03	5.87663E+02	4.47450E+01	5.81163E+02	0.00000E+00	0.00000E+00	9.77174E+05
16	2.27282E+03	7.16357E+03	6.18628E+02	4.27931E+01	6.03231E+02	0.00000E+00	0.00000E+00	6.28146E+05
17	2.24714E+03	2.39310E+02	5.44495E+02	4.71548E+01	5.47970E+02	0.00000E+00	0.00000E+00	0.00000E+00
19	2.24797E+03	1.09238E+03	6.81893E+02	3.81951E+01	6.43275E+02	0.00000E+00	0.00000E+00	0.00000E+00
20	8.86796E+02	9.49338E+04	6.18895E+02	1.11125E+01	5.29743E+02	1.40381E-01	7.98517E-01	2.05434E+06
110001	2.24553E+03	4.79903E+03	6.97800E+02	3.69156E+01	6.52198E+02	0.00000E+00	0.00000E+00	0.00000E+00
110002	2.24467E+03	4.79573E+03	6.98094E+02	3.68902E+01	6.52357E+02	0.00000E+00	0.00000E+00	0.00000E+00
110003	2.24380E+03	4.79560E+03	6.98090E+02	3.68893E+01	6.52351E+02	0.00000E+00	0.00000E+00	0.00000E+00
110004	2.24294E+03	4.79548E+03	6.98085E+02	3.68883E+01	6.52346E+02	0.00000E+00	0.00000E+00	0.00000E+00
110005	2.24207E+03	4.79536E+03	6.98080E+02	3.68874E+01	6.52341E+02	0.00000E+00	0.00000E+00	0.00000E+00
110006	2.24121E+03	4.79524E+03	6.98075E+02	3.68864E+01	6.52336E+02	0.00000E+00	0.00000E+00	0.00000E+00
110 LIQ REG	2.24031E+03	2.49804E+03	6.98065E+02	3.68858E+01	6.52328E+02	0.00000E+00	8.69763E-01	0.00000E+00
VAP REG		2.78972E+03	1.12112E+03	6.16818E+00	6.54024E+02	1.00000E+00		0.00000E+00

JUNCTION NUMBER	CONNECTS VOLUMES	CHOK/ PATH	JUN. FLOW (LB/SEC)	JUN. ENTH. (BTU/LB)	JUN. SPVL. (FT3/LB)	P R E S S U R E VEL. PSI	ELEV. PSI	D I F F E R E N T I A L S FRIC. PSI	ACCL. PSI	PUMP PSI
1	1 TO 2001		2.72899E+04	6.25051E+02	2.36088E-02	-1.00150E+01	2.58857E-01	-4.25892E+00	-7.01277E-02	0.00000E+00
2001	2001 TO 2002		2.72986E+04	6.24877E+02	2.36099E-02	1.68322E-01	-1.25150E-04	-1.36217E-01	-5.74650E-03	0.00000E+00
2002	2002 TO 2003		2.70638E+04	6.24662E+02	2.36018E-02	-6.10330E-03	-1.37044E-04	-1.33992E-01	-2.04707E-03	0.00000E+00
2003	2003 TO 2		2.70720E+04	6.24461E+02	2.35944E-02	-4.89166E-03	-1.20779E-04	-1.34025E-01	-7.09209E-03	0.00000E+00
2	2 TO 3		2.70793E+04	6.24279E+02	2.35877E-02	9.69749E+00	-1.15928E+00	-7.48511E+00	-3.14679E-02	0.00000E+00
3	3 TO 4		2.71055E+04	6.23619E+02	2.35617E-02	-9.26328E-01	-2.98947E+00	-4.08880E+00	-4.46128E-03	0.00000E+00
4	4 TO 5		2.71374E+04	5.91409E+02	2.24764E-02	7.69838E-02	-4.57590E+00	-4.85579E+00	-6.02607E-03	0.00000E+00
5	5 TO 6		2.71646E+04	5.69519E+02	2.18467E-02	4.45318E-02	5.32997E-02	-5.01165E+00	-4.39241E-03	0.00000E+00
6	6 TO 7		2.71878E+04	5.54732E+02	2.14619E-02	2.67181E-02	4.80441E+00	-4.53716E+00	-3.76286E-03	0.00000E+00
7	7 TO 8		2.72099E+04	5.44682E+02	2.12163E-02	-5.83511E+00	5.11426E+00	-4.81115E+00	-1.01440E-02	0.00000E+00
8	8 TO 9		2.72183E+04	5.44333E+02	2.12095E-02	6.86002E+00	-4.11838E-02	-1.21921E+00	1.58634E-02	4.36132E+01
9	9 TO 10001		2.72167E+04	5.44677E+02	2.12044E-02	-1.10921E+01	-4.73239E-01	-1.11651E+01	1.37930E-02	4.36132E+01
10001	10001 TO 10002		2.72166E+04	5.44677E+02	2.11988E-02	3.18020E-03	8.53274E-07	-1.20983E-01	3.53920E-03	0.00000E+00
10002	10002 TO 10003		2.72164E+04	5.44678E+02	2.11988E-02	2.41456E-04	8.48575E-07	-1.20982E-01	3.72771E-03	0.00000E+00
10003	10003 TO 10004		2.72163E+04	5.44678E+02	2.11988E-02	2.78702E-04	1.21010E-06	-1.20981E-01	3.92425E-03	0.00000E+00
10004	10004 TO 10		2.72161E+04	5.44679E+02	2.11989E-02	4.22522E-04	1.16197E-06	-1.20979E-01	3.77617E-03	0.00000E+00
10	10 TO 11		2.72158E+04	5.44682E+02	2.11990E-02	9.14617E+00	2.13416E+00	-1.29512E+01	1.97895E-02	0.00000E+00
11	11 TO 12		2.72136E+04	5.44680E+02	2.11994E-02	1.94575E+00	4.94971E+00	-4.11246E+00	1.00543E-02	0.00000E+00
12	12 TO 13		8.57516E+02	5.44678E+02	2.11986E-02	-1.35761E-01	-3.57848E+00	-1.32447E+01	-3.04172E-04	0.00000E+00
13	12 TO 14		2.63540E+04	5.44679E+02	2.11986E-02	-8.53589E-01	-2.25946E+00	-7.93769E+00	4.25666E-03	0.00000E+00
14	14 TO 15		2.63462E+04	5.68863E+02	2.18127E-02	-6.67264E-02	-1.26751E+00	-3.57022E+00	1.31341E-03	0.00000E+00
15	15 TO 16		2.63271E+04	6.06490E+02	2.29450E-02	-7.65438E-02	-1.21576E+00	-3.64187E+00	5.91889E-04	0.00000E+00
16	16 TO 1		2.63172E+04	6.30580E+02	2.38141E-02	8.96718E-01	-2.29450E+00	-7.78711E+00	-2.10807E-03	0.00000E+00
17	13 TO 1		8.57398E+02	5.44681E+02	2.12033E-02	1.35778E-01	-3.66527E+00	-9.59055E+00	-3.36826E-04	0.00000E+00
18	10 TO 17		1.65878E-01	5.44682E+02	2.11990E-02	1.10916E+01	-7.46627E+00	-4.95835E+01	-3.11599E-03	0.00000E+00
19	17 TO 110		1.05223E-01	5.44418E+02	2.12051E-02	-7.79367E-06	-6.79659E+00	-1.70603E-02	1.61083E-02	0.00000E+00
20	19 TO 110001		2.14496E+02	6.82140E+02	2.61950E-02	7.41435E-05	-1.59665E+00	-1.06069E+00	-6.42857E-03	0.00000E+00
21	2002 TO 19		2.43824E+02	6.24662E+02	2.36018E-02	0.00000E+00	-1.10497E+00	-1.02618E+00	-1.24593E-01	0.00000E+00
110001	110001 TO 110002		2.02369E+02	6.98011E+02	2.71021E-02	1.05480E-05	-8.65396E-01	-4.83671E-07	1.39847E-04	0.00000E+00
110002	110002 TO 110003		1.97880E+02	6.98010E+02	2.71031E-02	7.09036E-06	-8.65100E-01	-4.64228E-07	-2.03429E-04	0.00000E+00
110003	110003 TO 110004		1.93387E+02	6.98010E+02	2.71040E-02	6.93590E-06	-8.65077E-01	-4.45126E-07	-2.01379E-04	0.00000E+00
110004	110004 TO 110005		1.88890E+02	6.98007E+02	2.71049E-02	6.78109E-06	-8.65055E-01	-4.26374E-07	-1.99608E-04	0.00000E+00
110005	110005 TO 110006		1.84389E+02	6.98007E+02	2.71058E-02	6.62593E-06	-8.65033E-01	-4.07971E-07	-1.98095E-04	0.00000E+00
110009	110006 TO 110		1.79884E+02	6.98007E+02	2.71068E-02	6.77359E-05	-8.82515E-01	-9.74806E-07	1.68242E-02	0.00000E+00
31	0 TO 20		0.00000E+00	6.17307E+02	8.88171E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
30	0 TO 20		0.00000E+00	6.17307E+02	8.88171E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
29	0 TO 20		0.00000E+00	6.17307E+02	8.88171E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
28	0 TO 20		0.00000E+00	6.17307E+02	8.88171E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
27	0 TO 20		0.00000E+00	6.17307E+02	8.88171E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
26	0 TO 110		0.00000E+00	1.12110E+03	1.62156E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
25	0 TO 110		0.00000E+00	1.12110E+03	1.62156E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
24	0 TO 10002		0.00000E+00	5.44678E+02	2.11988E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
23	0 TO 20		-2.73979E+03	1.19682E+03	5.11832E-01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
22	0 TO 20		2.73979E+03	4.17089E+02	1.91099E-02	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

BUBL SET	VOL.	BUBBLE GRADIENT	BUBBLE VELOCITY	MIXTURE LEVEL	MIXTURE QUALITY	BUBBLE MASS

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NUMB.	NUMB.	PARAMETER	(FT/SEC)	(FT)		(LB)
1	110	1.00000E+00	1.00000E+00	1.75925E+00	0.00000E+00	0.00000E+00
2	20	0.00000E+00	1.41808E+01	6.19890E+01	0.00000E+00	1.30591E+04

PUMP NUMB.	VOL. NUMB.	PUMP SPEED (RPM)	NORM. PUMP TORQUE	NORM. FRIC. TORQUE	NORM. MOT. TORQUE	POWER TO H2O (BTU/HR)
1	9	1.18000E+03	9.94337E-01	0.00000E+00	0.00000E+00	3.37257E+07

HEAT COND. NUMBER	VOL. HT TRAN NUM.	MODE-COR	SURF. FLUX (BTU/HR-FT2)	CRIT. FLUX (BTU/HR-FT2)	H.T. COEF. (BTU/H-F2-F)	SURF. TEMP. (DEG. F)	MASS FLUX (LBM/HR-FT2)	STORD ENRGY (BTU)	POWR TO H20 (BTU/HR)	DRYOUT PNT ()
1 RGHT	14	1-DB-L	1.60504E+05	9.11599E+05	5.34107E+03	5.87764E+02	2.16808E+06	6.25935E+06	2.27169E+09	
2 RGHT	15	1-DB-L	2.48549E+05	9.12722E+05	5.44979E+03	6.26796E+02	2.16706E+06	8.21940E+06	3.51783E+09	
3 RGHT	16	1-DB-L	1.59772E+05	9.13857E+05	5.56603E+03	6.31946E+02	2.16605E+06	6.51631E+06	2.26132E+09	
4 LEFT	4	1-DB-L	-9.97020E+04	8.25021E+05	5.42992E+03	5.77045E+02	2.39076E+06		-3.06004E+09	
RGHT	20	2-THOM	8.82971E+04	2.54639E+05	8.34298E+03	5.40336E+02	2.90951E+05	4.50938E+06	3.05987E+09	
5 LEFT	5	1-DB-L	-6.70625E+04	8.27033E+05	5.33594E+03	5.63147E+02	2.39336E+06		-2.05827E+09	
RGHT	20	2-THOM	5.93822E+04	1.40568E+05	6.84188E+03	5.38432E+02	2.90951E+05	4.44231E+06	2.05785E+09	
6 LEFT	7	1-DB-L	-2.96137E+04	8.28257E+05	5.23663E+03	5.46425E+02	2.39758E+06		-9.08899E+08	
RGHT	20	2-THOM	2.61767E+04	1.40568E+05	4.54257E+03	5.35515E+02	2.90951E+05	4.35868E+06	9.07135E+08	
7 LEFT	6	1-DB-L	-4.46876E+04	8.28156E+05	5.27590E+03	5.53311E+02	2.39558E+06		-1.37155E+09	
RGHT	20	2-THOM	3.95554E+04	2.54639E+05	5.58404E+03	5.36837E+02	2.90951E+05	4.39372E+06	1.37076E+09	

CORE NUMB.	COND. NUMB.	DEPTH REAC. EXT. ZR-H2O (FT)	DEPTH REAC. INT. ZR-H2O (FT)	HEAT GEN. ZR-H2O (BTU/HR)	COND. HEAT-ING RATE (BTU/HR)	DIR. MODER-ATOR HT RT (BTU/HR)	AVG. METAL TEMPERATURE (DEG. F)	CENTERLINE TEMPERATURE (DEG. F)	FUEL ENTHALPY (CAL/GM)
1	1	0.00000E+00	0.00000E+00	0.00000E+00	1.74909E+09	0.00000E+00	1.27484E+03	1.63271E+03	0.00000E+00
2	2	0.00000E+00	0.00000E+00	0.00000E+00	2.70427E+09	0.00000E+00	1.66099E+03	2.31756E+03	0.00000E+00
3	3	0.00000E+00	0.00000E+00	0.00000E+00	1.74909E+09	0.00000E+00	1.31963E+03	1.68433E+03	0.00000E+00

0

AVERAGE CORE (RETRAN)		MINIMUM HEIGHT (HOT CHANNEL)		HOT SPOT (HOT CHANNEL)		MINUMUM DNBR POSITION (HOT CHANNEL)		
LHGR(KW/FT)	DNBR	LHGR(KW/FT)	DNBR	LHGR(KW/FT)	DNBR	POS. (FT)	LHGR(KW/FT)	MDNBR
6.38641E+00	4.75600E+00	1.53658E+01	2.68786E+00	1.95004E+01	1.46471E+00	9.00000E+00	1.39638E+01	1.27071E+00

REACTOR PERIOD (SEC)	FISSION POWER	DECAY HEAT POWER	TOTAL REACTIVITY ($)	CONTROL REACTIVITY ($)	COOL. TEMP. REACTIVITY ($)	VOID REACTIVITY ($)	FUEL TEMP. REACTIVITY ($)	DOPPLER REACTIVITY ($)
-1.14316E+00	8.09849E-01	0.00000E+00	-2.94725E-01	-2.70785E-01	0.00000E+00	0.00000E+00	0.00000E+00	-2.39405E-02

HEAT EXCGR. NUMBER	VOLUME NUMBER	POWR TO H2O (BTU/HR)
1	110	0.00000E+00
2	110	0.00000E+00
3	110	0.00000E+00

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REEDIT-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page    8
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:33
 UNCONTROLLED ROD WITHDRAWAL  --  RETRAN SAMPLE PROBLEM                                                         CPU TIME =     0.031
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *
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SYSTEM ELAPSED TIME (SEC)	SYSTEM ELAPSED TIME (SEC)	TIME STP ACTUAL	VOL 1 AVG. PRESS. (PSIA)	VOL 110 AVG. PRESS. (PSIA)	VOL 20 AVG. PRESS. (PSIA)	SYSTEM NORM. POWER	VOL 2 AVG. TEMP. (DEG F)	VOL 10 AVG. TEMP. (DEG F)
0.00000E+00	0.00000E+00	0.00000E+00	2.24180E+03	2.22000E+03	8.71120E+02	1.00000E+00	6.05991E+02	5.48092E+02
2.00000E-02	2.00000E-02	2.00000E+00	2.24182E+03	2.22000E+03	8.71120E+02	1.00137E+00	6.05991E+02	5.48093E+02
4.00000E-02	4.00000E-02	4.00000E+00	2.24185E+03	2.21999E+03	8.71120E+02	1.00296E+00	6.05992E+02	5.48093E+02
6.00000E-02	6.00000E-02	6.00000E+00	2.24188E+03	2.21999E+03	8.71120E+02	1.00455E+00	6.05992E+02	5.48093E+02
8.00000E-02	8.00000E-02	8.00000E+00	2.24190E+03	2.21999E+03	8.71120E+02	1.00617E+00	6.05992E+02	5.48093E+02
1.00000E-01	1.00000E-01	1.00000E+01	2.24191E+03	2.21999E+03	8.71120E+02	1.00779E+00	6.05992E+02	5.48093E+02
1.20000E-01	1.20000E-01	1.20000E+01	2.24193E+03	2.21999E+03	8.71120E+02	1.00943E+00	6.05992E+02	5.48093E+02
1.40000E-01	1.40000E-01	1.40000E+01	2.24196E+03	2.21999E+03	8.71120E+02	1.01109E+00	6.05992E+02	5.48093E+02
1.60000E-01	1.60000E-01	1.60000E+01	2.24198E+03	2.21999E+03	8.71120E+02	1.01276E+00	6.05993E+02	5.48093E+02
1.80000E-01	1.80000E-01	1.80000E+01	2.24201E+03	2.21998E+03	8.71120E+02	1.01444E+00	6.05993E+02	5.48093E+02
2.00000E-01	2.00000E-01	2.00000E+01	2.24203E+03	2.21998E+03	8.71120E+02	1.01614E+00	6.05994E+02	5.48094E+02
2.20000E-01	2.20000E-01	2.20000E+01	2.24205E+03	2.21998E+03	8.71120E+02	1.01785E+00	6.05995E+02	5.48094E+02
2.40000E-01	2.40000E-01	2.40000E+01	2.24206E+03	2.21998E+03	8.71120E+02	1.01957E+00	6.05997E+02	5.48094E+02
3.00000E-01	3.00000E-01	3.00000E+01	2.24211E+03	2.21998E+03	8.71120E+02	1.02482E+00	6.05996E+02	5.48094E+02
4.00000E-01	4.00000E-01	4.00000E+01	2.24217E+03	2.21999E+03	8.71120E+02	1.03382E+00	6.05991E+02	5.48094E+02
5.00000E-01	5.00000E-01	5.00000E+01	2.24221E+03	2.22000E+03	8.71121E+02	1.04313E+00	6.05987E+02	5.48094E+02
6.00000E-01	6.00000E-01	6.00000E+01	2.24226E+03	2.22002E+03	8.71121E+02	1.05275E+00	6.05984E+02	5.48095E+02
7.00000E-01	7.00000E-01	7.00000E+01	2.24231E+03	2.22005E+03	8.71121E+02	1.06266E+00	6.05984E+02	5.48095E+02
1.25000E+00	1.25000E+00	8.50000E+01	2.24319E+03	2.22039E+03	8.71123E+02	1.12279E+00	6.06006E+02	5.48099E+02
2.25000E+00	2.25000E+00	1.05000E+02	2.24672E+03	2.22273E+03	8.71137E+02	1.25363E+00	6.06340E+02	5.48117E+02
3.00000E+00	3.00000E+00	1.31000E+02	2.26364E+03	2.24031E+03	8.86796E+02	8.09849E-01	6.07100E+02	5.48201E+02

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REEDIT-3D/MOD004.7.1 08/28/14 EPRI BEST EST. THERMAL HYDRAULICS ANALYSIS CODE    --  NRC APPROVED VERSION       29/08/14  Page    9
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY Computer Simulation & Analysis            11:57:33
 UNCONTROLLED ROD WITHDRAWAL  --  RETRAN SAMPLE PROBLEM                                                         CPU TIME =    0.031
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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SYSTEM ELAPSED TIME (SEC)	JUN 13 FLOW (LB/SEC)	JUN 19 FLOW (LB/SEC)	JUN 21 FLOW (LB/SEC)
0.00000E+00	2.63380E+04	5.57113E+00	-5.57113E+00
2.00000E-02	2.63394E+04	4.22413E+00	-5.55787E+00
4.00000E-02	2.63405E+04	2.18021E+00	-5.50236E+00
6.00000E-02	2.63407E+04	3.25153E-01	-5.39584E+00
8.00000E-02	2.63406E+04	-2.36582E-01	-5.24195E+00
1.00000E-01	2.63405E+04	7.40410E-02	-5.04314E+00
1.20000E-01	2.63405E+04	2.63468E-01	-4.80566E+00
1.40000E-01	2.63405E+04	1.92058E-01	-4.52845E+00
1.60000E-01	2.63406E+04	1.42112E-01	-4.21747E+00
1.80000E-01	2.63406E+04	1.55028E-01	-3.87044E+00
2.00000E-01	2.63406E+04	1.68034E-01	-3.49099E+00
2.20000E-01	2.63407E+04	1.65953E-01	-3.08076E+00
2.40000E-01	2.63407E+04	1.62712E-01	-2.64174E+00
3.00000E-01	2.63407E+04	1.63764E-01	-1.17388E+00
4.00000E-01	2.63406E+04	1.63572E-01	1.81636E+00
5.00000E-01	2.63404E+04	1.63473E-01	5.24946E+00
6.00000E-01	2.63398E+04	1.63369E-01	8.88876E+00
7.00000E-01	2.63391E+04	1.63263E-01	1.27094E+01
1.25000E+00	2.63335E+04	1.62890E-01	4.42616E+01
2.25000E+00	2.63212E+04	1.61329E-01	1.55923E+02
3.00000E+00	2.63540E+04	1.05223E-01	2.43824E+02

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

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APPENDIX A

DEFINITION OF VARIABLES APPEARING ON RETRAN-3D MAJOR EDITS

Appendix A contains definitions of all variables that may appear on a RETRAN-3D major edit. The definitions are divided into specific groups describing particular features or options in RETRAN-3D.

1.0 OVERALL SYSTEM VARIABLES

1.1 Normalized Core Power

The normalized core power is the core power at time t, normalized to the initial power.

1.2 Core Power

The core power in megawatts. The core power is the power produced in the core sections at time t and is the product of the normalized power and the user-specified initial power. If the space-dependent kinetics option is used, core power is computed from the fission source term. The group fluxes are constrained to yield the user-specified initial power.

1.3 Thermal Power

The sum of all heat sources or sinks in the system including the core, pumps, turbines, and nonconducting heat exchangers.

1.4 Energy Balance

The system energy balance is the sum of fluid internal energy in all control volumes (excluding time-dependent volumes).

1.5 Total Mass Balance

The system total mass balance is the sum of the water and noncondensable masses in all control volumes (excluding time-dependent volumes).

1.6 Air Mass Balance

The air mass balance is the sum of the noncondensable mass in all control volumes.

1.7 Average Time Step

The average time-step size since the last minor edit (minor edit variable DTAV).

1.8 Current Time Step

Time-step size to reach current time value (minor edit variable DTOL).

1.9 Elapsed Time

Total problem time.

1.10 Standard Time-Step Number

An integer multiple of the maximum time-step size DELTM (see Section IV.5). Defined as the problem time divided by DELTM.

1.11 Actual Time-Step Number

Total number of time steps actually taken.

2.0 VOLUME VARIABLES

RETRAN-3D "volumes" are the fluid control volumes from which solutions to the continuity and energy equations are obtained. The momentum equation is solved about RETRAN junctions. Thus, the volume parameters represent the average thermodynamic state within a control volume. Refer to Figure A.2-1 for the RETRAN-3D volume/junction orientation.

The volume major edit for two-region nonequilibrium volumes will contain information for the liquid and vapor regions within the volume. The power to the H2O does not include the heater power that might be added to the liquid region. The void fraction edited for two-region volumes is the volume average value.

When the stratified pressurizer model is used, active subnodes are included in the volume block of the major edit. As subnodes are combined with the two-region volume, they become inactive and are omitted from the volume block major edit. When the multidimensional kinetics option is

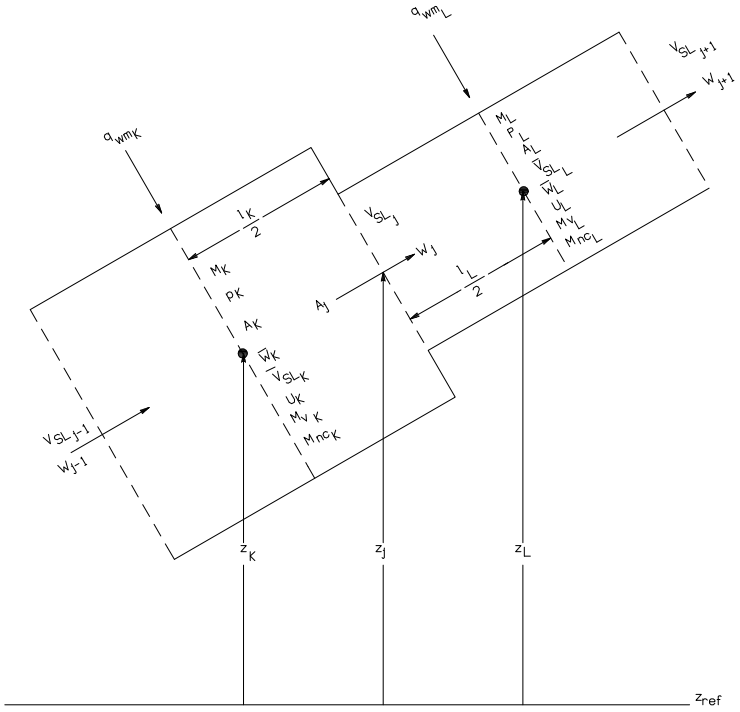


Figure A.2-1. Typical Computational Mesh for Two Junctions on a Volume

used, volumes associated with core channels will not be included in this edit. An abbreviated version of the volume edit is included in the channel edit as discussed in Section 10.

2.1 Volume Average Pressure

The volume average pressure is the pressure corresponding to the average thermodynamic state within the control volume.

2.2 Total Mass

The total mass is the sum of the liquid mass and the gas mass.

2.3 Average Enthalpy

The volume average enthalpy is the enthalpy corresponding to the average thermodynamic state within control volume center.

2.4 Average Density

The average fluid density in a RETRAN volume is the total mass divided by the volume displacement.

2.5 Average Temperature

The average temperature is the mixing cup temperature for both equilibrium and nonequilibrium models.

2.6 Average Quality

The average quality is the static quality corresponding to the average thermodynamic state within the control volume. The quality x is calculated as the mass of gas divided by the total mass in the control volume.

2.7 Void Fraction

The void fraction is the homogeneous volume fraction occupied by the gas in the volume. The relation between the average quality and the void fraction, α, is

$$\alpha = \frac{x\,\nu_g}{(1-x)\,\nu_\ell + x\,\nu_g} \quad . \tag{A.2-1}$$

where

x = average quality

ν_g = gas specific volume

ν_ℓ = liquid specific volume

2.8 Power to H_2O

The power to the water is the energy exchange rate between the fluid in the control volume and all adjacent conductors and heat exchangers.

2.9 Noncondensable Quality

The noncondensable quality is calculated as the mass of noncondensable divided by the sum of the noncondensable and vapor masses in the control volume.

3.0 JUNCTION VARIABLES

Most RETRAN-3D junctions are modeled using the momentum equation to determine the flow. There are however, two modeling options where algebraic equations are used to determine the flow, one being the choking model and the other the FIBWR model which can be used to model typical BWR leakage paths. The algebraic options can change some of the output that is included in the junction portion of the major edit. These differences are discussed below.

The momentum equation in RETRAN-3D is written about junctions. A junction is a flow path between two RETRAN-3D volumes. The momentum equation used in RETRAN-3D is (refer to Chapter II, Volume 1, Theory and Numerics, for a development of the momentum equation)

$$
\begin{aligned}
I_i \frac{dW_i}{dt} = & \left[\frac{\overline{W}_k^2}{\rho_k A_k^2} + \left(X_g^m X_\ell^m \rho \right)_k \overline{V}_{SL,k}^2 \right] \left| \cos \varphi_{i1} \right| \\
& - \left[\frac{\overline{W}_{k+1}^2}{\rho_k A_{k+1}^2} + \left(X_g^m X_\ell^m \rho \right)_{k+1} \overline{V}_{SL,k+1}^2 \right] \left| \cos \varphi_{i2} \right| + \left(p_k - p_{k+1} \right) - \left(\frac{F_{w,k}}{A_k} + \frac{F_{w,k+1}}{A_{k+1}} \right) \\
& + g_z \int_{z_{k+1}}^{z_k} \rho \, d\ell + \Delta p_p \\
& - \frac{1}{2\rho_i} \left[\frac{\left(\sum_{j \varepsilon Out_k} \left| W_j \right| \right)^2}{A_k^2} \left| \cos \varphi_{i1} \right| - \frac{\left(\sum_{j \varepsilon In_{k+1}} \left| W_j \right| \right)^2}{A_{k+1}^2} \left| \cos \varphi_{i2} \right| \right] - \frac{k_i}{2\rho_i A_i^2} W_i \left| W_i \right| \quad . \qquad \text{(A.3-1)}
\end{aligned}
$$

The first term on the right-hand side of Eq. A.3-1 represents the pressure difference between the volume centers. The next two terms account for momentum flux or spatial acceleration due to compressibility and the fourth term is the acceleration due to area changes. The fifth term represents junction form losses. The sixth term is for wall friction. The seventh term is the gravitational effect between two volumes and the eighth and final term is the pump head.

When the flow in a junction is limited by a choking model, the flow is given by

$$
F_W \left(p_j^0, h_j^0 \right) = C_j A_j(t) G_{crit} \left(p_j^0, h_j^0 \right) - W_j^n \quad . \qquad \text{(A.3-2)}
$$

where the critical flow model G_{crit} is either a curve fit or discrete table where the independent variables are the stagnation pressure and enthalpy.

A text field is included in the junction major edit block that identifies the particular choking model that was used. This is discussed below.

When a junction is modeled as a FIBWR leakage path, the junction flow is determined by

$$W = C_1 \Delta p^{0.5} + C_2 \Delta p^{C4} + C_3 \Delta p^2 , \qquad \text{(A.3-3)}$$

where Δp is the difference in the pressure for the adjacent volumes and all coefficients are input. Text fields are included in the output so FIBWR junctions can be easily identified.

When the stratified two-region model is used, exit junctions from active subnodes are included in the junction block of the major edit. As subnodes are combined with the two-region volume, they become inactive and the exit junctions are omitted from the major edit. The junction entering the two-region volume (surge junction) is always included and will appear as if connected to the top active subnode.

When the multidimensional kinetics option is used, junctions associated with core channels will not be included in this edit. Junctions at the channel inlet and channel exit are included, but the choking mode discussed above is replaced by the appropriate word, INLET or EXIT, and the channel number.

3.1 Choking Mode/Path Indicators

The choking mode/path indicator is a text field that indicates which choking model was used when the junction flow is limited by the choking model. It is also used to identify the path type for specific junctions associated with the FIBWR model. Both uses are discussed below. Note that FIBWR leakage junctions (LLK and BLK - see below) cannot choke.

Three models are available as user options for critical flow. If choking is determined to occur, a choking model indicator is included in the corresponding junction major edit. When no choking exists and the standard momentum equation or inertial solution is used, the choking mode indicator is blank. The following summarizes the choking mode indicators that can be included in a major edit

blank	- No choking, inertial solution	= 1.0
XHN	- Extended Henry-Fauske	= 2.0
MDY	- Moody	= 3.0
HEM	- Isentropic expansion	= 4.0

The choking mode for given junctions can be requested as minor edit parameters. For these minor edit parameters, the appropriate real floating point number listed above for the various choking (or no choking) modes will be edited.

When junctions are choked, the flow is determined by evaluating one of the choked flow models using the stagnation pressure and enthalpy where the flow is essentially the first term on the right-hand side of Eq. A.3-2. The stagnation conditions are defined using Eqs. A.3-4 and A.3-5.

$$p_j^0 = p_k - \Delta p_z + \frac{1}{2}\frac{\overline{W}_k^2}{\rho_k A_k^2} - \left(f_w \frac{\ell}{D_{hy}}\right)_k S_w W_{crit}^2 \ , \qquad \text{(A.3-4)}$$

and

$$h_j^0 = h_k + \frac{1}{2}\left(\frac{\overline{W}_k}{\rho_k A_k}\right)^2 + \Delta Q_k = h_j + \frac{1}{2}\left(\frac{\overline{W}_k}{\rho_k A_k}\right)^2 \ . \qquad \text{(A.3-5)}$$

Refer to Volume 1: Theory and Numerics, Chapters IV and VIII, for descriptions of the model option and solution methods.

The choking mode/path field will identify the FIBWR model path type when the model is active. The following list indicates the path types that are identified as part of the FIBWR model.

- AFI - Active Fuel Region Inlet,
- CHX - Channel Exit,
- CHI - Channel Inlet,
- BLK - Bypass Leakage (Eq. A.3-3),
- LLK - Lateral Leakage (Eq. A.3-3),
- WTI - Water Tube Inlet, and
- WTO - Water Tube Outlet.

Only junctions that are identified as “BLK” or “LLK” are modeled using Eq. A.3-3. The other five junction types use the mixture momentum equation.

3.2 Junction Flow

Junction flow, W_j, is the fluid mass flow rate at junction j in lbm/sec.

3.3 Junction Enthalpy

The junction enthalpy, h_j, is the thermodynamic enthalpy at junction j in Btu/lbm. The enthalpy is based on a "donor concept", in which the junction enthalpy is obtained from the upstream volume, modified to reflect any changes in fluid energy between the volume center and the junction. The exception to this model is the situation for countercurrent flow with the slip option activated. In this case, the junction properties are based on those of the phasic donor volume properties.

3.4 Junction Specific Volume

The junction specific volume is the specific volume of the fluid moving through junction j corresponding to fluid with enthalpy h_j and a junction pressure p_j. The junction pressure is estimated from the upstream volume pressure ("donor" volume). The donor volume pressure is modified to reflect any Fanning losses and elevation differences between the volume center and the junction.

3.5 Velocity psi

The junction velocity psi is the difference between the first two terms on the right-hand side of Eq. A.3-1 plus term seven. It is the recoverable pressure drop that results from the momentum flux and area change terms. Note: Earlier code versions included the volume pressure difference in a term called stagnation psi. The velocity head is more useful.

For choked junctions, the velocity head (Term 3 on the right-hand side of Eq. A.3-4) is associated with the upsteam volume. The stagnation pressure used to evaluate the critical flow is obtained by adding the upstream velocity head to the volume pressure, elevation head, and frictional pressure. Similarly, the stagnation enthalpy is obtained by adding the velocity head, multiplied by (144*spvz/779), to the junction enthalpy as illustrated by Eq. A.3-5.

For FIBWR LLK and BLK leakage junctions, the velocity head is computed as it would be for a normal junction, but it is not used by the model.

3.6 Elevation psi

The junction elevation psi is the pressure difference due to the gravity head change between the center of volumes on either side of the junction. The elevation psi is given by the fifth term in Eq. A.3-1.

For choked junctions, the elevation pressure is the hydrostatic head (term two on the right-hand side of Eq. A.3-4) between the upsteam volume center and the junction.

For LLK and BLK FIBWR junctions, the elevation pressure is computed as it would be for a normal junction, but it is not used by the FIBWR model.

3.7 Friction psi

The junction friction psi represents irreversible pressure losses due to form losses and wall friction. It is the sum of terms four and eight on the right-hand side of Eq. A.3-1. If the junction is choked, the friction psi will become large due to modification of the loss term in the critical flow calculation.

For choked junctions, the friction pressure is the irreversible pressure loss between the upsteam volume center and the junction (Term 4 on the right-hand side of Eq. A.3-4).

For LLK and BLK FIBWR junctions, the friction pressure is computed as it would be for a normal junction, but it is not used by the FIBWR model.

3.8 Acceleration psi

The junction acceleration psi is the total rate of change of momentum. The acceleration psi is represented by the left-hand side term Eq. A.3-1.

For choked junctions, the acceleration pressure is not a pressure difference, but rather the difference between the critical flow evaluated using the stagnation pressure and enthalpy, and the old time level value of the junction flow. It is the right-hand side of Eq. A.3-2. As the flow goes to a steady condition, this difference will approach zero like the acceleration pressure for the momentum equation solution. Nonzero values are indicative of the change that will occur in the junction flow over the time-step advancement.

For FIBWR LLK and BLK leakage junctions, the acceleration pressure is not a pressure difference, but rather the difference between the old junction flow and the flow obtained using the FIBWR leakage flow equation (Eq. A.3-3). As the flow goes to a steady condition, this difference will approach zero like the acceleration pressure for the momentum equation solution. Nonzero values are indicative of the change that will occur in the junction flow over the time-step advancement.

3.9 Pump psi

The pump psi is one-half of the head developed by the pump (the last term in Eq. A.3-1). The head produced by the pump is distributed equally to the inlet and outlet junction of the pump volume.

4.0 VAPOR MASS EQUATION VARIABLES

Variables associated with the vapor mass equation are edited only when the five-equation option is used (NEWEQS > 0 on Card 01000Y). Information is given only for the volumes using the nonequilibrium equation of state that have a two-phase conditions.

When the multidimensional kinetics option is used, nonequilibrium volumes associated with core channels will not be included in this edit.

4.1 Volume Flow Regime

The volume flow regime flag indicates the regime that was obtained from the interfacial mass transfer flow regime maps. The flow regime determines variables such as interfacial area density and interfacial heat transfer coefficient, which in turn are used to calculate the amount of interfacial mass transfer. The explanations of the flow regime flags are:

Vertical Flow	IFRV	Horizontal Flow	IFRV
Single-Phase Liquid	1	Single-Phase Liquid	11
Bubble	2	Bubble	12
Slug	3	Slug	13
Transition	4	Transition	14
Annular-Mist	5	Annular-Mist	15
Single-Phase Vapor	6	Single-Phase Vapor	16
Dispersed Droplet	7	Dispersed Droplet	17
		Stratified	19

4.2 Liquid Enthalpy

The liquid enthalpy is the volume enthalpy of the liquid phase in the two-phase mixture. This enthalpy value may be either less than the saturated liquid value or greater.

4.3 Gas Enthalpy

The gas enthalpy is the enthalpy of saturated vapor in the two-phase mixture.

4.4 Liquid Temperature

The liquid temperature is the temperature of the liquid phase in the two-phase mixture and corresponds to the liquid-phase enthalpy and the volume average pressure. It may be either subcooled or superheated.

4.5 Gas Temperature

The gas temperature is the saturation temperature corresponding to the total pressure for situations where noncondensables are not present. For situations where nonconsensables are present, the gas temperature is the temperature of the water vapor/noncondensable mixture. It is the saturation temperature that corresponds to the partial pressure for the water vapor.

4.6 Interfacial Area Density

This is the area of the interface between the liquid and vapor phases per unit volume. It is a strong function of flow regime, as well as volume void fraction and the physical dimensions of the control volume.

4.7 Interfacial Heat Transfer Coefficient

This is the effective heat transfer coefficient at the interface and is used to calculate the mass transfer rate between the liquid and vapor phases. It depends strongly on flow regime and whether the liquid is subcooled or superheated.

4.8 Interfacial Mass Transfer Rate

This is the mass transfer rate between the liquid and vapor phases based on the difference between the liquid temperature and gas temperature (the five-equation model constrains the vapor phase to saturation temperature).

4.9 Total Mass Transfer Rate

The total mass transfer rate is the rate of mass exchange between the liquid phase and the vapor phase in the two-phase mixture. A positive value corresponds to a net vapor formation and a negative value corresponds to a net liquid production. This value is equal to the sum of the mass transfer rate due to interfacial or bulk processes (Section 4.8 above) and the mass transfer rate due to wall heating (or cooling).

4.10 Liquid Heating Rate

The liquid heating rate is the rate at which the energy of the liquid phase is being changed due to heating.

5.0 SLIP VARIABLES

Variables associated with the slip model are edited only when ISFLAG on Card 01000Y is >0. Information is given only for junctions where slip is present.

When the multidimensional kinetics option is used, only junctions at the inlet and exit of channels will be included in this edit.

5.1 Flow Regime

The flow regime flag indicates the regime that was used to obtain the constitutive properties for the dynamic slip model (ISFLAG = 1 on Card 01000Y). The flow regime determines variables such as interphase friction, wall-to-phase friction, and interphase area. The flow regime is not determined for the other slip options. The explanations of the flow regime flags are

Vertical Flow	IFRJ	Horizontal Flow	IFRJ
Single-Phase Liquid	1	Single-Phase Liquid	11
Bubble	2	Bubble	12
Slug	3	Annular	15
Froth	4	Single-Phase Vapor	16
Annular	5	Dispersed Droplet	17
Single-Phase Vapor	6	Stratified	19
Dispersed Droplet	7		

Special Conditions	IFRL
$v^{\ell} = 0, v^{g} \neq 0$	-6
$v^{\ell} \neq 0, v^{g} = 0$	-1

When the algebraic slip model (IDFLAG =2 or 3) or the taugl model (ISFLAG = 4 or 5) is used, the flow regime will be shown as 0 unless IFRJ was used to specify a flow regime. In this situation the input value will be printed.

5.2 Slip Velocity

The slip velocity is the relative velocity between the liquid phase and the gas phase. The slip velocity is defined as the value (v_ℓ - v_g) where v_ℓ is the liquid velocity and v_g is the gas velocity. The slip velocity is determined at the junctions by solving either the dynamic slip equation or the algebraic slip equation.

5.3 Void Fraction

The junction void fraction is the vapor fraction flowing through the junction. The void fraction is based on the junction quality, the gas density, and the mixture density. That is

$$\alpha_g = \frac{x\,\rho}{\rho_g} \qquad \text{(A.5-1)}$$

where

x is the gas mass fraction

ρ is the mixture density

ρ_g is the gas density

5.4 Liquid Flow

The liquid flow is that portion of the total junction flow (mixture flow) that is assigned to the liquid phase in lbm/sec.

5.5 Gas Flow

The gas flow is that portion of the total junction flow (mixture flow) that is assigned to the gas phase in lbm/sec.

5.6 Slip Energy Convection

The slip energy convection term represents the contribution to the energy convected into or out of a control volume that is due to unequal phase velocity effects. The term is defined as

$$SLPCNV = \rho A V_{s\ell}\, x\,(1-x)\left(h_\ell - h_g\right) \qquad \text{(A.5-2)}$$

where

A is the flow area

$v_{s\ell}$ is the slip velocity

h_g is the gas enthalpy

h_ℓ is the liquid enthalpy

and the parameters x and p are as defined above.

5.7 Gas Velocity

The gas velocity is the gas velocity (ft/sec) at the junction.

5.8 Liquid Velocity

The liquid velocity is the liquid-phase velocity (ft/sec) at the junction.

5.9 Slip Ratio

The slip ratio is defined as the gas velocity divided by the liquid velocity.

5.10 Slip Acceleration

The slip acceleration is the time rate of change of the slip velocity.

6.0 BUBBLE-RISE VARIABLES

The variables associated with the bubble-rise model are summarized for all volumes using the model option. Each bubble set must be used only once.

6.1 Volume Number

Volume number is the number of the control volume using the bubble set variables.

6.2 Bubble Gradient

The bubble gradient is the value of the gradient of the bubbles within the mixture region.

6.3 Bubble Velocity

The bubble velocity is the velocity of gas at the steam-mixture interface relative to the interface (mixture level) velocity.

6.4 Mixture Level

The mixture level is the elevation of the gas-fluid boundary measured from the bottom of the control volume.

6.5 Mixture Quality

The mixture quality is the average quality within the mixture region and is equal to the bubble mass divided by the total mass in the mixture.

6.6 Bubble Mass

The mass of gas below the fluid mixture level in a RETRAN volume is defined as the bubble mass. In a normal, two-phase volume (i.e., a nonseparated volume), the fluid mixture level is equal to the volume height. Thus, the bubble mass and the gas mass are the same. If the volume is a separated volume, the mixture level may not be equal to the volume height. In this case, the bubble mass is not equal to the gas mass. According to the definition, if the control volume is single phase, the bubble mass is zero. The liquid case is obvious. If the control volume contains only gas, the mixture level is zero and, therefore, the bubble mass is zero, even though the gas mass is not.

7.0 PUMP VARIABLES

7.1 Volume Number

The volume number is the number of the control volume for the pump.

7.2 Pump Speed

The pump speed refers to the pump impeller speed in rpm.

7.3 Normalized Pump Torque

The pump hydraulic torque at time t normalized to the rated hydraulic torque defines the normalized pump torque.

7.4 Normalized Frictional Torque

The normalized frictional torque is the time t frictional torque normalized to the time zero or initial value of frictional torque.

7.5 Normalized Motor Torque

The normalized motor torque is defined as the time t pump motor torque normalized to the rated motor torque.

7.6 Power to H_2O

The power to H_2O is the thermal power (Btu/hr) dissipated in the pump field volume by the pump impeller.

8.0 HEAT CONDUCTOR VARIABLES

8.1 Heat Transfer Mode and Correlation

The heat transfer mode determines the correlation used for calculating wall heat transfer coefficients. RETRAN-3D includes the following heat transfer regimes and correlations.

H. T. Mode	Description	Correlation
1	Forced convection in subcooled liquid	Dittus-Boelter - F
2	Nucleate boiling	Thom
3	Forced convection vaporization	Schrock-Grossman
4	Flow transition boiling	McDonough
5	Flow film boiling	Groeneveld
7	Pool transition boiling	Interpolation
8	Forced convection in super-heated vapor	Dittus-Boelter - V
9	Low pressure flow film boiling	Dougall-Rohsenow
10	Free convection to liquid	Collier - F
14	Free convection to vapor	Collier - V
15	Condensation on horizontal tubes	Nusselt - Hor. Tube
16	Heat transfer above critical point	Jackson and Hall
17	Nucleate boiling to forced convection vaporization	Thom/Schrock-Grossman
20	Nucleate boiling for five-equation option	Dittus-Boelter and Thom
21	Condensation on vertical plate	Nusselt-Vertical Plate
22	Condensation on vertical surface	Chun-Seban
23	Condensation with noncondensables	Siddique
28	Condensation inside round tube	Bell et al.
30	Free and forced convection to liquid	Catton-Swanson
31	Free and forced convection to noncondensables	Catton-Swanson
32	Free and forced convection to liquid and noncondensable mixture	Dittus-Boelter
33	Free and forced convection to liquid and noncondensable mixture	Collier
34	Free and forced convection to liquid and noncondensable mixture	Catton-Swanson

8.2 Surface Heat Flux

The surface heat flux is the rate of heat transfer per unit area through a surface of a given conductor.

8.3 Critical Heat Flux

The critical heat flux is the heat flux at which the boiling crisis occurs. The boiling crisis is characterized by a sudden drop in the boiling heat transfer coefficient due to the change in heat transfer mechanisms.

8.4 Heat Transfer Coefficients

The heat transfer coefficient is defined as

$$\frac{\text{Surface Heat Flux}}{\text{Surface Temperature - Fluid Temperature}} \text{ Per Unit Area .} \qquad \text{(A.8-1)}$$

8.5 Surface Temperatures

The surface temperature is the temperature at the outer or right side of the heat conductor.

8.6 Mass Flux

The mass flux refers to the volume average mass flux of the fluid in the volume adjacent to the heat conductor.

8.7 Stored Energy

The stored energy is the energy in the conductor at time t, given by

$$\text{stored energy} = \sum_{i}^{N} (\rho_i Cp_i \Delta T_i)\, \Delta V_i \qquad \text{(Btu)} \qquad \text{(A.8-2)}$$

where the summation is over the number of conductor mesh points.

8.8 Power to H_2O

The power to H_2O is the energy transferred from the heat conductor to the adjacent fluid volume. The energy transferred is the product of the surface flux and the conductor surface area.

9.0 CORE CONDUCTOR VARIABLES

When the multidimensional kinetics option is used, core conditions associated with core channels will not be included in this edit.

9.1 Depth of Reaction (Zr - H_2 O)

The depth or reaction is the depth that the metal-water reaction has penetrated the cladding. The words Ext. and Int. are used to reflect the external path and the internal depth.

9.2 Heat Generation [Zr - H_2O)

The heat generation is the rate of heat produced by the reaction between zirconium and steam.

9.3 Conductor Heating Rate

The conductor heating rate is the rate of heat generation internal to the conductor.

9.4 Direct Moderator Heating Rate

The direct moderator heating rate represents the energy directly deposited into the adjacent fluid volume.

9.5 Average Metal Temperature

The average metal temperature is the volume weighted average temperature of the left (or the conductor's inner surface) material region. The volume used to compute the average is only the inner region which is normally the fuel. The total conductor volume is not used.

9.6 Centerline Temperature

The centerline temperature is the temperature of a conductor's left surface.

9.7 Fuel Enthalpy

The optional fuel enthalpy is the average enthalpy of fuel regions for core conductors. It is the volumetric average of the heat capacity integral (enthalpy) for all node points in the fuel region.

10.0 CHANNEL EDIT VARIABLES

When the multidimensional kinetics option is used, RETRAN-3D volumes, junctions, and conductors are associated into thermal-hydraulic channels which are wrapped to the three-dimensional neutronic solution mesh. With the large number of volumes, junctions, and conductors involved, the normal RETRAN-3D major edit format quickly becomes ungainly and indecipherable. The channel edit reduces and consolidates the information presented. The user still has access to all the major edit information; either through the use of minor edit requests or by setting NED14 = 1 on card series 67001Y.
Each set of channel data is edited separately. Channel numbering is sequential from 1 to NCHANL. RETRAN-3D assumes the channel volumes and channel conductors are numbered identically. Eleven parameters are edited for each axial plane in the channel.

10.1 Node Number

This is the volume number and conductor number associated with this axial plane of the channel.

10.2 Moderator Temperature

The average fluid temperature within the associated RETRAN-3D control volume.

10.3 Moderator Density

The average fluid density in the associated RETRAN-3D control volume.

10.4 Moderator Enthalpy

The enthalpy corresponding to the average thermodynamic state within the associated RETRAN-3D control volume.

10.5 Heat Transfer Mode

The heat transfer mode flag for the right surface of the associated RETRAN-3D conductor. See Section 8.1, for definition of mode types.

10.6 Power Density

The power density of a channel axial plane is defined as the normalized power fraction of the associated core conductor divided by the volume of the associated RETRAN-3D control volume.

10.7 Fuel Temperature

The fuel temperature is the volume average metal temperature of the fuel region for the core conductors (see Section 9.5 for detail).

10.8 Fuel Enthalpy

The optional fuel enthalpy is the average of fuel regions for core conductors. It is the volumetric average of the heat capacity integral (enthalpy) for all node points in the fuel region.

10.9 Heat Flux

The heat flux is the rate of heat transfer per unit area through the right surface of the associated core conductor.

10.10 Conductor Heating Rate

The rate of heat generation internal to the associated RETRAN-3D core conductor.

10.11 Direct Moderator (DIR. MOD.) Heating Rate

The direct heating rate represents the energy directly deposited into the associated RETRAN-3D volume.

11.0 REACTOR KINETICS VARIABLES

The type of reactor kinetics edits that appear on a major edit depends on the value of NODEL on Card Type 01000Y. If NODEL is 1, a point model has been requested. If NODEL is 2, the one-dimensional model has been requested. If NODEL is 3, the multidimensional kinetics model has been requested. Edit variables associated with each of these options are presented below.

11.1 Point Kinetics Variables

11.1.1 Reactor Period

The reactor period is the time constant of the exponential time behavior of the reactor power level. The period describes the amount of time required for the power level to increase (or decrease if negative) by a factor e.

11.1.2 Fission Power Fraction

The fission power fraction is power generated from both prompt and delayed neutrons, normalized to the total power generated in the core sections.

11.1.3 Decay Heat Power Fraction

The decay heat power fraction is the power produced by fission products normalized to the total power generated in the core sections.

11.1.4 Total Reactivity

The total reactivity is the sum of the feedback reactivity, the control reactivity, and any initial reactivity bias.

11.1.5 Control Reactivity

The control reactivity is the reactivity obtained from the user-specified Scram Table.

11.1.6 Coolant Temperature Reactivity

The coolant temperature reactivity is the change in reactivity due to a change in the adjacent bulk fluid temperature. The change is specified by a coefficient defined by the user.

11.1.7 Void Reactivity

The void reactivity is the change in reactivity due to a change in the adjacent volume bulk fluid density. A void reactivity table is specified by the user.

11.1.8 Fuel Temperature Reactivity

The fuel temperature reactivity is the change in reactivity due to a change in the fuel rod temperature. The change is specified by a coefficient defined by the user.

11.1.9 Doppler Reactivity

The Doppler reactivity is a change in reactivity due to a change in the fuel rod temperature. A Doppler reactivity table is specified by the user.

11.2 One-Dimensional Kinetics Variables

11.2.1 Total Reactivity

See definition of total reactivity for point kinetics edit.

11.2.2 Inverse Period

Reciprocal reactor period, where reactor period is defined in point kinetics edit.

11.2.3 Control Rod Position

The relative rod position is the distance that the rod bank has moved since the initial condition.

11.2.4 Prompt Power Fraction

The prompt power fraction is the power generated from both prompt and delayed neutrons normalized to the initial power.

11.2.5 Decay Heat Power Fraction

The decay power fraction is the power produced by fission products normalized to the initial power.

11.2.6 Normalized Power Distribution

The normalized power distribution is the integrated power density for the given region. The integration is carried out over the spatial mesh. That is

$$P_R(t) = \frac{1}{V_R}\left[\int_R \sum_{g=1}^{2} \Sigma_{fg}\, \Psi_g(r,t)\, dr\right] N(t) \qquad \text{(A.11-1)}$$

where

V_R = region volume

Σ_{fg} = region averaged fission cross section for energy group g

Ψ_g = shape function for group g

$N(t)$ = amplitude function

11.2.7 Region-Wise Reactivity

The region-wise reactivity is an adjoint weighted integral that reflects the time-dependent reactor configuration. The reactivity indicates changes in the coefficient matrix and the source term due to cross-section variations and flux shape changes. The reactivity is defined as

$$P_R(t) = \int \Psi^*(r)\left[-M + \frac{1}{K_o} F^P + \sum_i x_i^d F_i^d\right] \Psi(r)\, dr \qquad \text{(A.11-2)}$$

where

Ψ^* = adjoint flux

Ψ = forward flux

and the bracket term indicates the diffusion, scattering, absorption, and production process.

11.2.8 Change in Feedback Variables

This edit gives the user information about the thermal-hydraulic state parameters that are used to generate the time-dependent group constants from the polynomial expansion. The information is indicated as a net change from initial conditions. The definitions are

- Normalized p

$$\frac{\rho(t) - \rho(o)}{\rho(o)} \qquad \text{(A.11-3)}$$

where ρ is the RETRAN volume average density.

- Fuel Temperature

$$\sqrt{T_f(t)} - \sqrt{T_f(o)} \qquad \text{(A.11-4)}$$

where T_f is the RETRAN core conductor temperature.

- Moderator Temperature

$$T_{m(t)} - T_{(o)} \qquad \text{(A.11-5)}$$

where T_m is the RETRAN volume average fluid temperature.

11.3 Multidimensional Kinetics Variables

The multidimensional kinetics option generates approximate point kinetics reactivity valves to indicate important feedback effects and their effects on core power. The point kinetics parameters are determined by a reduction to a point kinetics model the three-dimensional nodal mesh solution. The 3-D nodal solution is reduced to a point model by multiplying by the transpose of a time dependent weight vector then integrating over the core. Two sets of reactivity terms are calculated, adjoint flux weighted and unity weighted. A detailed explanation of these reactivity calculation can be found in Volume 1: Theory and Numerics.

11.3.1 K-Infinity

This is the problem average k-infinity. k-infinity is a coarse measure of the instantaneous reactor state. Based on core wide, flux averaged cross sections, k-infinity is given by

$$k_\infty = \left[\sim\overline{\Sigma}_{f1} + \frac{\overline{\Sigma}_{f2}\,\overline{\Sigma}_R}{\overline{\Sigma}_{a_2}} \right] \left[\frac{1}{\overline{\Sigma}_{a_1} + \overline{\Sigma}_R} \right] \qquad \text{(A.11-6)}$$

where

$\sim\overline{\Sigma}_{f1}$ = core wide flux averaged fast group fission source

$\sim\overline{\Sigma}_{f2}$ = core wide flux averaged thermal group fission source

$\sim\overline{\Sigma}_R$ = core wide flux averaged fast group removal cross-section

$\sim\overline{\Sigma}_{a_1}$ = core wide flux averaged fast group absorption cross-section

$\sim \bar{\Sigma}_{a_2}$ = core wide flux averaged thermal group cross-section

The overbar " ¯ " indicates the following weighted average function.

$$\bar{\Sigma} = \int_v \bar{\Sigma}\phi / \int_v \phi \, dv \qquad \text{(A.11-7)}$$

where v is the core volume, Σ and φ are nodal values.

11.3.2 Adjoint Weighted Total Reactivity

This is the approximate total reactivity.

11.3.3 Adjoint Weighted Control Reactivity

This is an approximation of the changer in reactivity due to a change in control rod positions from their initial position.

11.3.4 Adjoint Weighted Moderator Reactivity

This is an approximation of the change in reactivity due to the change in moderator temperature from the initial time 0.0 valve.

11.3.5 Adjoint Weighted Density Reactivity

This is an approximation of the change in reactivity due to the change in moderator density for PWR problems or moderator void fraction in BWR problems. The reactivity changes are relative to time 0.0 values.

11.3.6 Adjoint Weighted Doppler Reactivity

This is an approximation of the change in reactivity due to the change in fuel temperature from initial values.

11.3.7 Adjoint Weighted Residual Reactivity

This residual reactivity is a result of the approximate nature of the reactivity terms. The residual is calculated as the total reactivity less the individual control, moderator, density, and Doppler reactivity terms.

11.3.8 Unity Weighted Total Reactivity

This is the approximate total reactivity.

11.3.9 Unity Weighted Control Reactivity

This is an approximation of the changer in reactivity due to a change in control rod positions from their initial position.

11.3.10 Unity Weighted Moderator Reactivity

This is an approximation of the change in reactivity due to the change in moderator temperature from the initial time 0.0 valve.

11.3.11 Unity Weighted Density Reactivity

This is an approximation of the change in reactivity due to the change in moderator density for PWR problems or moderator void fraction in BWR problems relative to time 0.0 values.

11.3.12 Unity Weighted Doppler Reactivity

This is an approximation of the change in reactivity due to the change in fuel temperature from initial values.

11.3.13 Unity Weighted Residual Reactivity

This residual reactivity is a result of the approximate nature of the reactivity terms. The residual is calculated as the total reactivity less the individual control, moderator, density, and Doppler reactivity terms.

APPENDIX B

DESCRIPTION OF RETRAN-3D SUMMARY EDITS

Appendix B contains a description of the time-step control, trip and minor edit summary edits generated by RETRAN-3D. Each of these summary edits is discussed below.

1.0 TIME-STEP CONTROL SUMMARY

The frequency that the Time-Step Control edits are generated is controlled by the TDMP parameter on the time-step data card 03XXX0. The algorithms used for the time-step controls are discussed in Section IV.5 of this manual.

The information presented in the time-step control summary edits effectively provides a map of the governing phenomena for the edit time interval. A careful review of these summary edits can often add additional insight into the transient being analyzed. It is reassuring to observe the location and type of controlling algorithms move through the system in a predictable manner as a transient progresses. Similarly, modeling problems can be isolated when a particular algorithm, volume, junction, or trip is a dominant factor in controlling the time step.

Some experience is required to interpret the information given in the edits. As a means of gaining experience interpreting the information given in the time-step control summary edits, it is suggested that they should be obtained every one or two major edits for problems that are well understood. It is then fairly simple to correlate the indicated control information to the physical phenomena occurring.

Time-step sizes used with the iterative numerics solution method are controlled by 13 different situations or time-step algorithms. The 13 algorithms are shown in the example timing edit as a horizontal line of information which begins with the heading "Upper Limit". The integer below each heading represents the number of times the particular algorithm controlled the time step.

These algorithms can be classified into by three categories. In Category 1, time-steps are governed by maximum time-step input specifications or edit requirements. Category 2 consists of predictive time-step control algorithms used to predict what the time step should be based on what has happened previously or what is anticipated to happen. Category 3 involves reevaluation of a time advancement by checking solution convergence or identifying outright failures of the solution or a constitutive model. In this category, if deemed necessary, the calculation will be reset to the beginning of the time-step and re-evaluated with a smaller time step.

In general, the basic flow of the time-step selection process is to evaluate all the criteria and algorithms in Categories 1 and 2 prior to taking a time step. After all the predictive time-step

criteria have been evaluated, the minimum time step from the criteria is selected as the next RETRAN-3D time step. During the time step, a solution failure may occur or the solution may not converge. If either is true the time-step control algorithms in Category 3 come into play. These algorithms may either force an iteration through the solution one more time, or halve the time step, reset the RETRAN-3D variables to their beginning of the time-step values, and do the calculation again.

The time-step control summary edit provides the necessary information for the user to review the computational behavior of the calculation and identify problems areas in the input model. The algorithms in each of the three categories are described below and a general discussion on interpreting the time-step summary follows.

1.1 Category 1 Time-Step Control Algorithms

Category 1 contains two controls that the user imposes on the code. First, the user supplies a maximum time-step size that will not be exceeded by the calculation. Second, the user requests edits at times that are multiples of the maximum time-step size. In this case, the time step may be reduced for the sole reason of performing an edit or writing a restart data record at a particular time. In the interest of efficiency it is best to minimize the edits and obtain them at the minimum frequency required for adequate printed detail or plotting resolution.

1.2 Category 2 Time-Step Control Algorithms

Category 2 consists of predictive algorithms that use prior time-step information (in one case, history from several prior time steps) to predict what time step the code should take. These algorithms evaluate use volume, junction and trip information. There are four algorithms.

The first algorithm anticipates the activation of a trip signal and selects a time step accordingly. Each trip signal is reviewed at the beginning of the time step using old time step information to anticipate when it will occur. Time trips are evaluated as the difference between the trip actuation time (including any delay) and the current time. For all other trip signals, an algorithm estimates the time each trip will occur by approximating first-order time derivatives of the signals, being monitored. The trip that is predicted to occur first will determine the time-step size selected by this algorithm.

The second algorithm computes the material transport time (COURANT LIMIT) for the fluid in each volume in the model. The minimum volume Courant limit will determine the time-step size selected by this algorithm. Notice that the Courant limit identifies a junction as controlling. This is because the junction flow is used to evaluate the Courant limit for either the upstream or downstream volume, whichever has the smallest mass. This algorithm is described further in Section IV.5.2.2.

The third algorithm evaluates the pressure convergence for each fluid volume for the last ten time steps. This information is then used to predict what time step should be taken to maintain pressure convergence. As was discussed earlier, it is possible to perform a second iteration or to reset the calculation and take a smaller time step. This second iteration, or repeat of the time step, takes approximately the same amount of CPU time as would normal time advancement. Consequently, it is in the best interest of computational efficiency to minimize second iterations or repeating the time advancement using smaller time steps. This algorithm is designed to improve the computational efficiency by trying to minimize this and is consequently called the "minimum effort" algorithm. This algorithm keeps track of the worst volume pressure convergence and the associated time-step size for the last ten time steps and uses this information to predict a time step that will not require a second iteration or reset. This algorithm is identified as the "Pressure Linearization Minimum Effort" heading on the timing edit page. The minimum effort algorithm is described in more detail in Section IV.5.2.1.

The fourth algorithm will not allow the time step to increase more than a certain percentage from the prior time step. This is the energy convergence "CON*DT" algorithm in the timing edit and is described in Section IV.5.2.3.

1.3 Category 3 Time-Step Control Algorithms

Category 3 algorithms are not predictive time-step algorithms. In fact, in most cases they are not actually algorithms at all, but, rather convergence checks and logic in various locations to prevent common solution failures from terminating the calculation. However, for the purpose of this discussion they will be called algorithms. These algorithms catch and try to correct convergence problems or discontinuities that might occur during the time step. Discontinuities can occur because of trip or control system action such as a valve opening or because of a discontinuous change in some physical model, i.e., single-phase to two-phase fluid.

In all cases, these controls force the calculation for the time step to be repeated. The calculated variables are reset to their value at the beginning of the time step and the time advancement is done with a smaller time step (in most cases half the prior time-step size). It is not uncommon for the code to halve the time step several times before the problem is overcome and the time advancement is accepted. The only limiting factor on how many times the time step is reduced is that the code will not allow a time-step size smaller than 1.0 E-6 seconds. If this limit is reached the code will write an error message and terminate normally.

The Category 3 algorithms fall into two classes, first, logic is included in the code to trap the more common solution failures that may occur during the calculation and try to correct the problem by resetting the calculation and taking a smaller time step. The second class of algorithms check the solution convergence after a time step is taken and if not converged it forces the time advancement to be repeated with a smaller time step. Category 3 algorithms are recognized by the "HALF DT" designation on the timing edit summary (there is one exception to this and will be discussed later).

There are three places in the code where solution failures are trapped and they comprise the first class of algorithms. They include the equation-of-state pressure search failure while obtaining volume fluid properties (PRS SRCH HALF DT), the equation-of-state failure obtaining junction fluid properties (JUN PROP HALF DT), and failure of the critical flow model calculation (FLOW HALF DT).

The second class of algorithm checks the convergence of the solution. If convergence is not achieved, the time advancement is repeated in the same manner as the first class of algorithms. The volume pressure convergence is checked and if any volume within the system has not converged, a second iteration is forced and, if that fails to yield a converged solution, the time step is halved (P LINEAR HALF DT).

1.4 Time-Step Summary Interpretation

The purpose of the time-step summary is to provide the user with some indication if the calculation is performing as efficiently as possible for a particular analysis. The time-step summary provides edits of the number of times a particular algorithm controls the time step and, where applicable, which volume, junction, or trip is causing the algorithm to control. This summary can then be used to determine if there is a certain area of the input model that is a problem or if the maximum time-step size should be changed. The number of time steps taken since the last time-step summary along with the arithmetic average of the time-step size over the period is shown at the top of the edit page.

There are no fixed rules as far as time-step control is concerned, only general guidelines. One consideration is that since RETRAN-3D has the ability to iterate and/or reduce the time step, it is possible for a calculation to take more CPU time than the same calculation that is constrained part of the time by the maximum time-step size, even though the latter case may actually take more time steps. On the other hand, the efficiency of a calculation that is limited by the maximum time step more than 60% of the time may be improved by increasing the input maximum time-step size.

If RETRAN-3D is taking a much smaller time step than one would expect, the time-step edit summary provides the information necessary to focus on the area of the model that is controlling the time step. Once the problem area is identified the user can look at that area in detail to ascertain if there is something that can be done with the input or if a RETRAN-3D model limitation or deficiency has been encountered. In most instances, the cause can be identified and remedied.

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```
1RETRAN-3D/MOD004.3   6/29/07 EPRI BEST ESTIMATE THERMAL HYDRAULICS ANALYSIS CODE   --   NRC APPROVED VERSION        29/06/07   PAGE
53
 LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY ** UNLICENSED TRIAL VERSION **            16:44:21
  ATWS   (LOSS OF FEEDWATER) - RETRAN-3D SAMPLE PROBLEM                                                              CPU TIME =
2.469
 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
*
0 TIMING EDIT    ACCUMULATED TIME =    2.469 SECONDS

  SUBROUTINE          CPU TIME (SEC)             PERCENT       NUMBER OF TIMING CALLS
  **********          **************          *************     **********************
    ADVFLO               0.391                    15.82              733
    CONTRL               0.000                     0.00              740
    EDIT                 0.031                     1.27               48
    ENERGY               0.219                     8.86              734
    JUNPRP               0.297                    12.03              736
    POWRT                0.000                     0.00              714
    PRESUR               0.734                    29.75              729
    PRZR                 0.047                     1.90              729
    PUMPS                0.016                     0.63              733
    SLABHT               0.219                     8.86              714
    SLIP                 0.000                     0.00              733
    SOLVE3               0.328                    13.29              714
    SOLVE4               0.063                     2.53               17
    STATEW               0.250                    10.13            30591

 TIME STEP CONTROL SUMMARY FOR  506 ACTUAL TIME STEPS.  THE AVERAGE TIME STEP SIZE FOR THE INTERVAL WAS 6.916996E-02 SECONDS.

                                 NUMBER OF TIMES EACH TEST CONTROLLED TIME STEP SIZE

 UPPER  MIN EDIT  PRS SRCH  P LINEAR  P LINEAR  PRESSURE  CONSTANT  JUN PROP  CH FLOW  COURANT    FLOW     TRIP     PNORM
 LIMIT  BOUNDARY  HALF DT   HALF DT   MIN EFF    LIMIT      *DT     HALF DT   HALF DT   LIMIT    REVERSE   ACTUATN   LIMIT

   23     14         3         8       384         1        70         0         0         0         0        5         0

 VOLUMES CONTROLLING PRES SEARCH HALF DT
 (VOLUME INDEX : TIMES CONTROLLING)

      34:   3

 VOLUMES CONTROLLING LINEAR PRES HALF DT
 (VOLUME INDEX : TIMES CONTROLLING)

      34:   8

 VOLUMES CONTROLLING LINEAR PRES MIN EFF
 (VOLUME INDEX : TIMES CONTROLLING)

      34: 384

 VOLUMES CONTROLLING PRESSUR RATE CHANGE
 (VOLUME INDEX : TIMES CONTROLLING)

      34:   1

 TRIP ID(S) CONTROLLING TIME STEP
```


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2.0 TRIP SUMMARY

A trip summary is edited at the end of each run. It lists the time each trip was activated along with the trip ID, action, reason, set point, delay, etc. If description information (optional text label) was entered on the trip control data cards, it will also be edited. An example of a trip summary edit follows.

3.0 MINOR EDIT SUMMARY

A minor edit summary is edited after the trip summary at the end of a RETRAN-3D run. It includes information for all minor edit variables requested on minor edit variable data cards 0200YY. It lists the minor edit variable, its description, units, the initial and final values of that variable, the maximum and minimum values and the times at which they occur. An example of a minor edit summary follows.

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```
RETRAN-3D/MOD004.3  6/29/07 EPRI BEST ESTIMATE THERMAL HYDRAULICS ANALYSIS CODE  --  NRC APPROVED VERSION        29/06/07  PAGE   64
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY ** UNLICENSED TRIAL VERSION **          16:44:21
 ATWS  (LOSS OF FEEDWATER) - RETRAN-3D SAMPLE PROBLEM                                                    CPU TIME =    2.906
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

                                                ******************
                                                * TRIP SUMMARY *
                                                ******************

     TIME(SEC)    TRP ID   ACTION      REASON          SET POINT     DELAY(SEC)     IX1    IX2    DESCRIPTION

  0.000000E+00     4   GEN TRIP ON ELAPSED TIME OF  0.00000E+00  0.00000E+00       0      0    GENERAL MISC TRIP AT TIME 0
  6.375000E+01    10   GEN TRIP ON HIGH PRESSUR OF  2.40000E+03  0.00000E+00      34      0    OPEN PRESSURIZER RELIEF VALVES
  6.750000E+01    10   RST TRIP ON LOW PRESSURE OF  2.30000E+03  0.00000E+00      34      0    CLOSE PRESSURIZER RELIEF VALVES
  7.175000E+01    10   GEN TRIP ON HIGH PRESSUR OF  2.40000E+03  0.00000E+00      34      0    OPEN PRESSURIZER RELIEF VALVES
  9.195403E+01    11   GEN TRIP ON HIGH PRESSUR OF  2.50000E+03  0.00000E+00      34      0    OPEN PRESSURIZER SAFETY VALVES
  9.325535E+01    11   RST TRIP ON LOW PRESSURE OF  2.40000E+03  0.00000E+00      34      0    CLOSE PRESSURIZER SAFETY VALVES
  9.439980E+01    11   GEN TRIP ON HIGH PRESSUR OF  2.50000E+03  0.00000E+00      34      0    OPEN PRESSURIZER SAFETY VALVES
  9.441084E+01    12   GEN TRIP ON LOW PRESSURE OF  5.00000E+02  9.00000E-01      51      0    VALVE ON SECONDARY
  9.443653E+01    13   GEN TRIP ON LOW PRESSURE OF  5.00000E+02  9.00000E-01      52      0    VALVE ON SECONDARY
  1.439190E+02    11   RST TRIP ON LOW PRESSURE OF  2.40000E+03  0.00000E+00      34      0    CLOSE PRESSURIZER SAFETY VALVES
  1.500000E+02     1   END PROB ON ELAPSED TIME OF  1.50000E+02  0.00000E+00       0      0    END PROBLEM ON TIME

                                                * END SUMMARY *
                                                ******************
```


PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390


```
RETRAN-3D/MOD004.3  6/29/07 EPRI BEST ESTIMATE THERMAL HYDRAULICS ANALYSIS CODE  --  NRC APPROVED VERSION      29/06/07  PAGE   65
LIGHT WATER REACTOR TRANSIENT ANALYSIS PACKAGE -- LICENSED FOR USE BY ** UNLICENSED TRIAL VERSION **          16:44:21
 ATWS  (LOSS OF FEEDWATER) - RETRAN-3D SAMPLE PROBLEM                                                         CPU TIME =    2.922
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
```

****
* MINOR EDIT SUMMARY *
****

MINOR EDIT		DESCRIPTION	UNITS	INITIAL VALUE	FINAL VALUE	MAXIMUM VALUE	MAXIMUM TIME (SEC)	MINIMUM VALUE	MINIMUM TIME (SEC)
TIME	STP	ACTUAL		0.00000E+00	8.33000E+02	8.33000E+02	1.50000E+02	0.00000E+00	0.00000E+00
VOL	34	AVG. PRESS.	(PSIA)	2.25000E+03	2.32056E+03	3.49177E+03	1.10000E+02	2.25000E+03	0.00000E+00
BUBL	34	MIX. LEVEL	(FEET)	1.70300E+01	3.29200E+01	3.29200E+01	9.75000E+01	1.70300E+01	0.00000E+00
VOL	51	POWR TO H2O	(BTU/HR)	4.64152E+09	3.51497E+08	4.64152E+09	0.00000E+00	2.51875E+08	1.02500E+02
BUBL	51	MIX. LEVEL	(FEET)	7.20300E+01	0.00000E+00	7.22342E+01	1.00000E+00	0.00000E+00	9.25000E+01
VOL	51	AVG. PRESS.	(PSIA)	8.57569E+02	6.04893E+02	9.41947E+02	5.00000E+01	3.71937E+02	1.02500E+02
VOL	51	LIQUID MASS	(LB)	1.38114E+05	0.00000E+00	1.38114E+05	0.00000E+00	0.00000E+00	9.25000E+01
VOL	25	AVG. TEMP.	(DEG F)	5.44204E+02	6.48317E+02	6.48317E+02	1.50000E+02	5.44204E+02	0.00000E+00
VOL	30	AVG. TEMP.	(DEG F)	6.01062E+02	6.52698E+02	6.55453E+02	1.25000E+02	6.01062E+02	0.00000E+00
CBLK	1	OUTPUT		1.02000E+00	7.19982E-02	1.02147E+00	3.00000E+00	7.19982E-02	1.50000E+02
CBLK	-2	OUTPUT		5.72633E+02	6.50507E+02	6.51000E+02	1.25000E+02	5.72633E+02	0.00000E+00
CBLK	-1	OUTPUT		8.70292E-01	6.98046E-01	8.71035E-01	3.00000E+00	6.98046E-01	1.50000E+02
JUN	82	FLOW	(LB/SEC)	1.54889E+03	0.00000E+00	1.70636E+03	5.00000E+01	0.00000E+00	1.02500E+02
JUN	89	FLOW	(LB/SEC)	0.00000E+00	-2.19674E+02	1.00000E-20	0.00000E+00	-3.77443E+02	1.10000E+02
JUN	90	FLOW	(LB/SEC)	0.00000E+00	0.00000E+00	1.00000E-20	0.00000E+00	-7.09792E+02	1.10000E+02
NEQV	34	LIQ REG MASS	(LB)	2.84320E+04	5.80529E+04	6.04106E+04	1.10000E+02	2.84320E+04	0.00000E+00
NEQV	34	LIQ REG TEMP	(DEG F)	6.54077E+02	6.40452E+02	6.54077E+02	2.00000E-01	6.40092E+02	9.50000E+01
NEQV	34	VAP REG TEMP	(DEG F)	6.54077E+02	0.00000E+00	6.76205E+02	9.50000E+01	0.00000E+00	9.75000E+01

* END SUMMARY *

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APPENDIX C

DESCRIPTION OF ENHANCED RETRAN-3D DIAGNOSTIC MESSAGES AND RECOMMENDATIONS FOR CORRECTIVE ACTION

C.1 INTRODUCTION

As errors are detected during a RETRAN-3D run, messages describing the error condition are written to both the standard output file and an error log file. In some instances additional information is also written that will help aid the user and/or maintenance contractor in diagnosing the problem.

Errors are detected and messages written during input processing, steady-state solution, and the transient solution. They are grouped by (1) input processing error messages, (2) memory allocation error messages, (3) transient solution error messages, and (4) steady-state solution error messages. Most memory allocation errors occur during input processing but are grouped separately from input error. Errors within each group are assigned a category depending on the type of error and each error is assigned a unique error number within its category. A description of the situation or conditions that cause each error, along with recommended actions that can be used to mitigate or avoid the error are given in the following sections.

C.2 INP FREE FORM INPUT ERRORS

During input processing, data items supplied in the input deck are checked for validity and consistency with model requirements. Any errors identified will be written to the output and error log files. The following section contains descriptions of the errors and recommended user actions to eliminate the error.

The Section III.2.0 of the User's Manual - Volume 3 provides the detailed requirements for the data content and formatting convention for the **inp** free form input processing package used by RETRAN-3D. No attempt is made to reproduce the input requirements in the User Recommendations given below. The recommendations are intended to be supplemented by the User's Manual.

Errors in this group result from errors that are trapped during the input processing by the **inp** free form input processing routines. These errors are typically related to data formatting and general content errors. Specifically, these errors will be due to data typing (integer, floating point or alphanumeric) errors, an incorrect number of data items on given cards, missing data cards, data cards that are provided but not used, etc. Each error is associated with an error code that is related to the input card series. They are presented below.

Detailed programming requirements and general user considerations for the **inp** free form input processing package are discussed in Section V "inp Free Form Input" in the Programmer's Manual – Volume 2. The User Recommendations associated with the various errors generally will not refer to the Programmer's Manual; it is assumed that the user will use it as a resource when needed.

The summary of input processing errors detected by the **inp** package is presented below.

Error Description

201 The card just processed contains a + as the first nonblank character, indicating that it is a continuation of the proceeding card number. The preceding card did not contain a card number and was not a continuation of a previous card, so there is no card to extend with the continuation card.

User Recommendations

Review the previous cards to identify the cause of the error, which might be due to an invalid card number or data formatting errors on one of the previous cards.

202 The number of data items on all cards processed to this point exceeds the maximum allowable, which is indicated.

User Recommendations

This is a programming limitation and will require the assistance of the RETRAN-3D maintenance support provider identified in Section VI.4.0 of the Programmer's Manual – Volume 2.

203 The number of data items on the previous card exceeds the maximum allowable, which is indicated.

User Recommendations

This is a programming limitation and will require the assistance of the RETRAN-3D maintenance support provider identified in Section VI.4.0 of the Programmer's Manual – Volume 2.

204 The previous card contains data in columns beyond column 80. Data beyond column 80 is truncated and may affect the value of the last data item on the card.

User Recommendations

The indicated card should be reviewed and corrected as necessary to avoid use of columns beyond 80 for specifying data. If the card is a comment or the information beyond column 80 is part of a comment field, there will be no affect on the value of data items specified.

Error Description

205 The size of the array used to store **inp** free form input data is too small to store all of the data contained in the current input deck. The size must be increased from the size listed.

User Recommendations

The size of the **inp** table storage array must be increased and may require the assistance of the RETRAN-3D maintenance support provider identified in Section VI.4.0 of the Programmer's Manual – Volume 2.

206 A deck terminator card (.) must terminate an input deck. An end-of-file was encountered before a terminator.

User Recommendations

Review the input deck and determine if there are other input cards missing, if so add data cars as necessary and make sure the last card is a deck terminator. Refer to Section III.2.0 of the User's Manual – Volume 3, for more information regarding the requirements of the free form input processing routines.

207 The card number field on a data card is invalid and the card number cannot be determined.

User Recommendations

Review the card number field and make any changes necessary to correct the card number. The error can be caused by including alphanumeric, punctuation or other special characters in the field that should contain an integer card number.

208 The input data card contains a data format error, the data type cannot be determined.

User Recommendations

Review the data card and make any changes necessary to correct the data field. The error can be caused by including alphanumeric, punctuation or other special characters in the field that should contain an integer or floating point number.

209 The format of the data supplied on the indicated card number does not match the format specified when the card was read.

User Recommendations

Refer to the User's Manual – Volume 3 for the particular card number. Revise the input to match the data typing specified for the data items.

Error	Description

210 The indicated card number is missing from the sequence of card numbers.

User Recommendations

Refer to the User's Manual – Volume 3 for the particular card number series containing the error. Revise the card numbers and input as necessary to match the card numbers required for the particular input data.

211 Too many data items were supplied on the indicated card numbers.

User Recommendations

Given card numbers or card number sequences have a maximum and minimum number of data items that can be provided. More data was provided than is allowed for the card numbers indicated.

Refer to the User's Manual – Volume 3 for the particular card number or series containing the error. Revise the data items as necessary to match the given requirements.

212 The indicated word (data item sequence) on the given card number should have been alphanumeric but was not.

User Recommendations

The program is expecting an alphanumeric data item on the indicated card number, but a nonalphanumeric item was supplied. The alphanumeric string may contain blanks, which will be interpreted as a data item separator unless the string is enclosed in quotes (single or double). If the alphanumeric string is not delimited by quotes, its content may be interpreted as an integer or floating point number. The number of data items on the card may be incorrect resulting in a misalignment with the format requirements.

Refer to the User's Manual – Volume 3 for the particular card number or series containing the error. Revise the data items as necessary to match the given requirements.

213 The indicated word (data item sequence) on the given card number should have been a floating point number but was not.

User Recommendations

The program is expecting the data item on the indicated card number to be a floating point number, but something other than a floating point number was supplied. A decimal point may have been omitted (making the floating point number an integer) or the number of data items may be incorrect resulting in a misalignment with the format requirements.

Error Description

Refer to the User's Manual – Volume 3 for the particular card number or series containing the error. Revise the data items as necessary to match the given requirements.

214 The indicated word (data item sequence) on the given card number should have been an integer but was not.

User Recommendations

The program is expecting an integer data item on the indicated card number, but an integer item was not supplied. A decimal point may have been included (making the integer a floating point number) or the number of data items may be incorrect resulting in a misalignment with the format requirements.

Refer to the User's Manual – Volume 3 for the particular card number or series containing the error. Revise the data items as necessary to match the given requirements.

215 Too few data items were supplied on the indicated card numbers.

User Recommendations

Given card numbers or card number sequences have a maximum and minimum number of data items that can be provided. Addition data items need to be provided to satisfy the minimum data requirement.

Refer to the User's Manual – Volume 3 for the particular card number or series containing the error. Revise the data items as necessary to match the given requirements.

216 The indicated card numbers are required for the modeling options requested, but they are not present in the input deck.

User Recommendations

An option is requested in the input deck that requires additional information that must be provided on the indicated card numbers. The option may be specified on the problem dimension data or other input.

Refer to the User's Manual – Volume 3 for the missing card number(s) to determine if they are necessary or if an option flag was inadvertently set on the problem dimension data card or related input. Revise the input as necessary to match the given requirements.

Error	Description

217 Subroutine **inp4** uses a dummy argument ntimes, which must be positive. A call was made with a negative or zero value.

User Recommendations

This is likely caused by a programming error and may require the assistance of the RETRAN-3D maintenance support provider identified in Section VI.4.0 of the Programmer's Manual – Volume 2.

218 The indicated data item is less than the minimum allowed.

User Recommendations

Refer to the User's Manual – Volume 3 for the indicated card number(s) to determine the input requirements. Revise the input as necessary to match the given requirements.

219 The indicated data item exceeds the maximum allowed.

User Recommendations

Refer to the User's Manual – Volume 3 for the indicated card number(s) to determine the input requirements. Revise the input as necessary to match the given requirements.

220 The set beginning at the data item indicated on the listed card number(s) contains a limit error.

User Recommendations

Refer to the User's Manual – Volume 3 for the indicated card number(s) to determine the input requirements. Revise the input as necessary to match the given requirements.

221 The indicated upper limit was not included on the cards listed.

User Recommendations

Refer to the User's Manual – Volume 3 for the indicated card number(s) to determine the input requirements. Revise the input as necessary to match the given requirements.

Error	Description

222 The data items entered on the indicated card numbers must be a multiple of the number shown, but are not.

User Recommendations

This is a data formatting error where the number of data items provided is incorrect. Refer to the User's Manual – Volume 3 for the indicated card number(s) to determine the input requirements. Revise the input as necessary to match the given requirements.

223 A nonspecific fatal error occurred while processing the indicated card series.

User Recommendations

Refer to the User's Manual – Volume 3 for the indicated card number(s) to determine the input requirements. Review and revise the input as necessary to match the given requirements. This error may also be due to a programming error, which may require the assistance of the RETRAN-3D maintenance support provider identified in Section VI.4.0 of the Programmer's Manual – Volume 2.

224 The data item on the indicated card is in error.

User Recommendations

Refer to the User's Manual – Volume 3 for the indicated card number(s) to determine the input requirements. Revise the input as necessary to match the given requirements.

225 The listed data cards were supplied in the input deck, but were not used.

User Recommendations

Data cards may have been supplied without activating the model option on the problem dimension card or other data card that activates the option. Another common cause for this error is using the wrong card. Refer to the User's Manual – Volume 3 for the indicated card number(s) to determine the input requirements. Revise the input as necessary to match the given requirements.

226 After deleting used cards and compressing the free form input data tables, there is a mismatch in the computed table lengths.

User Recommendations

This error condition is a due to a coding error and will require the assistance of the RETRAN-3D maintenance support provider identified in Section VI.4.0 of the Programmer's Manual – Volume 2.

Error	Description

227 An un-terminated Hollerith string was included on the data card shown.

User Recommendations

The Hollerith string has an initial string delimiter, either a double or single quote. The terminal delimiter is missing. Revise the string to include the terminal delimiter. If a single quote is used as the initial delimiter, it must also be used for the terminal delimiter. The same applies for the use of a double quote. Single and double quotes may not be mixed when delimiting strings.

228 A number was provided that exceeds the 24-character limit.

User Recommendations

Floating point or integer numbers are limited to a maximum length of 24 characters. Truncate the offending number so it is less than or equal to 24 characters in length.

229 A floating point conversion error was encountered when converting the indicated string to a floating point number.

User Recommendations

Review the content of the indicated string that is to be converted to a floating point number and revise it as necessary to satisfy the requirements for specifying floating point numbers for the **inp** free form input processing package. See Section III.2.0, "INPUT DATA FILE ORGANIZATION", of the User's Manual – Volume 3 or Section V.1.0, "inp FREE FORM INPUT", of the Programmer's Manual – Volume 2.

230 An integer conversion error was encountered when converting the indicated string to an integer number.

User Recommendations

Review the content of the indicated string that is to be converted to an integer and revise it as necessary to satisfy the requirements for specifying integers for the **inp** free form input processing package. See Section III.2.0, "INPUT DATA FILE ORGANIZATION", of the User's Manual – Volume 3 or Section V.1.0, "inp FREE FORM INPUT", of the Programmer's Manual – Volume 2.

C.3 INPUT PROCESSING RELATED ERRORS

Input processing error messages are grouped according to the following component/model type categories. Individual errors are assigned a unique number within the first two digits of the Error

Series, allowing up to 99 errors for each category. The individual error for each category is described in detail in the following sections.

Error Series	Component/Model
	INP Free Form Input Processing
200	Data Format and Content
	Problem Control and Constants
1000	Problem Description Input
	Initial Power Level
	Noncondensable Gas Mass Fractions
2000	Minor Edits and Related Input
3000	Time-Steps
4000	Trips
	Volumes and Related Models
5000	Volume Input
6000	Bubble Rise Model
6100	Profile Fit Model
7000	Time-Dependent Volume Input
	Junctions and Related Models
8000	Junctions Input
8200	Two-Region Enthalpy Transport
	Component Models
9000	Centrifugal Pumps
11000	Valves
12000	General Data Tables
13000	Fills
	Point Kinetics
14000	Point Kinetics Model
14100	Scram Data
14200	Density Reactivity Input
14400	Moderator Heating
14600	Decay Heat
	Heat Conductors and Related Models
15100	Heat Conduction Driver
15000	Heat Conductors
15200	Specified Heat Transfer Coefficient
16000	Core Conductors
17000	Heat Conductor Geometry
18000	Material Property

Error Series	Component/Model
21000	Nonconducting Heat Exchangers
22500	Dynamic Gap Conductance
	Steady-State Initialization
23000	Volume Initial Conditions
23100	Junction Initial Condition
23200	Steady-State Initialization
23600	Off-rated Power Initialization
	1-D Kinetics
30000	Space-Time Kinetics
31000	Cross-Section Data
	Iterative Thermal-Hydraulics Solver
38000	Purdue Numerics
	Auxiliary Models/Components
45200	General Transport
50000	Turbines
60000	Separator
61000	Two-Region Nonequilibrium
62000	Accumulator Input
63000	Method of Characteristics
80000	Auxiliary DNBR Model
	3-D Kinetics
67000	3-D Kinetics and Channel Model Input
68000	CDI File Input
	Control System
70000	Control Input and Blocks
	Miscellaneous
90000	Possible Programming Errors
95000	Restart and Re-edit

During input processing, data items supplied in the input deck are checked for validity and consistency with model requirements. Any errors identified will be written to the output and error log files. The following sections contain descriptions of the errors and recommended user actions to eliminate the error.

The Sections IV, V, and VI of the User's Manual - Volume 3 provide the detailed requirements for the data content and formatting for the various input data card series used by RETRAN-3D. No attempt is made to reproduce the input requirements in the User Recommendations given

below. The recommendations are intended to be supplemented by the appropriate section (card number series) of the User's Manual.

C.3.1 PROBLEM CONTROL AND CONSTANT SPECIFICATION INPUT RELATED ERRORS

The errors included in this section deal with general input requirements and those associated with the problem description input data cards and problem constant data cards.

Error Description

1001 Not enough space allocated to hold input data

User Recommendations

The error is the result of a programming error. The allocated space to store input data in the **inp** tables is not sufficient. The size of input tables specified by variable **len_tbl** must be increased

1002 A title card was not supplied with the input deck.

User Recommendations

Add a title card to the input deck. It begins with an '=' as the first nonblank character and the remaining text (excluding the '=') is included in the documentation header written at the top of each major edit and other pages that include the header.

1003 The required data card was not included in the input deck.

User Recommendations

The card contains flags that determine the type of problem to be executed and the problem options to be used. Refer to Sections IV, V, and VI in the User's Manual – Volume 3 for RETRAN, RESTRT, and REEDIT, respectively for the 01000Y data card requirements.

1004 The first word on problem dimension card LDMP is not a valid value.

User Recommendations

LDMP is used to specify the type of problem that is being run. The valid values are given in sections IV, V, and VI in the User's Manual – Volume 3 for RETRAN, RESTRT, and REEDIT, respectively for data cards 01000Y.

Error Description

1005 The data card contains too many data items.

User Recommendations

The short form for the card series allows a maximum of 12 data items while the long form allows up to 42 data items. Refer to Sections IV, V, and VI in the User's Manual – Volume 3 for RETRAN, RESTRT, and REEDIT, respectively for the 01000Y data card requirements and make revisions as necessary.

1006 The value of the indicated word on the problem control and description data card is out of range.

User Recommendations

Revise the value so it is within range. Note that there are two different forms for this input card, a long or historical form and a short form. The short form is recommended. An output edit gives the replacement cards needed to convert the input from the long to short form.

1007 The power option specified via the NODEL input flag requires that core conductors be supplied; however, no core conductors were supplied.

User Recommendations

Review and revise the input as necessary. Either add the necessary core data cards (and associated heat conductor data cards) or remove the power option.

1008 The input power option, NODEL, is out of range.

User Recommendations

The following are allowable values for NODEL**;**

-3	normalized power from 141XXY cards and power fractions from a restart file,
-2	normalized power and power fractions from a restart file,
-1	normalized power from a restart file,
0	power versus time table on 141XXY cards is NCOR>0,
1	for point kinetics,
2	for 1-D kinetics, or
3	for 3-D kinetics.

Correct the value of NODEL to select the desired model. The kinetics models require additional model dependent input.

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Error	Description

1009 When using the noncondensable flow option with the five-equation model, the slip option must also be selected.

User Recommendations

If the five-equation noncondensable flow model is desired, set the slip flag ISFLAG to one of the valid options. If the HEM noncondensable flow model is desired, disable the five-equation option currently specified on flag NEWEQS.

1010 An invalid option is selected for the NEWEQS flag.

User Recommendations

If the five-equation model is desired, set the NEWEQS to 1; otherwise, it must be 0.

1011 Iterative thermal-hydraulics solution method ITHSLV = 1 can only be used when the 3-D kinetics model is used for the power calculation.

User Recommendations

Change the value of ITHSLV to 0 on the problem dimension card(s) will cause the standard solution scheme to be used.

1012 Some of the input data cards that were provided were not used.

User Recommendations

This error can be due to a previous error. Check and correct any preceding errors. If there are data cards that not read and are not needed, remove those cards.

1013 The mass fractions of all component gases do not sum to 1.0.

User Recommendations

The sum must be between 0.99999 and 1.00001. Revise the component mass fractions as necessary so they satisfy the above criteria.

1014 The input power level is incorrect. It is either negative or not supplied

User Recommendations

If a core section is modeled or a normalized power nonconducting heat exchanger is used, the power must be specified on a 010005 data card. Review and revise the input as necessary.

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C.3.2 MINOR-EDIT AND OUTPUT EDIT OPTION RELATED INPUT ERRORS

The following descriptions are for the errors associated with the minor edit, auxiliary file and VIPRE boundary condition input processing.

Error Description

2001 The value of the auxiliary file header format flag I60HDR is in error.

User Recommendations

The value of I60HDR must be limited to 0 if no header information is wanted in the auxiliary file or 1 if header information is to be included.

2002 The number of volumes requested to include on the VIPRE boundary condition (VBC) file are incorrect.

User Recommendations

Either the number of volumes to include on VBC file is negative or greater than the total number of volumes for the problem. Review the input and revise as necessary

2003 The number of junctions request to include on the VIPRE boundary condition (VBC) file is incorrect.

User Recommendations

Either the number of junctions to include on VBC file is negative or greater than the total number of junctions for the problem. Review the input and revise as necessary

2004 The number of control blocks requested to include the VIPRE boundary condition (VBC) file is incorrect.

User Recommendations

Either the number of control blocks to include on VBC file is negative or greater than the total number of control blocks for the problem. Review the input and revise as necessary.

2005 Not Used

Error Description

2006 The number of minor edit data items supplied is incorrect.

User Recommendations

NEDIT pairs of minor edit variable and region number are required when the long form of the problem control and description data card 01000Y is used.

When using the short form for the 01000Y data card, this error should not be encountered.

2007 The region associate with the indicated minor edit flag is invalid. The region number must satisfy the region requirements for the particular minor edit flag specified.

User Recommendations

Revise the region number to a valid value for the associate minor edit variable flag.

2008 The indicated minor edit flag is invalid.

User Recommendations

Revise the minor edit variable to one of the valid character string flags. The string is case insensitive.

2009 The value of the R3D_PLOT flag R3DPLT is incorrect.

User Recommendations

The value of R3DPLT must be 0 if no plot file is requested, 1 if an ASCII file is requested, or 2 if a binary file is requested.

2010 The value for the optional built-in minor edit list for the plot file is incorrect.

User Recommendations

The value of PLTLST must be 0 if no built-in list of plot variables will be used, 1 if the short list will be used, or 2 if the long list will be used.

C.3.3 TIME-STEP AND SI UNIT SPECIFICATION RELATED INPUT ERRORS

The following descriptions are for errors associated with input processing for the SI unit output option and the time-step selection data cards.

Error Description

3001 The flag used to specify either SI or British output units is invalid.

User Recommendations

The flag must either be 1 for British units or 2 for SI output units. Review and revise the value as necessary. If the card in omitted, the default output will be in British units.

3002 The value of NCHK is invalid.

User Recommendations

The NCHK flag specifies whether to use fixed time steps or to use the iterative time step control algorithms to determine the time-step size for the problem solution. Its value must be 0 for the iterative algorithm or 1 for fixed time-step sizes. For most applications, the iterative method is recommended.

3003 The maximum time-step size supplied was <= 0.

User Recommendations

The maximum time-step size must be > 0. Review and revise the input as necessary.

3004 The time-step size DELTM specified on the input card is less than the minimum allowable time-step size.

User Recommendations

Increase the time-step size such that it is > the minimum allowed value.

3005 The sum of the time step-size and the end-of-interval time for the previous time-step set exceeds the current time-step interval end time.

User Recommendations

Review the time-step size and end-of-interval time and revise as necessary such that the sum of the time step-size and the end-of-interval time for the previous time-step is < the current time-step interval end time. This requires that at least one time step be taken for the interval.

3006 The end times supplied for the time-step intervals defined on the time-step data cards must be in ascending order.

User Recommendations

Revise the end times so they are in ascending order.

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Error Description

3007 Too few time-step data sets were supplied, at least one data set is required.

User Recommendations

Review and revise the input as necessary so the required number of time-step data cards is provided.

3008 The time-step control coefficient specified for the constant time DT time-step algorithm <= 1.

User Recommendations

Revise the input such that the coefficient is > 1.

C.3.4 TRIP INPUT ERRORS

Input errors associated with trip input data cards 04XXX0 are described below.

Error Description

4001 Too few trip cards were supplied.

User Recommendations

The indicated number of expected trip cards was specified on the long form problem dimension card, but fewer cards were actually provided. Either reduce the number of trips on the problem dimension card (01000Y) to match the number of cards supplied, or supply additional trip card(s) as necessary.

Another option would be to use the short form problem dimension card, in which case this error will not be encountered.

4002 The indicated card number is not a valid trip description data card.

User Recommendations

Review and revise the card number as necessary so it satisfies the card number template 04XXX0, where XXX is the trip set number.

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Error	Description

4003 The absolute value of IDTRP on the trip data cards cannot exceed 999.

User Recommendations

The maximum allowable value of IDTRP is 999. Revise the value of IDTRP to use a value <= 999.

4004 An invalid value was supplied for IDSIG.

User Recommendations

Review and revise the value of IDSIG as necessary.

4005 The value of IX1 used to specify the core section number for the average fuel temperature trip is not a valid core section.

User Recommendations

The value of IX1 must be a valid core section number (0 < IX1 <= ncor).

4006 For and indirect or coincidence trip, IX1 and IX2 must either be 0 or equal to a value of IDTRP specified on any other trip cards.

User Recommendations

Review and revise the value of IX1 and/or IX2 as necessary to satisfy the requirements indicated above.

4007 The value of IDSIG for the first trip card (040010) must specify an end-of-problem time (IDSIG = 1).

User Recommendations

Revise the content of the 040010 card to specify idsig = 1 and an end-of-problem trip time (specified using SETPT and DELAY), at which time the problem solution will be terminated.

4008 The trip monitors the mixture level, but volume specified is not a bubble rise volume. The volume must be a bubble rise volume.

User Recommendations

Change the volume specified to another volume, which is a bubble rise volume or change the trip signal from mixture level to other signal.

Error	Description

4009 The volume number specified via either IX1 or IX2 (as indicated) is not a valid volume number.

User Recommendations

Revise the value of IX1 or IX2 to be a valid volume number if the IDSIG specifies the desired trip signal. Otherwise revise as necessary.

4010 The conductor number specified via IX1 on the indicated trip does not correspond to a valid heat conductor number.

User Recommendations

Review and revise the value of IX1 to be a valid heat conductor number if the IDSIG specifies the desired trip signal; otherwise, revise as necessary.

4011 The conductor number specified via IX2 on the indicated trip does not correspond to a valid heat conductor number.

User Recommendations

Review and revise the value of IX1 to be a valid heat conductor number if the IDSIG specifies the desired trip signal; otherwise, revise as necessary.

4012 The control block number specified via IX1 does not correspond to a valid control block number.

User Recommendations

Review and revise the value of IX1 to be a valid control block number if the IDSIG specifies the desired trip signal; otherwise, revise as necessary. Note: The card number displayed with the error message is not an actual card number but an indication of the type of control card, such as control input or control block. The user may be required to locate the actual card using INC1 or INC2.

4013 The junction number specified via IX1 on the indicated trip does not correspond to a valid junction number.

User Recommendations

Review and revise the value of IX1 to be a valid junction number if the IDSIG specifies the desired trip signal; otherwise, revise as necessary.

C.3.5 VOLUME RELATED INPUT ERRORS

Individual errors described below, result from errors identified in the input processing for the volume description data cards.

Error Description

5001 The laminar friction model coefficients were specified using obsolete 05000X data cards.

User Recommendations

Revise the input to use the 2332XX data cards rather than the obsolete 5000X data cards.

5002 The turbulent wall friction flag specified via LTURB is invalid.

User Recommendations

Revise the input to use one of the valid values for LTURB, either 1 for the Blasius or 2 for the Moody turbulent wall friction model.

5003 The wrong number of turbulent wall friction model coefficients were supplied.

User Recommendations

If using the Blasius form of the turbulent wall friction model, 2 coefficients must be supplied. For the Moody form of the model, 4 coefficients are required.

5004 An invalid value was specified for the indicated turbulent wall friction model coefficient.

User Recommendations

The turbulent wall friction model coefficients must be >= 0. Review and revise the associated input as necessary.

5005 An invalid value was specified for the indicated laminar wall friction model coefficient.

User Recommendations

The laminar wall friction model coefficients must be >= 0. Review and revise the associated input as necessary.

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Error	Description
5006	The input does not include any volume data cards.

User Recommendations

At least one volume must be included in a model. This error is highly unlikely to occur. Review and revise the input as necessary to include at least one volume data card series.

5007 Fewer volume data cards were supplied than indicated by the value of NVOL on the long form problem dimension card.

User Recommendations

This error will only occur when using the long form of the problem description data card 01000Y. Either correct the value of NVOL or add the necessary volume description data card(s). This error will not be encountered when using the short form of the problem description data card.

5008 The profile fit coefficient set number specified IVFIT for the indicated volume is invalid.

User Recommendations

The profile coefficient set number must correspond to one of the profile fit coefficient sets (XX) described using the 061XX1 data cards. Review and revise the input to satisfy this requirement.

5009 The laminar friction model coefficient set number specified via the YY field of IFRIC for the indicated volume is invalid.

User Recommendations

The laminar friction coefficient set number must correspond to one of the laminar friction coefficient sets (XX) described using the 2332XX data cards. Review and revise the input to satisfy this requirement.

If the component is 'CHAN VOL', the input specifying the laminar friction model to use is from the CDI file. The CDI file will have to be examined and revised as necessary.

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Error Description

5010 The turbulent friction model coefficient set number specified via the XX field of IFRIC for the indicated volume is invalid.

User Recommendations

The turbulent friction coefficient set number must correspond to one of the turbulent friction coefficient sets (XX) described using the 2331XX data cards. Review and revise the input to satisfy this requirement.

If the component is 'CHAN VOL', the input specifying the turbulent friction model to use is from the CDI file. The CDI file will have to be examined and revised as necessary.

5011 The turbulent/ laminar wall friction coefficient set specified via IFRIC is invalid for the indicated volume.

User Recommendations

The turbulent/laminar friction coefficient set number must be > 0 and any nonzero value of XX or YY must correspond to one of the turbulent or laminar friction model coefficient sets, respectively. Review and revise the input as necessary to meet these requirements.

If the component is 'CHAN VOL', the input specifying the turbulent/laminar friction model to use is from the CDI file. The CDI file will have to be examined and revised as necessary.

5012 The time-dependent volume option was requested via a nonzero value of IREAD, but no time-dependent volume descriptions were provided.

User Recommendations

Either remove the time-dependent volume specification by setting IREAD = 0, or provide a time-dependent volume description using the 07XXYY data cards. The value of IREAD should then be the XX value.

5013 The value of the time-dependent volume table supplied via IREAD does not match any of the time-dependent tables supplied.

User Recommendations

Either add the specified time-dependent volume description using the 07XXYY data cards or revise the value of IREAD to match that of a described time-dependent volume. If a time-dependent volume description is added, the value of XX must match that of IREAD.

Error Description

5014 The transport delay option is specified for a time-dependent volume.

User Recommendations

A time-dependent volume cannot use transport delay option; therefore, it is necessary to removal the transport delay option from the time-dependent volume description by setting MESH = 0 on the corresponding volume data card.

5015 The value specified for mesh on the indicated volume data card is invalid.

User Recommendations

The value of MESH must be between 2 and 999 if the model is invoked. The recommended mesh value is 4 to 5 for most applications. Enter 0 if the model is not used in the volume.

5016 The value of IHTLG is invalid for the five-equation model option (NEWEQS = 1 on the problem description data card 01000Y).

User Recommendations

The value of IHTLG must be 0 or 1 when the five-equation model is invoked. A value of 0 uses the five-equation solution for the volume, while a value of 1 indicates that the four-equation solution will be used for the volume. Revise the value as necessary.

Error Description

IHTLG is ignored for the three- and four-equation models, so any value is valid, but 0 is recommended.

If the component is 'CHAN VOL', the input specifying the IHTLG flag is from the CDI file. The CDI file will have to be examined and revised as necessary.

5017 The value of IMAP is invalid for the five-equation model option (NEWEQS = 1 on the problem description data card 01000Y).

User Recommendations

IMAP parameter is meaningful only if the five-equation option is selected on the problem dimension card (NEWEQS on 01000Y). The five-equation interphase mass and energy transfer requires a prediction of the flow regime. This parameter selects the appropriate flow regime map to be used. The value of IMAP must be 0, 1, or 2 when the five-equation model is invoked. A value of 0 uses the vertical flow regime map, 1 and 2

Error Description

indicate the horizontal flow regime map will be used for a cylindrical geometry (IMAP = 1) or a rectangular geometry (IMAP = 2).

IMAP is ignored for the three- and four-equation models, so any value is valid, but 0 is recommended.

If the component is 'CHAN VOL', the input specifying the IMAP flag is from the CDI file. The CDI file will have to be examined and revised as necessary.

5018 The pressure specified via P is out of range.

User Recommendations

The pressure must be greater than zero and less than the indicated maximum value. Review the specified pressure and revise it as necessary.

The recommended method for specifying the initial pressure for a volume is to use the 231XXX volume initial condition data cards rather than the volume data cards.

5019 The value specified for the physical fluid volume V is invalid.

User Recommendations

The volume is the physical fluid volume for the given control volume and must be greater than zero. Revise the input such that the value satisfies the give requirements.

5020 The value specified for the volume height ZVOL is invalid.

User Recommendations

The height is the difference in the elevation of the top and bottom of the given control volume and must be > 0. Revise the input such that the value satisfies the given requirements.

The indicated upper limit is a test for reasonableness to insure that an extremely large value is not inadvertently input and used. This requires that the volume height be < the indicated limit.

5021 The value specified for the volume flow area FLOWA is invalid.

User Recommendations

The flow area must be > 0. Revise the input such that the value satisfies the given requirements.

Error Description

5022 The value for the equivalent hydraulic diameter specified via DIAMV must be >= 0.

User Recommendations

The hydraulic diameter must be >= 0. If entered as zero the hydraulic diameter will be compute from the volume and flow length by assuming that the volume is a right circular cylinder; otherwise, the value must be > 0. Review the specified value and revise it as necessary.

5023 The bubble rise set specified via IBUB is invalid.

User Recommendations

Valid values for IBUB range from 1 to the total number of bubble rise sets in the problem. It cannot be negative. Review and revise the value as necessary.

5024 The indicated bubble set IBUB is used by multiple volumes. Each bubble rise volume must use a unique bubble set description.

User Recommendations

Either add a new bubble set description using the 060XXY data cards and change IBUB to be equal to the XX value or change IBUB to an unused bubble set description (if it has the desired conditions).

5025 The indicated time-dependent volume IREAD is used by multiple volumes. Each time-dependent volume must use a unique time-dependent volume description (07XXYY data cards).

User Recommendations

Either add a new time-dependent volume description using the 07XXYY data cards and change IREAD to be equal to the XX value or change IREAD to an unused time-dependent volume description (if it has the desired conditions).

C.3.6 BUBBLE RISE VOLUME RELATED INPUT ERRORS

The errors described in the following section are related to input for the bubble rise model and related options.

Error	Description

6001 The volume number supplied as part of the indicated level stack is invalid.

User Recommendations

The stack must be comprised of valid volume numbers ordered from top to bottom. Review the stack input and revise as necessary.

6002 The volumes are stacked incorrectly in the level model stack. The indicated volume is out of order.

User Recommendations

Volumes supplied on stack cards must be stacked from top to bottom. The indicated volume is below the other volume, but should be above it. Review and revise the volume order in the stack list.

6003 The output of the control block used to specify the bubble gradient or velocity is negative.

User Recommendations

Both the bubble gradient and velocity must be >= 0. Review and revise the initial condition specified for the control block indicated.

6004 The control block number specified to define the bubble gradient or velocity is invalid.

User Recommendations

Revise the input so a valid control block number is used to define the bubble gradient or velocity.

6005 The bubble rise model set uses a control block, but no control system definitions were provided.

User Recommendations

Either revise the bubble rise model to not use the control block output, or add the needed control block definitions using the 703XXX control block definition cards.

6006 The bubble gradient parameter ALPH is out of range.

User Recommendations

The bubble gradient must range between 0 and 1. Revise the input to satisfy this requirement.

Error Description

6007 Conflicting options were specified for the bubble velocity definition in the indicated bubble rise set.

User Recommendations

Both a control block and the Wilson correlation were specified for the defining the bubble rise velocity. Only one option is allowed for the bubble velocity specification. Revise the input as necessary.

6008 The flag IWILSN used to activate the Wilson bubble velocity correlation flag is invalid.

User Recommendations

IWILSN must be 0 to not use the Wilson correlation or 1to use it, no other values are allowed. Revise the input as necessary. If the desired bubble rise model is to use the control system to define the bubble rise velocity, IDVBUB < 0, IWILSN must be 0. If the Wilson model is the desired model, IDVBUB must be 0.

6009 The bubble rise volume mixture level is less than zero.

User Recommendations

For a Bubble rise volume, the mixture level must be >= 0 and volume height ZVOL. Revise the input as necessary for the desired initial mixture level.

6010 The bubble rise volume mixture level is greater than the volume height.

User Recommendations

For a Bubble rise volume, the mixture level must be <= ZVOL, the volume height. Revise the input as necessary for the desired initial mixture level.

6011 More than one level stack volume has a mixture level that is less than the volume height and > 0.

User Recommendations

For the time = 0 (steady state) problem specification, only one volume in a mixture level stack can have a mixture level that is less than the volume height and > 0.

6012 When the pressurizer stratification model is selected, the number of pressurizer volumes defined must be equal to NNODEP on the two-region nonequilibrium volume data cards (610XXX).

User Recommendations

Change the number of pressurizer volumes defined so that it matches NNODEP or change NNODEP so that it matches the number of pressurizer volumes.

C.3.7 PROFILE FIT RELATED INPUT ERRORS

The errors described below result from errors identified during the input processing for the profile fit and related data cards.

Error Description

6101 Input for the profile fit model was provided, but no heat conductors are included in the model. The profile fit model requires that powered heat conductors be included in the input model.

User Recommendations

Either remove the profile fit input or add powered heat conductors.

6102 The number of profile fit sets (of coefficients) requested is more than maximum number of sets allowed. The maximum number of profile fit sets allowed is 99.

User Recommendations

Remove the profile fit input for sets greater than the maximum allowed.

6103 The channel geometry factor KAPPA1 was supplied as a negative value.

User Recommendations

Correct the input value of KAPPA1 so it is a positive value.

6104 The drift velocity coefficient CGL was supplied as a negative value.

User Recommendations

Correct the input value of CGL so it is a positive value.

Error Description

6105 The Dittus-Boelter heat transfer coefficient CDB was supplied as a negative value.

User Recommendations

Correct the input value of CDB so it is a positive value.

6106 The Hancox-Nicoll heat transfer coefficient CHN was supplied as a negative value.

User Recommendations

Correct the input value of CHN so it is a positive value.

C.3.8 TIME-DEPENDENT VOLUME RELATED INPUT ERRORS

The errors described below are those detected during input processing for time-dependent volume descriptions.

Error Description

7001 The number of data points IRIN for the time-dependent volume must be greater than zero.

User Recommendations

Some tables allow extrapolation, which is requested using a negative value for the number of points. This is not allowed for time-dependent volumes. Make sure that the points supplied cover the desired range and then define IRIN as a positive value.

7002 The time-dependent volume data has an incorrect number of table entries. In other words, IRIN and total number of data points supplied do not match.

User Recommendations

Revise the input so the number of points defined on the time-dependent volume input agrees with the value of IRIN.

7003 The saturation properties cannot be computed for the temperature and quality listed. The temperature and quality are being converted to the equivalent pressure and enthalpy, which are used to interpolate for time-dependent volume conditions.

User Recommendations

Revise the temperature and/or quality to be representative of a valid two-phase condition.

Error	Description

7004 Noncondensable gas is present in a time-dependent volume; however, the noncondensable flow option is not selected on problem dimension data card.

User Recommendations

Either set the noncondensable flow option flag NCFLOW to 1 on 01000Y (if noncondensable gas flow is desired) or revise the state specification so it does not include noncondensable gas.

7005 An incorrect time-dependent volume state condition specification has been specified. When noncondensable gas is present in time-dependent volume, both pressure and temperature must be > 0 when humidity is < 1.

User Recommendations

If noncondensable gas is wanted in the time-dependent volume, the only valid input option is pressure-temperature-quality. Specify the appropriate values for the desired conditions. If noncondensable gas is not wanted, make the necessary revisions to the input.

7006 The time-dependent volume requests use of a control block that does not exist.

User Recommendations

If a control block is intended to define conditions for the time-dependent volume, correct the control block number or provide input for the indicated control block.

7007 The pressure and temperature values shown are not a valid combination for single phase conditions. The pressure and temperature are being used to convert to the equivalent pressure and enthalpy, which are used to interpolate for time-dependent volume conditions.

User Recommendations

Revise the pressure and temperature to be representative of a valid single phase condition.

7008 The saturation properties cannot be computed for the pressure and quality listed. The pressure and quality are being converted to the equivalent pressure and enthalpy, which are used to interpolate for time-dependent volume conditions.

User Recommendations

Revise the pressure and/or quality to be representative of a valid two-phase condition.

C.3.9 JUNCTION RELATED INPUT ERRORS

The errors described below result from errors identified during the input processing for the junction and related data cards.

Error Description

8001 The number of junctions data card supplied is less than the value of NJUN specified on the long form of the problem description data card 01000Y.

User Recommendations

Either provides additional junction description data cards so the total number matches the value of NJUN or revise the value of NJUN to match the number of junction descriptions supplied.

This error will not be encountered when the short form of the problem description data card is used.

8002 Either the value of the "From" volume (IW1) or "To" volume (IW2) given on the junction input card is invalid. The error message indicates which one is invalid.

User Recommendations

Revise the invalid value so it references the correct volume. It is also possible that the reference volume was not defined in the volume description data 05XXXY. If this is the case, add the volume description.

IW1 = 0 is also valid input that identifies the junction as a fill or flow boundary condition.

8003 The value of IPUMP specified does not correspond to a valid pump description. It must correspond to a value of XX for a pump description data card 090XXY.

User Recommendations

Either revise the value of IPUMP to be equal to an existing pump description or add a new pump description (09XXYY data card) that corresponds to the value of IPUMP.

Error Description

8004 The pump index given by IPUMP must be a unique number. The value is used by more than one pump.

User Recommendations

If a pump inlet or exit is wanted at this junction correct the value of IPUMP so it corresponds to the associated pump or add the necessary description (09XXYY data cards) for the given pump. Otherwise, set the value to 0 for no pump inlet or exit.

If two (or more) pumps are identical, they must be described.

8005 The valve index IVALVE refers to an invalid valve number.

User Recommendations

Revise the value of IVALVE to be equal to a valid valve description, or if necessary define a new valve using a valve description data card 11XXX0. IVALVE must be equal to XXX for a valve description data card.

8006 The "From" volume is 0, IW1 = 0, which indicates that the junction is a fill or flow boundary condition. The value of IPUMP is not equal to a valid fill number.

User Recommendations

Either revise the value of IPUMP to be equal to an existing fill description or add a new fill description (13XXYY data card) where the value of IPUMP corresponds to XX for the new fill description.

8007 The junction flow area AJUN is zero or negative, but must be > 0.

User Recommendations

Revise the value of AJUN to be the physical area of the flow path.

8008 Forward and reverse loss coefficients for fill junctions should be specified as zero since they are not used in the flow calculation. To prevent steady-state initialization errors, negative form loss coefficients (in particular values of -1.0 used to flag that the loss coefficients are to be calculated) are not allowed.

User Recommendations

Revise the values of FJUNF and FJUNR to be 0.0.

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Error	Description

8009 The value of IPUMP for a FIBWR lateral leakage junction is invalid. For lateral leakage junctions, the value of IPUMP corresponds to (100 + XX) on lateral leakage cards (6351XX).

User Recommendations

Revise the value of IPUMP so it satisfies the above requirement.

8010 The value of IPUMP for a FIBWR bypass leakage junction is invalid. IPUMP = 201 is the only valid value

User Recommendations

Revise the value of IPUMP so it satisfies the above requirement if the junction represents a bypass leakage junction. Otherwise, change as required for its intended use.

8011 A core support plate bypass leakage path was specified (IPUMP=201), but no FIBWR bypass leakage coefficients supplied on bypass leakage cards (6352XX).

User Recommendations

If the junction is a FIBWR bypass leakage junction, supply the necessary bypass leakage coefficients as indicated above. Otherwise, change IPUMP as required for its intended use.

8012 The value of IPUMP specified is invalid (>=300).

User Recommendations

Revise the value of IPUMP as required for its intended use.

8013 The junction elevation ZJUN does not reside within the region defined by the elevation of the volume bottom (ELEV) and the elevation of the volume top (ELEV + ZVOL).

User Recommendations

Either change junction elevation ZJUN or volume elevation ELEV and/or the volume height ZVOL to match the actual geometry.

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Error Description

8014 The Input value of JCALCI is equal to 1, 3 or 1000 and form loss coefficient FJUNF or FJUNR is equal to -1.0. These are incompatible options,

User Recommendations

If the value of JCALCI is correct set the form loss coefficient to 0.0. In the situation where the form loss is desired to be -1.0 so steady-state initialization will compute the loss coefficient from the pressure drop, set JCALCI to 0 or 2 depending on whether or not the inertial is input or calculated.

8015 The specified junction inertia INERTA is negative, but must be > 0.

User Recommendations

Either allow the code to compute the inertia via JCALCI = 2 or 3 (and set INERTA = 0), or provide a positive value for INERTA that is representative of the flow path.

8016 A negative form loss coefficient, either FJUNF or FJUNR, was supplied. Generally, form loss coefficients must be >= 0. The only exception is for loss coefficients that are computed by steady-state initialization where this is requested by specifying FJUNF or FJUNR as -1.0 (flag requesting calculation).

User Recommendations

Provide a loss coefficient that is representative of the geometry, which is >= 0.

Early versions of RETRAN-3D used FJUNF or FJUNR to request that steady-state initialization compute the loss coefficient required to balance the pressure drop at the junction. FJUNF or FJUNR was set to -1.0 to request this calculation. The recommended approach is to supply 0 for FJUNF or FJUNR and us the junction initial condition data cards 232XXX to request steady-state to compute that loss coefficient.

If the offending form loss coefficient is for a junction created by the channel model, the value of the form loss coefficient in the CDI file may be in error. An examination of the CDI file content will be required to insure that the correct form loss coefficients are included in the file.

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Error Description

8017 A control system was specified to define the form loss coefficient; however, the control block ID is invalid.

User Recommendations

If the form loss was intended to be computed by a control system (JCALCI = 1000), provide a valid control block ID for the block that defines the loss via FJUNF or FJUNR. It might be possible that the control block needs to be added via 703XXX data cards.

If it was not intended to use a control system to define the form losses, revise JCALCI as appropriate and supply a value of FJUNF or FJUNR that is representative of the geometry.

8018 The form loss coefficient is given by a control block output, but the initial output of the control block is < 0.

User Recommendations

The initial condition specified on the appropriate 703XXX card for the indicated control block must be >= 0. Also make sure that the block is not allowed to return a negative value during the transient solution.

8019 The vapor-only choking option was specified via the value of JCHOKE. A control block ID was also specified (via CONCO) to define the enthalpy multiplier used with the vapor-only choking option; however, the specified control block ID is invalid.

User Recommendations

If the vapor-only choking model is desired, either revise the value of CONCO to reference a valid control block ID or add a definition for the block using the 703XXX data cards. Otherwise, revise the value of JCHOKE to specify the desired choking options.

8020 The control block specified for defining the junction inertia is invalid.

User Recommendations

If the inertia is to be defined by a control system, revise the control system ID to reference a valid block or supply the necessary block definition using 703XXX data cards.

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Error Description

8021 The value of the JCALCI option flag is out of range. Valid values are 0, 1, 2, 3, and 1000.

User Recommendations

Revise the value of JCALCI to a supported option.

8022 The automatic junction overlap option (JVERTL = 3) is not allowed for a fill junction.

User Recommendations

Set the value of JVERTL to 0 or 1 as appropriate. JVERTL = 1 only has meaning when the "to" volume is a bubble rise volume.

8023 The input value for the vertical junction flag JVERTL is out of range.

User Recommendations

Revise the input value of JVERTL to a supported option.

8024 The input value for the choking flag JCHOKE is out of range.

User Recommendations

Revise the input value of JCHOKE to a supported option.

8025 The input value for momentum solution flag MVMIX is out of range.

User Recommendations

Revise the value of MVMIX to a supported option.

8026 CONCO is a multiplier applied to the choke flow value. The input value for CONCO must be >= 0.

User Recommendations

An input value of 0 will default to 1.0. Revise the value of CONCO to satisfy the requirement noted above.

8027 The input value for the enthalpy transport flag IHQCOR is out of range.

User Recommendations

Revise the value of IHQCOR to a supported option.

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Error	Description
8028	The input value for the two-phase multiplier flag JTPMJ is out of range. User Recommendations Revise the value of JTPMJ to a supported option.
8029	The input value for the pressurizer spray junction flag ISP is out of range. User Recommendations Revise the value of ISP to a supported option.
8030	The control block ID specified to provide the slip multiplier is invalid. User Recommendations Revise the value of the control block ID to a valid control block. It may be necessary to define the desired control block by defining it using the 703XXX data cards.
8031	The specified FIBWR model lateral leakage junction elevation for the given channel does reside within the bounds of the core. User Recommendations Revise the elevation of leakage junction to fit within the core.
8032	The water tube junction for the given channel does not connect to the channel at given elevation. User Recommendations Review and revise the elevation and/or connection information as necessary.
8033	A water tube junction is expected from given input, but no water tube junctions were found. User Recommendations This is probably a code error; contact the maintenance support provider for assistance with this problem.

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Error Description

8034 The trip number used to deactivate enthalpy transport IDENTR must be >= 0.

User Recommendations

IDENTR either must be 0 to use the standard deactivation criteria or a valid trip number if enthalpy transport is to be deactivated by a trip.

8035 The enthalpy transport flow reversal flag IFLWRV flag must be 0 or 1.

User Recommendations

IFLWRV either must be 0 to use the standard deactivation criteria or 1 for not deactivation on a flow reversal.

8036 The countercurrent flow deactivation flag ICCFLO must be 0 or 1.

User Recommendations

ICCFLO either must be 0 to use the standard deactivation criteria or 1 for not deactivation on the occurrence of countercurrent flow.

8037 The number of junction groups ISELCT used to specify specific lists of junctions where enthalpy transport is to be deactivated is invalid.

User Recommendations

ISELCT either must be 0 to use the standard deactivation criteria, or >0 where the lists of junctions are provided on the selective enthalpy transport deactivation data cards 08000X.

8038 The trip number specified via IDENTR for the enthalpy transport deactivation option must be a valid trip number when input is > 0.

User Recommendations

Review and revise the value of IDENTR as necessary to specify the desired trip. It may be necessary to define the desired trip using the trip description data cards 04XXX0.

8039 The trip ID specified via IETID on the selective enthalpy transport deactivation data card is invalid.

User Recommendations

Review and revise the value of IETID as necessary to specify the desired trip. It may be necessary to define the desired trip using the trip description data cards 04XXX0.

Error	Description

8040 The junction number included in the enthalpy transport deactivation group list via NETJUN is not a valid junction number.

User Recommendations

Review and revise the value of NETJUN so only valid junction numbers are included in the group list.

8041 A data format error was detected on the selective enthalpy transport deactivation data card indicated.

User Recommendations

Review and revise the data on the card to correct the INP format error.

8042 A selective enthalpy transport deactivation data card was expected to be included in the input deck but the expected card was not found.

User Recommendations

Either revise the value of ISELCT on the 080000 enthalpy transport deactivation data card so the selective deactivation data cards 08000X are not expected, or provide the necessary information on a 08000X data card.

8043 The indicated junction requested use of the jvertl = 3 automatic overlap option, but the junction is not connected to a bubble rise volume. Either the "from" and/or "to" volume must be a bubble rise volume.

User Recommendations

Change the jvertl flag to one of the other available options for the indicated junction. It may be possible that the jvertl = 3 option was specified for the wrong junction, in which case, move the specification to the correct junction data card.

8044 The indicated junction requested use of the jvertl = 3 automatic overlap option, but the junction is a fill. This option is invalid for fill junctions.

User Recommendations

Change the jvertl flag to one of the other available options for the indicated junction. It may be possible that the jvertl = 3 option was specified for the wrong junction, in which case, move the specification to the correct junction data card.

8044 JVERTL=3 INVALID FOR FILL JUNCTION

C.3.10 TWO-REGION ENTHALPY TRANSPORT MODEL RELATED INPUT ERRORS

Error Description

8201 The two-region enthalpy transport model used to predict superheated steam in a steam generator that is drying out is activated via SHSFLG = 1 on data card 008001, but no conductors are found with two-sided heat conduction between normal volumes.

User Recommendations

The two-region model is intended for use where two-sided heat conductors are used to model a steam generator. The intended purpose of the model is to accurately predict the heat transfer in a volume that dries out and experiences both heat transfer to two-phase fluid and superheated steam. Remove the model input if enthalpy transport is not used in a steam generator configuration with two-surface heat conductors.

8202 The input value of the two region enthalpy transport model flag SHSFLG is invalid; it must be 0 or 1.

User Recommendations

Review and revise the value of SHSFLG as required, a value of 1 to activate the model; otherwise the value should be 0 or the card removed from the input deck.

C.3.11 COMPONENT MODEL RELATED INPUT ERRORS

This section contains the error message discussion for errors related to a number of component models.

C.3.11.1 CENTRIFUGAL PUMP RELATED INPUT ERRORS

The following describes errors detected during input processing for centrifugal pumps.

Error Description

9001 An incorrect number of data items were provided on the pump curve set data. A data pair consisting of the curve set number and the number of curves to be supplied for the curve set is required for each pump.

User Recommendations

Review and revise the input and make sure pairs of input are provided for each pump description. If built-in pump curves are used as is, the number of curves should be input as 0. Nonzero values indicate that additional information will be provided to either define a new pump description or to modify a built-in pump.

Error	Description

9002 The specified pump curve set sequence number IPC is invalid.

User Recommendations

Review and revise the input value of IPC to match a pump curve set sequence number that is defined in the model. It may be necessary to add the desired pump curve set definition.

9003 The control block ID IMT specified for controlling either the pump motor torque or pump speed is invalid.

User Recommendations

Review and revise the input value of IMT to match the desired control block ID. If the desired control block has not been defined, do so using the control block description data cards 703XXX.

9004 The initial pump speed ratio PSRAT was specified as a negative value.

User Recommendations

Review and revise the input value of PSRAT to match the desired value, which must be >= 0.

9005 The rated motor torque TORKMR was specified as a negative value.

User Recommendations

Review and revise the input value of TORKMR to satisfy the requirement that it must be >= 0.

9006 The trip number specified as the trip used to start or stop the pump ITPUMP, is invalid.

User Recommendations

Review and revise the input value of ITPUMP to match the desired trip number. If the desired trip has not been defined, do so using the trip description data cards 04XXX0.

9007 When a pump is initially off (ITPUMP < 0) and is to be started using a trip, the initial speed ratio PSRAT must be 0 and the motor torque TORKMR must be > 0. One or both of the input values is incorrect.

Error Description

User Recommendations

Review and revise the input values of PSRAT and TORKMR so they satisfy the requirements noted above. If it was not intended to have the pump off initially, revise the value of ITPUMP accordingly.

9008 The two-phase difference curve set specified via IPM is invalid.

User Recommendations

Review and revise the input value of IPM such that it refers to a two-phase difference curve set that has been defined. If the desired curve set has not been defined, define it using the pump curve set input data card 100000 and the pump head and torque data cards 10XYYZ as may be required given the selection made on the 100000 card.

9009 The rated pump speed POMGAR was specified either as zero or a negative value.

User Recommendations

Review and revise the input value of POMGAR to a positive value that corresponds to the rated speed.

9010 The rated pump head PHEADR was specified as a negative value.

User Recommendations

Review and revise the input value of PHEADR to a positive value that corresponds to the rated pump head.

9011 The rated pump torque PTORKR was specified as a negative value.

User Recommendations

Review and revise the input value of PTORKR to a positive value that corresponds to the rated pump torque.

9012 The rated pump inertia PTORKR was specified as a negative value.

User Recommendations

Review and revise the input value of PINRTA to a positive value that corresponds to the rated pump inertia.

Error	Description

9013 The rated pump density VRHOI was specified as a negative value.

User Recommendations

Review and revise the input value of VRHOI to a positive value that corresponds to the rated pump density.

9014 Pump friction coefficient TORKF1 was specified as a negative value.

User Recommendations

Review and revise the input value of TORKF1 to a positive value.

9015 The two-phase difference curve set specified by IPM does not exist. Word 4 on pump description data card is either less than zero or greater than total number of difference curve specified.

User Recommendations

Review and revise the input value of IPM to a positive value that corresponds to a two-phase difference curve set. It may be possible that the curve set may need to be defined using the pump curve set input data card 100000 and the pump head and torque data cards 10XYYZ as may be required given the selection made on the 100000 card.

9016 No head multipliers were supplied for the two-phase degradation curve set.

User Recommendations

Review the input requirements for the 091XXY data cards and provide the necessary data.

9017 No torque multipliers were supplied for the two-phase degradation curve set.

User Recommendations

Review the input requirements for the 092XXY data cards and provide the necessary data.

9018 The number of table entries on the pump head multiplier data cards is incorrect.

User Recommendations

Review and revise the table entries as necessary such that there are NPHM pairs of void fraction and head multiplier data.

Error Description

9019 The number of table entries on the pump torque multiplier data cards is incorrect.

User Recommendations

Review and revise the table entries as necessary such that there are NPTM pairs of void fraction and head multiplier data.

9020 A motor torque curve was not supplied for the indicated motor torque curve set.

User Recommendations

Revise the input to supply the required motor torque curve using the motor torque data cards 097XXY. If the pump speed is to remain constant, change IMT on the pump description data cards 090XXY to 0.

9021 The number of data items supplied for either a pump motor torque curve (IMT > 0) or a time-dependent speed curve (IMT < 0) is incorrect.

User Recommendations

Revise the input to supply NTMO pairs of data (points).

9022 The number of data items supplied for the indicated curve and curve set is incorrect.

User Recommendations

Revise the input to supply N pairs of data (points).

9023 The built-in pump curve set index is invalid.

User Recommendations

Revise the input to use one of the valid built-in curve sets, which are 1, 2, or 3. Otherwise, set NPC to 0 and supply a user-supplied curve set defined using the pump head and torque data cards 10XYYZ.

9024 The pump index specified on the junction input data card is incorrect. A pump with the given pump index (IPUMP) was not defined.

User Recommendations

Either specify a pump index for a pump that is defined, or add the necessary pump description using the pump curve set input data card 100000 and the pump head and torque data cards 10XYYZ as may be required given the selection made on the 100000 card.

Error Description

9025 The indicated pump volume has been assigned multiple suction or discharge junctions. A pump must have only one suction and one discharge junction.

User Recommendations

Review and revise as necessary, the pump suction (IPUMP < 0) and discharge (IPUMP > 0) specifications on the junction input provide using the 08XXXY data cards for normal junctions (IW1 > 0 and IW2 > 0). Note that |IPUMP| must correspond to a valid pump number.

9026 The total number of pumps connected in the model using the junction suction and discharge junction connection specification (IPUMP) on the junction data cards 08XXXY does not match the number of pumps described.

User Recommendations

Either connect the unused pump using the IPUMP variable of the appropriate junctions, or remove the unused pump description.

Error Description

9027 Multiple pumps are specified for a single control volume. Only one pump is allowed for a give control volume.

User Recommendations

Review and revise the value of IPUMP specified on the junction data cards 08XXXY. For normal junctions (IW1 > 0 and IW2 > 0), one unique negative value and one unique positive value of IPUMP respectively define the suction and discharge junctions for a given pump volume.

9028 The pump speed is positive but the selected motor torque model has returned a zero value for the normalized motor torque at steady-state conditions. A zero value is not allowed for steady-state conditions.

User Recommendations

Review and revise the value of IMT specified on the pump description data cards 090XXY for the indicated pump (XX in card number).

C.3.11.2 Valve Input Related Errors

The following describes errors detected during input processing for various valve models.

Error Description

11001 The trip specified to open or close the indicated valve is invalid.

User Recommendations

Revise the value ITCV to refer to a valid trip number that will activate in valve action (opening or closing).

11002 A generalized data table was specified for use via the value of IACV. For the valve type determined by the value of ITCV, an area tables is not used and should not be provided.

User Recommendations

Check the type of valve being modeled; ITCV specifies the type of valve that is desired, set the value of IACV to 0. If a valve that requires us of an area table, revise the value of ITCV.

11003 A negative back pressure or friction coefficient was supplied for a check valve description. All of these values must be >= 0 so the input value(s) is invalid.

User Recommendations

Check the type of valve being modeled as requested via ITCV. If a check valve is desired, revise the invalid input as necessary. If a check valve is not wanted, revise the value of ITCV to specify the type of valve desired.

11004 A negative value of friction coefficient CV2 was supplied for the valve. For the valve type specified via ITCV, this is invalid.

User Recommendations

Check the type of valve modeled and revise the value of CV2 as appropriate.

11005 The valve area is governed by a control block output, but the specified control block ID is invalid.

User Recommendations

Either revise the control block ID to reference a valid block ID, or define the desired block using the control block description data cards 703XXX.

Error Description

11006 The value of the area table specified via IACV (or INACV2) is invalid. It must refer to a valid general data table number.

User Recommendations

Either revise the value of IACV (or IACV2) to refer to a valid general data table number, or use the general data table definition cards 12XXYY to provide a description for the referenced general table number.

C.3.11.3 Generalized Data Table Related Input Errors

The following describes errors detected during input processing for generalized data tables.

Error Description

12001 The number of points entered for the generalized data table is incorrect. The number of values use to define the table must be 2*NAREA.

User Recommendations

Revise the table definition values supplied so the requirement given above is satisfied.

12002 The number of points entered for a table used with a 2-D function generator (F2D) is incorrect. NAREA is used as a flag and must be set to the number of points plus 1000.

User Recommendations

Verify that NAREA is defined correctly. Also, tables used with a 2-D function generator are limited to 1000 points. Reduce the number of points to satisfy this limit.

12003 The size of the array used to read input table data is insufficient for the current table

User Recommendations

The RDATA array is used to read input data. The retran.cfg file can be used to increase the size of the RDATA array by setting “inp_data” to a larger value. Refer to Volume 2, Programmer’s Manual, for more information on setting up and using the retran.cfg file.

An alternative would be to reduce the size of the table to satisfy the current limit.

Error Description

12004 The independent variables must be supplied in ascending order, but the independent variable for the indicated point is not.

User Recommendations

The independent variables (time, angle etc) must be supplied in ascending order so that table values can be interpolated to obtain correct value of dependent variable. Revise the input table values to satisfy this requirement.

C.3.11.4 Fill Related Input Errors

The following describes errors detected during input processing for fills.

Error Description

13001 The number of fill table entries is incorrect. The value of NFILL and actual number of table entries specified must match

User Recommendations

Revise either the value of NFILL to match the actual number of table entries provided or the number of table entries such that NFILL points are provided.

13002 The fill references the indicated trip number which is invalid.

User Recommendations

Either revise the trip to a valid trip number or define the referenced trip using the trip description data cards 04XXX0.

13003 The independent variables for the fill table are not ascending order.

User Recommendations

Revise the table entries to satisfy the requirement noted above.

13004 A control block ID used to define the enthalpy, pressure or flow for the fill is invalid. The variable controlled with the invalid ID is identified.

User Recommendations

Revise the appropriate input to us a valid control block ID. If necessary, define the desired control block using the control block description data cards 703XXX.

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Error Description

13005 The fill dependent variable specifies mass flow (lbm/sec); however, the associated junction contains a valve. When a fill junction contains a valve, mass flux must be used as the dependent variable.

User Recommendations

If the valve is to be used, revise the fill to use the mass flux option (JY = X0) and make sure that the flow values are converted to mass flux. If the fill completely defines the boundary condition, the valve can be removed from the junction description (08XXXY data card).

13006 The value for the multi-field flag JY is invalid. JY is used to specify the fill fluid type, i.e., noncondensable gas or water and units for the flow boundary condition.

User Recommendations

Review the input requirements and make the appropriate revision to the value of JY.

13007 The portion of the multi-field flag JY that specifies the fill is for noncondensable gas is active, but NCFLOW on problem dimension card is 0. Noncondensable gas flow must be activated via NCFLOW before a fill can specify noncondensable gas flow.

User Recommendations

Either activate the noncondensable gas flow option via NCFLO on the problem dimension card 01000Y or revise the value of JY so noncondensable gas is not requested for the fill.

C.3.12 POINT KINETICS RELATED INPUT ERRORS

The following sections describe errors detected during input processing for various model options related to the point kinetics model.

C.3.12.1 Point Kinetics Constants Related Input Errors

The following describes errors detected during input processing for the point kinetics model constants.

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Error Description

14001 The input value of the effective delayed neutron fraction divided by the prompt neutron generation time BOVL was <= 0.

User Recommendations

Revise the input value of BOVL so it is representative of the delayed neutron yield fractions and neutron generation time (all of which are positive).

14002 The sum of the user defined delayed neutron yield fractions must sum to 1.0, but they do not.

User Recommendations

Revise the yield fraction input values so they sum to 1.0.

C.3.13.2 Scram Related Input Errors

The following describes errors detected during input processing for the scram reactivity data tables for the point kinetics model.

Error Description

14101 The independent variable (time or rod position) supplied for the scram or power table as indicated must be in ascending order, but is not.

User Recommendations

Revise the table entries so they satisfy the requirement noted above.

14102 The trip number specified via ITSCRM is invalid.

User Recommendations

Revise the trip number specified via ITSCRM to refer to a valid trip or define the trip number using the trip description data cards 04XXX0.

14103 The general data table number specified via KTBL and used to give rod position versus time since scram is invalid. The table is used to give the rod insertion distance used to interpolate the reactivity versus distance data provided in the TSCR table.

Error Description

User Recommendations

Revise the value of KTBL to refer to a valid general data table, or use the general data table description data card 12XXYY to define the desire rod position versus time since scram initiation.

14104 The control block ID specified via NSCR is invalid.

User Recommendations

Revise the NSCR to refer to a valid control block ID or define the desired control block using the control block description data card 703XXX.

14105 The indicated data table was not found.

User Recommendations

If the point kinetics model is used (NODEL = 1), provide the necessary scram curve.

If the power is defined via a table of normalized power versus time (NODEL = 0 and POWER on card 010005 > 0), provide the necessary power versus time curve.

14106 The number of data items provided via TSCR to define the indicated scram or normalized power table are incorrect.

User Recommendations

Revise the table entries so 2*NSCR data values are provided to define the NSCR table points.

14107 The size of the array used to read input table data is insufficient for the current power or scram table.

User Recommendations

The RDATA array is used to read input data. The retran.cfg file can be used to increase the size of the RDATA array by setting "inp_data" to a larger value. Refer to Volume 2, Programmer's Manual, for more information on setting up and using the retran.cfg file.

An alternative would be to reduce the size of the table to satisfy the current limit.

C.3.11.3 Reactivity Related Input Errors

The following describes errors detected during input processing for the reactivity feedback models for the point kinetics model.

Error Description

14201 The number of density reactivity table entries is incorrect. NDEN pairs of density and void reactivity are required.

User Recommendations

Revise the table entries so 2*NDEN data values are provided to define the NDEN table points.

14202 The independent variables (density) supplied for the void reactivity table must be in ascending order, but are not.

User Recommendations

Revise the table entries so the densities are in ascending order.

14203 The number of Doppler reactivity table entries is incorrect. NDOP pairs of fuel temperature and reactivity are required.

User Recommendations

Revise the table entries so 2*NDOP data values are provided to define the NDOP table points.

14204 The independent variables (fuel temperature) supplied for the Doppler reactivity table must be in ascending order, but are not.

User Recommendations

Revise the table entries so the densities are in ascending order.

C.3.12 MODERATOR HEATING RELATED INPUT ERRORS

The following describes errors detected during input processing for the moderator heating model.

Error Description

14401 The volume specified via the channel model as the bypass volume does not exist.

User Recommendations

Review and revise the channel model bypass volume specification.

Error Description

14402 The number of data items supplied was incorrect. NCOR (on problem description data card 01000Y) pairs of information must be provided where a pair is comprised of a value for QPMOD and another for QDMOD.

User Recommendations

Review and revise the input so a prompt and delayed power fraction is included for each core volume.

14403 There are an insufficient number of values supplied on the direct moderator heating cards. (1440XX)

User Recommendations

The number of parameters supplied on this card must be twice the number of core sections (NCOR on Card 01000Y). For each core section, a prompt power fraction and a decay heat fraction must be entered.

C.3.13 DECAY HEAT RELATED INPUT ERRORS

The following describes errors detected during input processing for the decay heat model.

Error Description

14601 The decay heat multiplier KMUL on the decay heat description data cards is specified to use control block, but no control blocks are defined in the model.

User Recommendations

Either revise the value of KMUL to be >= 0 or define the desired control block using the control block description data cards 703XXX.

14602 The decay heat multiplier is specified as being defined by the control block ID given by KMUL, but the control block ID is invalid.

User Recommendations

Either revise the value of KMUL to be >= 0 or define the desired control block using the control block description data cards 703XXX.

Error Description

14603 The value of the actinide selection flag IACT is invalid.

User Recommendations

Review and revise the value of IACT to be a valid value.

14604 The sum of the isotope power fractions must be 1.0 for the 1979 ANS decay heat model.

User Recommendations

Revise the individual values of FRC so they sum to 1.0 and also give the desired isotopic split in power fraction.

14605 The U-235 power fraction must be input as either 0.0 or 1.0 for ISOTOP = 1. An input value of 0.0 will result in a default value of 1.0 being used for the power fraction. This applies for both the 1971 and 1979 ANS decay heat models.

User Recommendations

Revise the value of ISOTOP as indicated above.

14606 The number of isotopes via ISOTOP is incorrect. Only values of either 1 or 3 are allowed.

User Recommendations

Review and revise the value of ISOTOP to the desired option.

14607 An invalid specification was made for the ANS decay heat model via IANS. Only values of either 0 or 1 are allowed.

User Recommendations

Review and revise the value of IANS to the desired decay heat model option.

14608 Only a single isotope is allowed with 1971 ANS decay heat model.

User Recommendations

For the 1971 decay heat model (IANS = 1), the value of ISOTOP is limited to 1. To include more than 1 isotope in the decay heat model, the 1979 model must be used (IANS = 0). Make the necessary revisions to either IANS or ISOTOP.

C.3.14 HEAT CONDUCTION MODEL RELATED ERRORS

The heat conduction model requires descriptions for the heat conductor, which includes boundary conditions, physical description, heat transfer options, geometry, and material properties. This input errors associated with input processing for these descriptions options and features are described in the follow sections.

C.3.14.1 Heat Conductor Related Input Errors

The heat conductor input provides a description of the boundary conditions, heat transfer options and physical description. Input related errors identified while processing these input descriptions are found below.

Error Description

15001 The value specified for the heat conductor geometry index IGOM is invalid. It must correspond to a valid geometry number XX, defined by a geometry data card 17XXYY.

User Recommendations

Either revise the value of IGOM to reference a valid geometry description or describe the specified geometry index using a geometry data card 17XXYY.

15002 The conductor boundary flag IVSL for the left surface or IVSR for the right surface, is incorrect. It must correspond to a valid volume number or heat flux boundary condition flag. A valid volume number must match a XXX value for a volume data card 05XXXY.

User Recommendations

Either revise the value of IVSL or IVSR to reference a valid volume number or heat flux boundary condition.

15003 The inlet junction number for the left INJL or right INJR boundary volume (used by the EPRI CHF correlation) does not exist. It must correspond to the inlet or outlet junction for the volume on the left surface of the heat conductor.

User Recommendations

Revise the value of INJL or INJR to be a valid inlet junction number for the corresponding boundary volume.

Error Description

15004 Fewer heat conductor data cards 15XXXY were supplied than the number specified by NSLB on the long form for the problem description data card 01000Y.

User Recommendations

Either add additional heat conductor data cards or revise the value of NSLB. This error should not be encountered when using the short form problem dimension card.

15005 The value of the conductor stack option flag ISHD is invalid.

User Recommendations

Revise the value of the option flag to that of a valid option. All values of ISHD for a given stack must be the same.

15006 Heat conductors are used in the problem but material properties are not specified. Material properties for heat capacity and thermal conductivity are required.

User Recommendations

Provide the required material properties using the 18XXYY and 19XXYY data cards.

15007 The heat transfer correlation specification for the left surface, IMCL or right surface, IMCR is out of range. Refer to the User's Manual – Volume 3 for possible values.

User Recommendations

Review and revise the value as necessary.

15008 Input provided for both boundary condition flags IVSL and IVSR were < 1. A valid volume number must be specified for one of the surfaces.

User Recommendations

Review and revise the value of IVSL or IVSR as necessary.

15009 Heat conductors associated with a two-region nonequilibrium volume (pressurizer) must be insulated on one side (generally the right side) unless the pressurizer steady-state initialization option is used. If the pressurizer steady-state initialization option is used, the left boundary flag IVSR can remain insulated (IVSR = 0) or it can be a volume number, in which case environmental heat losses will be determined.

Error Description

User Recommendations

To include environmental heat losses, revise the input to activate the pressurizer steady-state initialization feature. This is done by specifying a nonzero spray flow. Otherwise, revise the right surface to use the insulated surface boundary condition.

15010 The heat conductor is adjacent to a two-region nonequilibrium volume (pressurizer), but does not belong to a heat conductor stack. Such heat conductors must belong to a stack for use by the local condition heat transfer model.

User Recommendations

Either add the heat conductors that are adjacent to the volume to a conductor stack or remove the conductor(s). Remember that conductor stacks must contain at least two heat conductors.

15011 The conductor volume (VOLS) is <= 0. It must represent the volume all tubes, rods or wall material that comprise the conductor.

User Recommendations

Revise the value to be representative of the physical volume of the heat conductor.

15012 The hydraulic diameter for the left or right conductor surface given by HDML or HDMR respectively is < 0. Negative values are not allowed.

User Recommendations

Revise the value to be representative of the heat conductor surface hydraulic diameter. If the value is entered as zero and the corresponding volume boundary condition flag (IVSL or IVSR) refers to a valid control volume, the conductor surface hydraulic diameter will be set to that of the adjacent volume.

15013 The indicated heat conductor is used in more than one stack. Conductors specified in each stack must be unique

User Recommendations

Modify the stack data cards so the conductor is a member of only one stack.

15014 The conductor has a valid boundary volume on the left surface (IVSL), but the heat transfer surface area (ASUR) is zero.

Error Description

User Recommendations

Either provide a positive value that is representative of the left surface area for the conductor or revise the boundary condition flag.

15015 Fewer than two conductors were specified for the conductor stack but the model requires a minimum of two conductors.

User Recommendations

Either supply at least two heat conductors or remove the indicated heat conductor stack.

15016 The inlet junction number for the left or right surface boundary volume INJL or INJR respectively, which was specified for used with EPRI CHF correlation does not exist.

User Recommendations

The junction number specified for INJL and/or INJR (when EPRI CHF is used) must be positive and must be a valid junction connected to the boundary volume. Revise the value to reference the correct junction number.

15017 A negative value was supplied for either the left or right surface area, ASUL or ASUR. Positive values are required unless the surface is insulated (IVSL=0 or IVSR=0), in which case the corresponding area can be = 0.

User Recommendations

Review and revise the input value so it is representative of the conductor surface area.

15018 A maximum number of 9 heat conductor stack are allowed, but more were requested.

User Recommendations

Revise the value of NSTK on the long form of the problem description data card 01000Y. This error should not be encountered when using the short form of the data card.

15019 All conductors in a stack using the local conditions option must be adjacent to a common volume. A conductor within the stack is not adjacent to the common volume.

User Recommendations

Either modify the conductor data and specify the same IVSL or IVSR for all conductors which are part of a local stack or remove the offending conductor and replace it with another if necessary.

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Error Description

15020 A bubble rise model is not specified for the volume where the local conditions heat transfer model is specified.

User Recommendations

A bubble rise model must be added to the volume if the local conditions heat transfer model is used on this side of the stack conductors.

15021 The sum of the conductor lengths specified in the stack exceeds the height of the adjacent volume.

User Recommendations

Review and adjust the stack conductor lengths (CNDL on the 15XXXY cards) so they sum to the volume height.

15022 The condensation correlation for this conductor is not the same as other conductors in the same stack. All conductors within a stack must use the same condensation option.

User Recommendations

Modify the conductor data cards 15XXXY as necessary for the conductors which are part of this stack such that they use the same condensation correlation specified via ICONDN.

15023 A positive conductor length CNDL is required when using the condensation model requested via ICONDN.

User Recommendations

Provide a value that represents the length of the conductor.

15024 The conductor specified for the stack model is not in sequence of ascending order. The bottom conductor must be specified first and the top conductor must be specified last.

User Recommendations

Specify the conductors in the stack from bottom to top and in ascending order of elevation.

15025 The number of heat transfer multiplier Data items is incorrect.

User Recommendations

Revise the input to satisfy the input requirements.

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Error Description

15026 The heat transfer mode specified on heat transfer multiplier card via IHTMOD is invalid.

User Recommendations

Revise the value of IHTMOD to satisfy the input requirements.

15027 A negative heat transfer multiplier HTMULT was supplied.

User Recommendations

Revise the multiplier so a positive value is supplied.

15028 The value of the heat transfer multiplier HTMULT supplied is not supported for the heat transfer mode.

User Recommendations

Revise the value of HTMULT to satisfy the input requirements.

15029 The heated equivalent diameter for the left or right conductor surface, DHEL or DHER respectively, is < 0. Negative values are not allowed.

User Recommendations

Revise the value to be representative of the heat conductor surface heated equivalent diameter. If the value is entered as zero and the corresponding volume boundary condition flag (IVSL or IVSR) refers to a valid control volume, the conductor surface heated equivalent diameter will be set to the hydraulic diameter of the adjacent volume.

15030 The heat conductor is flagged as belonging to a steam generator (IHXQF>0), but the conductor does not have fluid boundary conditions defined for both the left and right surfaces (IVSL and IVSR) as required for a steam generator tube.

User Recommendations

Either set IHXQF to 0 if the conductor does not belong to a steam generator or add the appropriate fluid volume numbers in IVSL and IVSR for the primary-side and secondary-side volumes.

Error Description

15031 The number of conductors included in stacks exceeds the total number of conductors.

User Recommendations

A conductor may be listed in more than one stack or an invalid conductor is included in a stack. A conductor can only reside in one stack. Review and revise the input as necessary.

C.3.14.2 Specified Heat Transfer Coefficient Related Input Errors

Input related errors identified while processing the specified heat transfer coefficient input descriptions are found below.

Error Description

15201 The specified heat transfer mode given via MODE is invalid.

User Recommendations

Revise the value of MODE to refer to a valid mode for the specified heat transfer coefficient model.

15202 Specified heat transfer coefficient data cards are missing. They are required to be sequential

User Recommendations

Revise the input for the specified heat transfer coefficient model to satisfy the requirements noted above.

15203 More specified heat transfer coefficient data cards were requested than are allowed. A total of 999 cards are allowed as per card numbering scheme.

User Recommendations

This error should not be encountered when using the short form for the problem description data card 01000Y. Revise the value of NCHT on the data card to be <= 999.

Error Description

15204 The control block ID given to define the heat transfer coefficient HID is invalid.

User Recommendations

Revise the value of HID to refer to a valid control block ID that defines the heat transfer coefficient. If necessary, use the control block description data cards 703XXX to define the desired control block output.

15205 The multiplier for the Uchida correlation UCHMUL must be greater than zero.

User Recommendations

Revise the value of UCHMUL to the desired positive value or allow it to default by supplying a zero value.

15206 The estimated time of the blow down phase BLOTIM must be greater than zero.

User Recommendations

Revise the value of BLOTIM to the desired positive value that satisfies the model requirements.

15207 The trip ID specified to initiate blowdown IBLO is invalid.

User Recommendations

Revise the value of IBLO to reference a valid trip ID. If the desired trip ID is not defined, add the necessary trip definition using a trip description data card 04XXX0.

15208 The ratio of primary coolant energy to containment volume QOVRV must be greater than zero.

User Recommendations

Revise the value of QOVRV to the desired positive value that satisfies the model requirements.

15209 The Tagami correlation multiplier TAGMUL must be greater than zero.

User Recommendations

Revise the value of TAGMUL to the desired positive value that satisfies the model requirements.

Error Description

15210 The minimum pre-blowdown heat transfer coefficient HMIN must be greater than zero.

User Recommendations

Revise the value of HMIN to the desired positive value that satisfies the model requirements.

15211 The transition decay constant TRNCON must be greater than zero.

User Recommendations

Revise the value of TRNCON to the desired positive value that satisfies the model requirements.

15212 A specified constant heat transfer coefficient HCONST must be specified greater than zero.

User Recommendations

Revise the value of HCONST to be the desired positive value.

C.3.14.3 Core Conductor Related Input Errors

Core heat conductors are conductors with an internal heat source. Input related errors identified while processing these input descriptions are found below.

Error Description

16001 The head conductor number specified as a core section (powered conductor) via ISLB does not must match a valid conductor.

User Recommendations

Revise the value of ISLB to refer to a valid heat conductor number or provide the necessary heat conductor description data cards 15XXXY to define the referenced conductor.

16002 The input requests that the power fraction be determined by a control block, but the control block ID specified via QFRAC is invalid.

User Recommendations

Revise the input to refer to a valid control block ID or define the desired control block ID using the control description data cards 703XXX.

Error Description

16003 The power fraction obtained from the indicated control block is negative.

User Recommendations

The time zero value for the control block is obtained from the initial condition specified on the control description data cards 703XXX for the indicated control block. Check the initial condition that was specified for the control block and revise it as necessary.

16004 When using control blocks to specify the power fraction for core sections, all core sections must us a control block to determine the power fractions.

User Recommendations

Specify a control block ID (via QFRAC < 0) to obtain power fraction for this core section.

16005 The power fractions for all core sections must sum to 1.0.

User Recommendations

Revise the initial power fractions so they sum to 1 + or – 1.e-6.

16006 The cladding thickness CLTI was specified as a negative value, but it must be >= 0.

User Recommendations

A positive value will activate the metal water calculation, which generally isn't used. A value of 0 is generally used for most analyses, unless the metal water calculation is wanted in which case the cladding thickness is provided.

16007 The head conductor is specified as a core section but is also flagged as being a conductor in steam generator IHXQF. The conductors can only be used for either the core section or steam generator.

User Recommendations

Revise the input as necessary by setting the value of IHXQF to 0 on the appropriate heat conductor description data card 15XXXY or revise the value if ISLB to refer to the core conductor that is not a member of a steam generator.

16008 The neutronics region referred to for either the first or last region number for the 1-D kinetics model was supplied as a negative value. The values for IRGF and IRGL identify the neutronics mesh numbers that are mapped to this core section.

Error Description

User Recommendations

To satisfy the above requirements, provide positive values for IRGF and IRGL that correspond to the desired neutronics mesh region to map to this core section.

C.3.14.4 Conductor Geometry Related Input Errors

Input related errors identified while processing the geometry descriptions for heat conductors are found below.

Error Description

17001 When a region uses a gap model, the region must use a single space step for NDX.

User Recommendations

Revise the input value of NDX to specify 1 space step.

17002 An invalid control block ID was specified via MULT for defining the thermal conductivity multiplier.

User Recommendations

Revise the input value of MULT to refer to a valid control block ID. If necessary, use the control block description data cards 703XXX to define the desired control block function.

17003 A control block was specified for determining the thermal conductivity multiplier, but no control systems are included in the model.

User Recommendations

Use the control block description data cards 703XXX to define the desired control block function or use a constant multiplier.

17004 The value of the geometry type indicator IG is invalid.

User Recommendations

Revise the input value of IG to specify one of the valid geometry types, which are limited to 1 for slab geometry and 2 for cylindrical geometry.

Error Description

17005 The value of the material index IM refers to an invalid material number.

User Recommendations

Revise the material index IM to refer to a valid material or define a new material using the material property data cards 18XXYY, 19XXYY, and 20XXYY.

17006 The power fractions PF for all regions within a geometry description must sum to 1.0 + or – 1.0e-8.

User Recommendations

Revise the values of the power fractions for the geometry to sum to 1.0.

17007 The number of material regions NR must > 0.

User Recommendations

Revise the number of regions to be positive.

17008 The distance to the left surface of the conductor XO must be >= 0.

User Recommendations

Revise the distance to the center XO (or left surface) to be >= 0. This is the distance from the center of a hollow tube to the inside of the boundary wall. For a solid rod or slab, it is 0.

17009 The value for the number of space steps for the region NDX must be > 0, but is <= 0.

User Recommendations

Revise the number of space steps NDX to be > 0. This along with the region width XR is used to define the spatial gradient of the temperature.

17010 The value of the width of the region XR must be > 0, but is <= 0.

User Recommendations

Revise value of XR to be > 0.

Error Description

17011 The region power fraction PF must be > 0.

User Recommendations

Revise value of PF to be > 0.

17012 Gaps were specified in adjacent regions, but this is not allowed.

User Recommendations

Remove the gap flag IGP in one of the regions.

17013 A gap was specified in the outer region, but this is not allowed.

User Recommendations

Remove the gap flag IGP from the outer region and specify a gap in one of the interior regions if desired.

C.3.14.5 Material Properties Related Input Errors

Input related errors identified while processing the input material property descriptions for heat conductors are found below.

Error Description

18001 The number of data items entered for the thermal conductivity is incorrect. Data points must be entered in pairs (temperature and thermal conductivity). 2*|NKP| values of temperature and thermal conductivity must be supplied. A negative value of NKP indicates that the extrapolation beyond the bounds of the table is allowed.

User Recommendations

Revise the number of data items to satisfy the requirement noted above.

18002 The number of data items entered for the fuel density is incorrect. Data points must be entered in pairs (temperature and fuel density). 2*|ND| values of temperature and fuel density must be supplied. A negative value of ND indicates that the extrapolation beyond the bounds of the table is allowed.

User Recommendations

Revise the number of data items to satisfy the requirement noted above.

Error Description

18003 The number of data items entered for the heat capacity is incorrect. Data points must be entered in pairs (temperature and heat capacity). 2*|NCP| values of temperature and heat capacity must be supplied. A negative value of NCP indicates that the extrapolation beyond the bounds of the table is allowed.

User Recommendations

Revise the number of data items to satisfy the requirement noted above.

18004 The number of data items entered for the linear expansion coefficient is incorrect. Data points must be entered in pairs (temperature and linear expansion coefficient). 2*|NXP| values of temperature and linear expansion coefficient must be supplied. A negative value of NXP indicates that the extrapolation beyond the bounds of the table is allowed.

User Recommendations

Revise the number of data items to satisfy the requirement noted above.

18005 An error was encountered while interpolating the fuel density table that was supplied.

User Recommendations

Review the table and revise as necessary. Fuel temperatures must be in ascending order. Also check the range of the fuel temperatures included in the table. Note that the lower temperature bound is also used as the reference temperature for the fuel enthalpy.

C.3.15 NONCONDUCTING HEAT EXCHANGER RELATED INPUT ERRORS

Input related errors identified while processing the input descriptions for nonconducting heat exchangers are found below.

Error Description

21001 The trip number ITHTXQ specified to activate the heat exchanger is not a valid trip.

User Recommendations

Revise the value of ITHTXQ to match a valid trip number > 1 or define the desired trip using the trip description data cards 04XXX0.

Error Description

21002 The heat exchanger volume JVOL does not have any inlet or outlet junctions.

User Recommendations

Revise the value of IHTYPE to use a heat exchanger that does not require junctions to define the flow rate for the volume.

21003 An invalid nonconducting heat exchanger type IHTYPE was specified.

User Recommendations

Revise the value of IHTYPE to use a valid heat exchanger type.

21004 The number of data items provided on the indicated card series do not agree with the value of IHTX specified.

User Recommendations

Review and revise the number of data items provided as necessary to satisfy the nonconducting heat exchanger type specified by the IHTYPE flag.

21005 A control system is specified to define the heat exchanger heating rate (ITHTXQ = 1000) but no control systems are defined in the input model.

User Recommendations

Revise the value of ITHXQ to use a different heat exchanger model that does not use a control system or define the desire control block function using the control block description data cards 703XXX.

21006 The volume number JVOL specified for the heat exchanger does not match any existing volumes.

User Recommendations

Revise the value of JVOL to match a valid volume number or define the volume using the volume data cards 05XXXY.

21007 The heat exchanger heating rate is defined by an invalid control block.

User Recommendations

Revise the value of IHTX to refer to a valid control block ID or define the given block using the control block description data cards 703XXX.

Error Description

Another option would be to revise the value ITHTXQ from 1000 (indicates use of a control block defined by IHTX) to another nonconducting heat exchanger type.

C.3.16 DYNAMIC GAP MODEL RELATED INPUT ERRORS

Input related errors identified while processing the input descriptions for the dynamic gap model are found below.

Error Description

22501 Sum of all 6 fill gas molar fractions GSFRAC specified on the 225XXY cards must be equal to 1.0.

User Recommendations

Revise the individual molar fractions GSFRAC such that they sum to 1.0 + or – 1.0e-6.

22502 Different dynamic gap model sets are referenced in the same heat conductor stack. The dynamic gap model requires use of the stack model to identify all conductors that comprise a rod. For a given stack, all conductors must use the same dynamic gap model set if the model is activated on any of the corresponding geometry data cards where IGP = -1 and IM the gap model number.

User Recommendations

Revise the geometry descriptions associated with the conductors in the stack to use the same dynamic gap model set. It may be possible that one or more of the conductors specified in the stack should not be included, in which case they should be removed from the stack and others added if necessary.

22503 The number of dynamic gaps described do no match the number specified via NGAP on the long form of the problem description data card 01000Y.

User Recommendations

Either revise the value of NGAP to match the number of gap descriptions provided or provide additional gap descriptions such that there are NGAP descriptions provided. This error should not be encountered if the short form of the problem description data card is used.

Error Description

22504 The number of gap models is greater than the number of heat conductor stacks. Each gap model requires a unique stack.

User Recommendations

Revise the input as necessary so each gap model is associated with a separate heat conductor stack. This may require defining more stacks using the stack description data cards 220XXY.

C.3.17 STEADY-STATE INITIALIZATION RELATED ERRORS

Various types of input related to steady-state initialization are required. They include convergence criteria, solution strategies and the specification of initial conditions. Input errors that are related to steady-state initialization are discussed the following sections.

C.3.17.1 STEADY STATE POWER REMOVAL RELATED ERRORS

Input errors related to the overall energy balance and steady-state convergence are discussed below.

Error Description

23001 The junction specified as the overall energy balance bias junction JBIAS is not a fill junction. Only a fill junction can be biased. Feed water junction biasing is required for steady state convergence

User Recommendations

Revise the value of JBIAS to refer to a fill junction. Typically this will be a junction that describes the feedwater boundary condition.

23002 The junction specified as the bias junction JBIAS for the overall energy balance does not exist. The bias junction must be valid junction that is also a fill junction

User Recommendations

Either revise the value of JBIAS to refer to a valid fill junction or define the desired junction using the junction description data cards 08XXXY and fill description data cards 13XXYY.

Error Description

23003 The outlet junction used in the overall energy balance, junction JBAL does not exist.

User Recommendations

Either revise the value of JBAL to refer to a valid junction that represents the outlet of a hydraulic network, e.g. the steam line for a pressurize water reactor steam generator or boiling water reactor, or define the desired junction using the junction description data cards.

23004 There are no heat conductors associated with the given steam generator number. The value of IHXQF on the conductor data cards is used to associate the conductor with a give steam generator.

User Recommendations

Modify the value of IHXQF on the conductor cards to refer to the steam generator.

23005 The sum of power fractions removed by the steam generators must be 1.0 + or – 1.0e-8.

User Recommendations

Revise the power fractions as necessary for each steam generator so that the sum of the steam generator power fractions satisfies the above requirement.

23006 The low power steam generator initialization data cards 2350XY are required when the low power steam generator steady-state initialization option is used (JSST = 2 on problem dimension cards).

User Recommendations

Add the required cards noted above.

23007 An incorrect number of data items are supplied on the lower power steady state initialization cards. A minimum of 2 items are required.

User Recommendations

Revise the input to supply the required input.

23008 The steam generator type specified via ISGTYP is invalid.

User Recommendations

Revise the input value of ISGTYP such that it corresponds to a valid steam generator type flag.

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Error	Description

23009 The value of the adjustment flag IPHFLG is invalid.

User Recommendations

Revise the input value of IPHFLG such that it corresponds to a valid adjustment type flag.

23010 The volume number specified for secondary side volume IPVOL is invalid.

User Recommendations

Either the value of IPVOL be a valid volume number or define the given volume number using the volume description data cards 05XXXY.

23011 The initial pressure for volume the secondary-side volume given by IPVOL is zero or negative. The pressure must be > 0 for this volume.

User Recommendations

Either specify the initial pressure for the volume using a volume initial condition data card 231XXX or specify a different volume number for IPVOL.

23012 An incorrect number of conductor power fractions were supplied. A power fraction value must be provided for each heat conductor that belongs to the steam generator.

User Recommendations

Remove any extra power fraction or add missing power factions as necessary. Provide one power fraction for each conductor.

23013 A negative conductor power fraction was supplied. Conductor power fractions must be >= 0.

User Recommendations

Revise the power fraction to be a positive value.

23014 The conductor number specified as belonging to the feed water heater is invalid.

User Recommendations

Either replace the conductor number with a valid conductor number or define the given conductor using the conductor description data cards 15XXXY.

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C.3.17.2 Volume Initial Condition Related Errors

The errors related to specifying volume initial conditions are given below.

In order to help resolve many of the errors listed below that deal with specifying volume initial conditions for the full range of thermodynamic states, with and without noncondensable gas, please refer to Tables IV.19-1, IV.19-2, and IV.19-3 to determine the input requirements for the desired initial conditions.

Error Description

23101 A single phase property evaluation error occurred while calculating properties for the pressure and temperature shown.

User Recommendations

Revise the input as necessary to eliminate the error.

23102 Input pressure is < 0 or > than the upper pressure limit of the water property curve fits.

User Recommendations

Revise the input pressure to satisfy the requirements given above.

23103 The initial conditions imply super heated vapor and air over liquid, which is not allowed in RETRAN-3D.

User Recommendations

Revise the input as necessary.

23104 Volumes consisting of dry air are not permitted

User Recommendations

Revise the input as necessary.

23105 The initial state for a volume with noncondensables cannot be determined from the input temperature (and possibly pressure), which results in a partial vapor pressure that is greater than total pressure. This would give an unrealistic negative pressure for the noncondensable pressure since the sum of the partial vapor pressure and noncondensable pressure equals the total pressure.

User Recommendations

Revise the temperature and/or pressure as necessary to obtain the desired state for a mixture of noncondensable gas and water.

Error Description

23106 The pressure supplied for volume initial condition is negative.

User Recommendations

Revise the input as necessary to eliminate the error.

23107 When the quality is specified as a nonzero value, the pressure or temperature must be specified. For two phase conditions at least 2 property values are required to define the thermodynamic state of the fluid.

User Recommendations

Revise the input as necessary to satisfy the requirements given above.

23108 The quality supplied with the volume initial conditions is incorrect.

User Recommendations

Revise the quality such that 0 <= X <= 1.

23109 The specified volume number does not exist.

User Recommendations

Revise the volume number to reference a valid volume number.

23110 Both the volume temperature and enthalpy are supplied. Only one can be supplied.

User Recommendations

Revise the input to provide either the temperature or enthalpy. If temperature is input, the pressure is also required.

23111 The value specified for the humidity is invalid. If XNC is flagged to use noncondensable gas, the humidity must be -1 (a flag).

User Recommendations

Revise the value of XNC to satisfy the desired initial thermodynamic conditions and state according to the requirements given above.

Error Description

23112 Supplying pressure, temperature, and quality over specifies the state of a two-phase separated volume that does not contain noncondensable gas.

User Recommendations

Revise the input to satisfy the requirements above.

23113 When the pressure and enthalpy are specified for a bubble rise volume, the quality must be set to -1.0 (flag).

User Recommendations

Revise the input to satisfy the requirements above.

23114 For a five-equation volume with XNC = -1 (indicating noncondensable is present), the quality and enthalpy must be zero, but the temperature and pressure must be > 0.

User Recommendations

Revise the input to satisfy the requirements above.

23115 When noncondensable gas is present in any volume, the humidity must be between 0 and 1.0 and the pressure and temperature must be > 0. P-T-X is the only valid option when noncondensable gas is present.

User Recommendations

Revise the input as necessary to satisfy the requirements given above.

23116 The input pressure for a two-phase volume is greater than the critical pressure. The pressure for a two-phase volume must be less than the critical pressure.

User Recommendations

Either revise the input so the volume is single phase or revise the pressure to the appropriate value that satisfies the requirements above.

23117 The input temperature for a two-phase volume is greater than the critical temperature. The temperature for a two-phase volume must be less than the critical temperature.

User Recommendations

Either revise the input so the volume is single phase or revise the temperature to the appropriate value that satisfies the requirements above.

Error Description

23118 The thermodynamic conditions supplied (pressure, temperature, quality) for the bubble rise volume is inconsistent with input mixture level. The liquid volume exceeds the mixture volume.

User Recommendations

Revise the input as necessary to obtain the desired initial conditions. This may require increasing the quality or enthalpy to increase the amount of vapor in the volume.

23119 For a separated volume containing noncondensable gas, the input pressure must be between PLOW=1.0E-8 and PCRIT=3208.2 psia or a temperature between TLOW=32.7628 F and TCRIT.

User Recommendations

Revise the input as necessary to satisfy the given requirements.

23120 The temperature supplied must be between TLOW=32.7628 F and TCRIT.

User Recommendations

Revise the input as necessary to satisfy the given requirements.

23121 The saturation property calculation failed.

User Recommendations

Revise the temperature or quality to be representative of the desired two phase state.

23122 The saturation property calculation failed.

User Recommendations

Revise the pressure or quality to be representative of the desired two phase state.

C.3.17.3 Junction Initial Condition Related Input Errors

The errors related to specifying junction initial conditions are given below.

Error Description

23201 Initial conditions were provided for an invalid junction number JUN.

User Recommendations

Revise the input as necessary to use a valid value for JUN.

23202 An invalid value of JESTW was specified for the junction. Valid values of JESTW are 0, 1, or 2.

User Recommendations

Revise the input as necessary to use a valid value for JESTW.

23203 The indicated volume number identifying a volume that provides a boundary pressure for the flow split option is invalid.

User Recommendations

Revise the input to refer to a valid volume number (generally the lower or upper plenum volume).

23204 The initial volume pressure is not defined for the indicated boundary volume.

User Recommendations

Either revise the volume number to refer to a boundary volume where the initial pressure is defined or provide the initial pressure for the given volume number.

23205 Three data items are required when JESTW = 0.

User Recommendations

Provide the value of the junction flow for the indicated junction that is to be used for the flow initial condition. No other information (beyond word 3) can be provided with this option.

23206 When using the FIBWR total core flow boundary condition (JUN = -1), three data items are required, but fewer were supplied.

User Recommendations

Provide the required input including the total core flow.

Error Description

23207 When using the flow split option (JESTW = 2) a total of 5 items are required, but fewer were supplied.

User Recommendations

Revise the input as necessary so the estimated flow is supplied via WP and the volumes bounding the parallel channels are supplied via SPLTV1 and SPLTV2.

23208 When the flow split option (JESTW = 2) and FIBWR model are used, a total of 3 items are required, fewer were supplied.

User Recommendations

Provide the required flow estimate or initial condition via WP.

23209 FJUNF and/or FJUNR are specified as negative but the flow split option (JESTW = 2) is requested. Negative values of FJUNF and FJUNR are only allowed if they are = -1.0, which indicates that the form loss coefficient is to be computed for the junction during steady-state initialization. This option conflicts with the flow split option.

User Recommendations

Change the value of the offending form loss coefficient to the positive value that is representative of the component geometry.

23210 An invalid two-phase multiplier option LSET is specified on grid model description data card.

User Recommendations

Revise the input to use a valid two-phase multiplier option.

23211 When the grid loss model option is selected through the CDI file and grid loss description data cards 233XXX are provided to over ride the channel model definitions, the number of grid loss model cards is limited to the number of model descriptions in the CDI file.

User Recommendations

Remove the extra grid loss model definition cards from the input deck.

C.3.17.4 Off-Rated Power Steady-State Initialization Related Errors

The errors related to the off-rated steady-state initialization procedures are discuss below.

Error Description

23601 An invalid value for the nominal full power FULPOW was supplied. The nominal full power must be greater than zero.

User Recommendations

Revise FULPOW as necessary to satisfy the requirements given above.

23602 An invalid value for the energy balance option IEBAL was supplied. Valid values for the energy balance option are 0 to turn the energy balance off, or 1 to activate the energy balance.

User Recommendations

Revise the value of IEBAL provided to be one of the valid options.

23603 The input provided for the pump power PPOWER adjustment option is invalid. The pump power adjustment value may be 0.0 or greater.

User Recommendations

Revise the value of PPOWER to the desired pump power that should be obtained by the steady-state initialization option. Otherwise, enter 0 and no adjustment will be made to obtain a desired pump power.

23604 The general data table number IGTPRS specified for defining the pressurizer pressure as a function of power is invalid.

User Recommendations

Review and revise the value of IGTPRS as necessary to refer to the correct table or define the required general data table using the general data table description data cards 12XXYY.

23605 The general data table number IGTPZL specified for defining the pressurizer level as a function of power is invalid.

User Recommendations

Review and revise the value of IGTPZL as necessary to refer to the correct table or define the required general data table using the general data table description data cards 12XXYY.

Error Description

23606 The volume number given for the pressurizer IPZR is not a valid volume number. The volume number may be zero if both pressure and level are not functions of power

User Recommendations

Revise the value of IPRZ to refer to the pressurizer volume number.

23607 The volume number specified as pressurizer via IPRZ is not a two-region nonequilibrium volume (pressurizer).

User Recommendations

Revise the value of IPRZ to refer to the pressurizer volume number.

23608 The junction specified for the turbine control valve junction number ITVJUN is invalid.

User Recommendations

If a flow specification is desired for the junction containing the turbine control valve, provide the correct junction number. A negative value indicated that the sign of the flow will be negative.

23609 The general data table number IGTSGP specified for defining the steam generator pressure as a function of power is invalid.

User Recommendations

Review and revise the value of IGTSGP as necessary to refer to the correct table or define the required general data table using the general data table description data cards 12XXYY.

23610 The general data table number IGTSGR specified for defining the steam generator recirculation ratio as a function of power is invalid.

User Recommendations

Review and revise the value of IGTSGR as necessary to refer to the correct table or define the required general data table using the general data table description data cards 12XXYY.

23611 The general data table number IGTFWS specified for defining the steam generator feedwater/steam flow as a function of power is invalid.

Error Description

User Recommendations

Review and revise the value of IGTFWS as necessary to refer to the correct table or define the required general data table using the general data table description data cards 12XXYY.

23612 The specified steam generator dome volume number ISGNOL is invalid. The dome volume is used to specify the secondary side pressure.

User Recommendations

Revise the volume number such that it refers to the steam generator dome volume.

23613 The junction number specified for the main feed water junction IFWJUN is invalid. This junction is used for specification of the feed water flow.

User Recommendations

Revise the junction number such that it refers to the feedwater junction.

23614 The junction number specified for the steam flow junction ISTJUN is invalid. This junction is used for specification of the steam line flow.

User Recommendations

Revise the junction number such that it refers to the steam line junction.

23615 The junction number specified for the steam generator recirculation flow junction IRRJUN is invalid. This junction is used for specification of the recirculation flow.

User Recommendations

Revise the junction number such that it refers to the recirculation junction.

23616 The mass flow rate as fraction of RCS flow RAPFRC specified is invalid. The mass flow rate must be > 0.

User Recommendations

Revise the value of RAPFRC to satisfy the requirements given above.

Error Description

23617 The specified junction number IAPJUN where the primary-side flow rate is defined is invalid.

User Recommendations

Revise the value of IAPFRC to refer to the junction where the primary-side junction flow is defined.

23618 The mass flow rate fraction RASFRC for the steam generator feed water flow is incorrect. The mass flow rate must be greater than zero.

User Recommendations

Revise the value of RASFRC to satisfy the requirements given above.

23619 The junction number given for the flow rate specification IASFRC on the secondary-side is invalid.

User Recommendations

Revise the value of IASFRC to refer to the correct secondary-side junction.

23620 The number of data items is incorrect. A minimum of 3 and a maximum of 5 values may be specified.

User Recommendations

Revise the input to satisfy the requirements above.

23621 The specified lower plenum volume number ILPVOL is invalid.

User Recommendations

Revise the value of ILPVOL to refer to the reactor vessel lower plenum volume.

23622 The general data table number IGTWRS specified for defining the RCS volumetric flow as a function of percent power is invalid.

User Recommendations

Review and revise the value of IGTWRS as necessary to refer to the correct table or define the required general data table using the general data table description data cards 12XXYY.

Error Description

23623 The general data table number IGTTAV specified for defining the RCS average loop temperature as a function of percent power is invalid.

User Recommendations

Review and revise the value of IGTTAV as necessary to refer to the correct table or define the required general data table using the general data table description data cards 12XXYY.

23624 A water property failure occurred while calculating enthalpy for off-rate power initial conditions. This error is the result of specified values of pressure, temperature and flow conditions for the off-rated condition option.

User Recommendations

Review the input for the off-rated condition option and revise the pressure and/or temperature specifications as necessary. The problem may be in one of the general data tables use by the option.

23625 A water property failure occurred while calculating the RCS cold leg density for off-rate power initial conditions. This error is the result of specified values of pressure, temperature and flow conditions for the off-rated condition option. Note that the enthalpy is a computed value obtained from the input pressure and temperature.

User Recommendations

Review the input for the off-rated condition option and revise the pressure and/or temperature specifications as necessary. The problem may be in one of the general data tables use by the option.

23626 Too few data items were provided on the indicated data card.

User Recommendations

Revise the input to satisfy the requirement above.

23627 For the indicated secondary-side loop, the specified RCS flow rate fraction RLPFRC is invalid. The flow fraction must be > 0.

User Recommendations

Revise the value of RLPFRC to satisfy the requirements above.

Error Description

23628 The specified RCS pump outlet junction number IPOJUN is invalid.

User Recommendations

Revise the value of IPOJUN to refer to a pump outlet junction.

23629 The specified hot leg volume number IHLVOL is invalid.

User Recommendations

Revise the value of IHLVOL to refer to the desired hot leg volume to be used in determining the average loop temperature.

23630 The specified cold leg volume number ICLVOL is invalid.

User Recommendations

Revise the value of ICLVOL to refer to the desired cold leg volume to be used in determining the average loop temperature.

23631 The pump outlet junction number specified via IPOJUN points to a valid junction, but it is not a pump discharge or outlet junction.

User Recommendations

Revise the value of IPOJUN to point to a RCS pump outlet junction.

23632 The general data table number IGTMAS specified for defining the steam generator secondary mass inventory as a function of percent power is invalid.

User Recommendations

Review and revise the value of IGTMAS as necessary to refer to the correct table or define the required general data table using the general data table description data cards 12XXYY.

23633 The enthalpy in the steam generator lower downcomer volume ILDVOL is zero or negative, but must be a valid fluid enthalpy

User Recommendations

Either revise the value of ILDVOL to refer to a volume where the enthalpy initial condition is specified, or provide the enthalpy initial condition for the given volume.

Error Description

23634 The specified steam generator lower downcomer volume number ILDVOL is invalid.

User Recommendations

Revise the value of ILDVOL to refer to the desired steam generator lower downcomer volume where the enthalpy initial condition is specified.

23635 The steam generator upper downcomer or combined separator and upper downcomer volume must be a bubble rise volume where IBUB for volume number IUDVOL is > 0.

User Recommendations

Either revise the value of IUDVOL to refer to the upper downcomer or add a bubble rise model to the given volume.

23636 The specified steam generator upper downcomer volume number IUDVOL is invalid.

User Recommendations

Revise the value of IUDVOL to refer to the desired steam generator upper downcomer volume where the level is specified.

23637 The control block ID ICOUTM specified to calculate the steam generator level or mass inventory is invalid.

User Recommendations

Revise the value of ICOUTM to refer to a valid control block ID or define the desired function using the control block description data cards 703XXX.

C.3.18 1-D KINETICS RELATED INPUT ERRORS

Input errors associated with the 1-D kinetics model description, feedback models and cross section data are discussed in the following sections.

C.3.18.1 1-D Kinetics Model Description Related Input Errors

Input errors associated with the 1-D kinetics model description are discussed below.

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Error	Description

30001 The indicated word supplied on the 1-D Kinetics constant data is out of range.

User Recommendations

Revise the value of the indicated word to a valid option.

30002 The 1-D kinetics option has been requested via NODEL = 2 on the problem description data card, but the kinetics constant data cards are missing.

User Recommendations

Either revise the value of NODEL or supply the kinetics constant data cards.

30003 The elevation ELEVR for the top of the indicated region, referenced from bottom of the region 1, must be greater than the elevation of previous region.

User Recommendations

Revise the elevations as necessary to satisfy the requirement above.

30004 The core section number IRCOR specified for the indicated neutronic region is invalid. IRCOR must be > 0 and <= the number of core sections.

User Recommendations

Revise the value of IRCOR to refer to a valid core section.

30005 The control volume IRVOL specified to provide feedback values for the indicated neutronic region does not exist.

User Recommendations

Revise the value of IRVOL to refer to a valid control volume number that is adjacent to the core IDCOR.

30006 The control block number IDABS (1 or 2) supplied for determining the absorption cross section for the indicated region is invalid.

User Recommendations

Revise the value of IDABS to refer to a valid control block number that computes the change in absorption cross section.

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Error Description

30007 The number of data items supplied on the absorption cross section modification data cards is incorrect. The number of data items that are required is two times the number of neutronic regions.

User Recommendations

Revise the input to provide the required data items.

C.3.18.2 1-D Kinetics Cross-Section File Related Errors

Errors that are detected when processing input data related to cross sections for the 1-D kinetics model are discussed below.

Error Description

31001 The cross section file (TAPE40) is incompatible with the core section geometry specified. The number of neutronic regions specified on the 1-D kinetics constant data cards and number of neutronic regions obtained from the cross-section file are different.

User Recommendations

Either revise the geometry description provided in the input to match that of the cross-section file or use a cross-section file that was generated for the geometry used in the input.

31002 The cross section data set contained an insufficient number of control states. More controls state data was expected (NOFCS on problem description data card 01000Y).

User Recommendations

Revise the value of NOFCS to match the number of control states included in the cross-section file or supply a cross-section file that contains the number or control states given by NOFCS.

31003 The cross section file is incompatible with the core section geometry that was specified. The number of mesh points per region specified on the 1-D kinetics constant data cards and the number of mesh points per neutronic region obtained from the cross-section file (TAPE40) are different.

User Recommendations

Revise number of mesh points to match the number included in the cross-section file or supply a cross-section file that contains data for the number of mesh points specified in the input.

Error Description

31004 An end of file was encountered while reading the 1-D Kinetics Cross section file (TAPE40). More data from TAPE40 was expected, but was not found.

User Recommendations

Review the 1-D kinetics constant input and revise it as necessary to make sure the input data is compatible with the cross-section file. It is also possible that the wrong cross-section file was used.

31005 An error occurred while reading the cross-section file 'TAPE40'. Either incorrectly formatted data or insufficient data on the cross-section file may be the cause. Check the 1-D Kinetics constant input and make sure input data is compatible with cross section file.

User Recommendations

Review the 1-D kinetics constant input and revise it as necessary to make sure the input data is compatible with the cross-section file. It is also possible that the wrong cross-section file was used.

31006 The control rod entry flag IBOT is invalid. It must either be 0 for a BWR (bottom entry) or 1 for a PWR (top entry).

User Recommendations

Revise the value of IBOT to the desired rod entry modeling.

31007 The control rod source mixing fraction FSRC is out of range. It must be between 0 .0 and 1.0

User Recommendations

Revise the value of FSRC to satisfy the requirements above.

31008 The control rod bank tip position is defined by the control block given by IDCNTL, but the control block ID does not exist.

User Recommendations

Revise the value of IDCNTL to refer to the control block ID that defines the control rod tip position or define the desired control block rod position function using the control rod description data or control block definition card 703XXX.

Error Description

31009 An error occurred while opening the 1-D kinetics cross section file TAPE40. The file is either missing or the file format is incorrect. TAPE40 is an ASCII file.

User Recommendations

Provide the cross section file as TAPE40. If the file was present, make sure is the correct format. The value of the IOSTATUS flag may aid in determining the error. If necessary refer to your local IT support staff or contact the RETRAN-3D maintenance support provider for assistance. The value of the flag can be dependent on the compiler used to install the executable, so have that information available.

Some execution scripts or batch files allow the actual file name to be used, e.g. pb_eoc15.t40, which gets renamed or linked to TAPE40 prior to executing RETRAN-3D.

C.3.19 ITERATIVE THERMAL-HYDRAULICS SOLVER (PURDUE NUMERICS) RELATED INPUT ERRORS

Errors that are detected when processing input data related to the iterative thermal-hydraulics solver are discussed below.

Error Description

38001 The number of core planes NCOAXL supplied is <= 0.

User Recommendations

Revise the number of core planes to the correct positive value.

38002 Incorrect number of channels NCOCHL supplied on input card 380000

User Recommendations

Revise the number of core channels to the correct positive value.

38003 The number of core rows NCOROW is <= 0.

User Recommendations

Revise the number of core rows to the correct positive value.

Error Description

38004 The number of core rows NCOROW exceeds the maximum value allowed.

User Recommendations

Revise the number of core rows to less than the maximum number allowed. To increase the number of core rows beyond the maximum currently allowed will require a code revision.

38005 The core type flag ICTYPE specified is invalid. The accepted value for ICTYPE is 0, 1, 2, 3, or -1.

User Recommendations

Revise the input value to be one of the valid core type flags.

38006 The maximum number of GMRS iterations MOITRS exceeds the allowed maximum of 150.

User Recommendations

Revise the input value to be <= to the maximum value allowed.

38007 An invalid value was provided for the preconditioning option flag NPCOND. Allowed values for NPCOND are 0, 1, 2, or 3.

User Recommendations

Revise the input value of NPCOND to be one of the allowed values.

38008 The selection for the model subdomain NMDSUB is in error. The model subdomain is meaningless for cores without cross flow junctions.

User Recommendations

Revise the input as necessary to correctly specify the model subdomain.

38009 The GMRES convergence criteria EPSGMR is out of bounds. The limits are listed with the error message.

User Recommendations

Revise the convergence criteria to satisfy the limits indicated.

Error Description

38010 The reorthogonalization convergence criteria EPSROR is out of bounds. The limits for the convergence criteria are listed with the error message.

User Recommendations

Revise the convergence criteria to be within the indicated limits.

38011 The value specified for the number of subdomains NSUBDM is out of range.

User Recommendations

Revise the number of subdomains as necessary.

38012 The value for the domain decomposition preconditioning flag NPCOND is specified as 0, or one channel per subdomain. Therefore, the domain decomposition data is not used.

User Recommendations

Revise the input as necessary.

38013 The number of volumes per row NVOL01 is invalid.

User Recommendations

Revise the input as necessary to satisfy the requirements given in the User's Manual.

38014 The sum of all channels supplied for all rows does not equal to the total number of channels.

User Recommendations

Revise the channels specified for all rows, such that the sum of the number of channels in each row is equal to the total number of channels.

38015 The number of channels and rows are inconsistent for a square core model. For a square core model, the total number of vertical core channels must be equal to the square of number of rows.

User Recommendations

Revise NCOCHN or NCOROW on the iterative control parameters data card 380000 as necessary.

38016 The type of core model selected is inconsistent with row information provided. One of the rows has more channels than other, which is not allowed. The quarter core model must be the lower right quadrant.

User Recommendations

Revise the input as necessary to satisfy the requirements above.

38017 For a full or half core model specification, the number of channels specified on a row has fewer channels than the previous. This is required up to the mid-plane.

User Recommendations

Revise the input as necessary to satisfy the requirements above.

38018 For a full or half core model specification, the number of channels specified on a row has fewer channels than the previous. This is required beyond the mid-plane.

User Recommendations

Revise the input as necessary to satisfy the requirements above.

38019 When using other core types ICTYPE = -1, and preconditioning NPCOND > 0, the number of subdomains NUMSUB must be greater than zero and all the channels of the subdomain on card 3802XX must be defined.

User Recommendations

Supply the additional information as is required for the options given.

C.3.20 AUXILIARY AND COMPONENT MODEL RELATED INPUT ERRORS

Error messages related to various component and auxiliary models are discussed in the following sections.

C.3.20.1 General Transport Model Related Input Errors

Input errors associated with the general transport model are discussed below.

Error Description

45201 The initial impurity concentration TPPMIN was supplied as a negative value when it must be >= 0.

Error Description

User Recommendations

Revise the initial concentration to satisfy the requirements given above.

45202 An incorrect number of data items were supplied on the indicated general transport volume data card. Three items must be provided for each volume.

User Recommendations

Either supply the additional information required (NGSVCB and/or RVCB), or remove the extraneous input (NGSV and/or NGSVCB).

45203 The volume specified on the on general transport volume card does not exist.

User Recommendations

Revise the input to refer to a valid volume number that has been defined.

45204 The control block ID specified for controlling the volume source or sink is invalid.

User Recommendations

Revise the input to refer to a valid control block ID or define the desired control block ID using the control block description data cards 703XXX.

45205 The concentration bias RSVB is subtracted from the initial concentration for the volume. It must be less than the initial concentration to prevent the biased concentration from being negative.

User Recommendations

Revise the concentration bias according to the requirements above, to keep the biased concentration positive.

45206 An incorrect number of data items were supplied on the indicated general transport junction data card. Three items must be provided for each junction.

User Recommendations

Either supply the additional information required (NGSJCC and/or NGSJCE), or remove the extraneous input (NGSJ and/or NGSJCC).

Error Description

45207 The junction specified on the on general transport volume card does not exist.

User Recommendations

Revise the input to refer to a valid volume number that has been defined.

45208 The control block ID NSJCC controlling the fill junction concentration is invalid.

User Recommendations

Revise the input to refer to a valid control block ID or define the desired control block ID using the control block description data cards 703XXX.

45209 The control block ID NSJCE controlling the fill junction efficiency is invalid.

User Recommendations

Revise the input to refer to a valid control block ID or define the desired control block ID using the control block description data cards 703XXX.

C.3.20.2 Turbine Model Related Input Errors

Input errors associated with the turbine model are discussed below.

Error Description

50001 The specified turbine shaft number is greater than number of turbine shafts NTSH specified on the long format problem control and description data card 01000Y.

User Recommendations

Either revise the value of NTSH to match the number of turbine shaft descriptions provided or revise the shaft descriptions to match the value of NTSH.

This error should not be encountered when using the short form of the problem control and description data card.

50002 A negative turbine shaft number ITSHA was specified for the turbine description.

User Recommendations

Revise the value of ITSHA to refer to a valid turbine shaft that has been described.

Error Description

50003 The junction number specified for turbine inlet JINTUR is invalid.

User Recommendations

Revise the junction number to reference a valid junction number that represents the inlet flow path to the turbine.

50004 Junction number JINTUR specified for the turbine inlet is invalid.

User Recommendations

Revise the junction number to reference a valid junction number that represents the inlet flow path to the turbine.

50005 For each turbine, NG stage group cards 51XYYZ are required, where X corresponds to turbine number and YY corresponds to the stage group number which should range from 1 to NG. More stage group data cards are supplied than required.

User Recommendations

Either revise the number of stage groups NG to match the number of stage groups for which data was provided, or remove the data for the groups that exceed the value of NG.

50006 No stage group data are specified for the indicated stage group.

User Recommendations

Supply the stage group data for the indicated stage.

50007 Since more than 11 data items were supplied on the data card, the stage is assumed to be a governing stage. However, the number of stages specified was > than 1. A governing stage is limited to 1 stage.

User Recommendations

If the stage is intended to be a governing stage, revise the input to specify a single stage and remove any stage input that may then be extraneous. If the stage is not a governing stage, remove the input beyond GXE (word 11).

50008 The volume number specified for the turbine stage group is invalid.

User Recommendations

Revise the volume number to refer to a valid volume number.

Error Description

50009 The inlet junction for the stage IJUNSG is not a valid junction number.

User Recommendations

Revise the input such that IJUNSG refers to the junction that is the inlet to the stage.

50010 The stage volume number IVOLSG supplied for the turbine stage group must be the downstream volume for the inlet junction IJUNSG, but it is not.

User Recommendations

Revise the value of IVOLSG to reference the volume associated with the stage. If the specified volume is correct, revise the inlet junction number so that it refers to the inlet junction to volume IVOLSG.

50011 The turbine shaft speed integration is requested; however, the control block ID ISIN that is to provide the generator load torque is invalid.

User Recommendations

Revise the value of ISIN to refer to the control block that defines the generator load. If the generator load is not available, define the necessary load control block by using the control block description data cards 703XXX.

C.3.20.3 Separator Input Related Errors

Input errors associated with the steam-water separator model are discussed below.

Error Description

60001 The indicated data item supplied on the separator description card is out of range. The value is outside the valid range for quality, carryover or carryunder, which must be >= 0 and <= 1. The value for design parameters and the index for general data tables must be > 0.

User Recommendations

Revise the offending data item to satisfy the requirements given above.

Error Description

60002 The carryunder CUND can only be supplied if steady-state initialization is not used.

User Recommendations

Either omit the value of CUND or set the steady-state initialization flag JSST on the problem control and description data card 01000Y to 1.

60003 The carryunder term CUND is require when steady-state initialization is not used.

User Recommendations

Either specify CUND or set the steady-state initialization flag JSST on the problem control and description data card 01000Y to 1.

60004 The upper downcomer volume IUDC associated with the separator volume must be a bubble rise volume with a mixture level.

User Recommendations

Modify the volume data card for the upper downcomer volume to make it a bubble rise volume with a mixture level that lies between the bottom and top of the volume.

60005 The upper downcomer volume specified via IUDC is invalid.

User Recommendations

Revise the value of IUDC to refer to a valid volume that represents the upper downcomer adjacent to the given separator.

60006 The number of separators specified via ISEPN must be > 0.

User Recommendations

Revise the value of ISEPN to be the number of separators.

60007 The separator vane angle THETA specified on the separator data cards must be > 0.

User Recommendations

Revise the angle to be representative of the separator vane angle relative to horizontal.

Error Description

60008 The separator hub radius RHUB must be > 0.

User Recommendations

Revise the hub radius to be representative of the separator geometry.

60009 The separator pick-off ring radius RRNG must be > 0.

User Recommendations

Revise the pick-off ring radius to be representative of the separator geometry.

60010 The separator barrel height HDFS must be > 0.

User Recommendations

Revise the barrel height to be representative of the separator geometry.

60011 The separator first stage volume VOLFS must be > 0.

User Recommendations

Revise the first stage volume to be representative of the separator geometry.

60012 The separator volume number ISEV is invalid.

User Recommendations

Revise the value of ISEV to refer to a valid volume that represents the separator.

60013 The control block ID ICO2 or ICU2 used to define the separator carryover of carryunder respectively, is invalid.

User Recommendations

Revise the control block ID given for defining the carryover or carryunder to be a valid ID that defines the indicated value. If the desired function is not defined, use the control block description data cards 703XXX to define it.

C.3.20.4 Two-Region Nonequilibrium Volume Related Input Errors

Input errors associated with the two-region nonequilibrium model are discussed below.

Error Description

61001 The interphase heat transfer flag IHTC for a two-region nonequilibrium volume is out of range. The value of IHTC must be 0-3 for the 610XXX cards or 0-2 for the 611XXX cards.

User Recommendations

Revise the value of IHTC to be one of the valid options.

61002 The two-region nonequilibrium volume number NEQVOL is invalid.

User Recommendations

Revise the value of NEQVOL to reference the volume where the two-region nonequilibrium model is to be applied.

61003 The rainout velocity VRAIN specified for the indicated two-region nonequilibrium volume is negative. It must be >= 0.

User Recommendations

Revise the value of the rainout velocity to satisfy the requirements given above.

61004 The two-region nonequilibrium is specified via either IPRZR or NSEP on the long form of the problem control and description data card 01000Y, but no volume is flagged as a nonequilibrium volume (pressurizer of separator).

User Recommendations

Either remove the values of IPRZR or NSEP from the long form of the problem description data card or provide the necessary nonequilibrium volume data for a pressurizer, separated volume, or separator.

61005 The two-region nonequilibrium volume interregion heat transfer coefficient is to be obtained from the control system. The specified control block ID specified by the user does not exist.

User Recommendations

Revise the value of VLHTC on the 610XXX cards or CFCV on the 611XXX cards to refer to a valid control block ID that defines the interregion heat transfer coefficient. If the block defining the heat transfer coefficient has not been defined, add a definition for it using the control block description data cards 703XXX.

Error Description

61006 Two-region nonequilibrium volume NEQVOL must also be a bubble rise volume, which allows a level to be defined within the volume.

User Recommendations

Revise the input for volume NEQVOL on the corresponding volume description data card 05XXXY so it uses a bubble rise model specified via IBUB. If a bubble rise set has not been defined for this volume, it must be defined using the bubble rise description data cards 060XXY.

61007 The two-region nonequilibrium volume interregion heat transfer coefficient is to be obtained from the control block given by VLHTC on the 610XXX cards or CFCV on the 611XXX cards.. The initial output of the control block is negative.

User Recommendations

The value of heat transfer coefficient must be positive, which requires modifying the initial condition for the control block on the appropriate control block description data card 703XXX.

61008 The two-region nonequilibrium volume used as a separator is also used as an accumulator. Separate volumes are required for the separator and accumulator.

User Recommendations

If the volume is a separator, modify the accumulator input to use a different volume. If the volume is intended to be an accumulator, revise the nonequilibrium volume number to the separator volume, or remove the separator input data.

61009 The two-region nonequilibrium flag used to identify the volume as a separator is out of range. Valid values are 0 and 1. A value of 1 indicates the model is used with the separator model while 0 is used for nonequilibrium separated volumes such as a pressurizer or downcomer.

User Recommendations

Change the input value to one of the valid values depending on the component being modeled.

61010 Both 610XXX and 611XXX cards are present in the input deck.

User Recommendations

Remove or comment out all two region nonequilibrium cards that are not the same format as the desired accumulator model.

Error Description

61011 The constant interregion heat transfer coefficient supplied using VLHTC for the 610XXX cards or CFCV for the 611XXX cards for the two-region nonequilibrium model is out of range. Only values greater than or equal to zero are valid.

User Recommendations

Change the input value so it is greater than or equal to zero.

C.3.20.5 Accumulator Model Related Input Errors

Input errors associated with the accumulator model are discussed below.

Error Description

62001 The volume specified for the accumulator does not exist.

User Recommendations

Revise the volume number IDVACC to refer to the volume that is also the accumulator.

62002 An accumulator volume cannot be bubble rise model, but the volume uses the bubble rise model.

User Recommendations

Modify the volume data cards 05XXXY to remove bubble rise flag from the accumulator volume or revise the volume number if it doesn't refer to the accumulator volume.

62003 Accumulator vessel descriptor VESGEO, has a value other than 0 or 1.

User Recommendations

Revise the value of VESGEO to be either 1 for a cylindrical vessel and hemispheric ends or 0 for a cylindrical vessel with flat ends.

62004 The initial accumulator water level ACCLEV must be > 0 and < ZVOL (volume height).

User Recommendations

Revise the value of ACCLEV to define the correct liquid and gas inventories.

Error Description

62005 The accumulator wall thickness is not within a valid range.

User Recommendations

Revise the value of DXWALL to be greater than zero and less than one. Note that the dimensions are in feet.

62006 Insufficient input data was provided. At least two data items are required, the accumulator volume number IDVACC and the initial accumulator level ACCLEV.

User Recommendations

Provide the additional required data.

62007 The value of GAMMA must be greater than or equal to one.

User Recommendations

Revise the value of GAMMA to 0.0 or > 1.0 for isentropic expansion or 1.0 for isothermal expansion.

62008 The expansion coefficient (gamma) cannot be controlled by a control system.

User Recommendations

Manually revise the value of gamma to either 1.0 (Isothermal Expansion) or 0.0 (Isentropic Expansion) or use the MOD004.7 accumulator model (621XXX cards) which allows the user to model heat transfer from the cover gas to the vessel wall and liquid region.

62009 Both 620XXX and 621XXX cards are present in the input deck.

User Recommendations

Remove or comment out all accumulator cards that are not the same format as the desired accumulator model.

C.3.21 3-D KINETICS MODEL RELATED INPUT ERRORS

The 3-D kinetics model uses the channel model and CDI file to simplify the input requirements. Errors associated with these features are given in the following sections.

C.3.21.1 Channel Model Related Input Errors

Input errors associated with the 3-D kinetics channel model are discussed below.

Error Description

67001 Due to previously encountered errors, the binary cross-section file (BXF) will not be read.

User Recommendations

This may lead to subsequent errors as the input is processed further. Correcting previously encountered errors will eliminate this error.

67002 The number of core conductors specified does not match the number of powered channels.

User Recommendations

The total number of powered channels must match the number of core conductors. Both are created by the channel model so this is probably a code error. Contact the maintenance support provider.

67003 The number of volumes associated with a bypass channel were not encountered.

User Recommendations

They are created by the channel model so this is probably a code error. Contact the maintenance support provider.

67004 The control volume number associated with the reflector is invalid.

User Recommendations

Review and revise the volume number to refer to a valid volume that represents the reflector region.

67005 Total number of control block IDs specified for boron injection does not match the number of channels times the number of core axial planes.

User Recommendations

When boron injection is defined using the control system, each axial plane for each channel must be assigned a control block ID. The control block ID does not have to be unique, so the same control block ID can be specified multiple times or even for whole assignment specification. Revise the input to satisfy the requirements given.

Error Description

67006 The value of the boron search flag NBORON is invalid.

User Recommendations

Revise NBORON to 0 for no search or use a valid search option.

67007 The number of entries specified for the control rod control group data is incorrect. Two entries are required for each rod group.

User Recommendations

Revise the input so a pair of data items is provided for each control rod group. Each pair is comprised of the rod group number and a control block ID.

67008 Control block ID specified for the control rod group data is invalid.

User Recommendations

Revise the input to refer to a valid control block ID. If the desired control block function is not defined, define it using the control block description data cards 703XXX.

67009 The specified channel volume does not exist.

User Recommendations

The channel volume number created in GEOM3D does not match a volume created in INVOL. This is a possible programming error. Contact the maintenance support provider.

67010 The control block ID specified for boron injection is invalid.

User Recommendations

Revise the control block ID to refer to a valid control block ID, of if the desired control block does not exist, define the desired function using the control block description data cards 703XXX.

67011 The bypass channel IBYPCH associated with the indicated channel is invalid. It is either negative or greater than the total number of bypass channels NBYPSS on the 67000Y data cards.

User Recommendations

Either increase the total number of bypass channels defined via NBYPSS, or revise the value of IBYPCH to refer to a valid channel number that represents a bypass channel.

Error Description

67012 No Bypass channels are specified for the model. At least one bypass channel is required when using the channel model for 3D-Kinetics

User Recommendations

Revise the input to define a bypass channel(s), which can be specified through either the CDI file or by using the core geometry and model option data cards 67000Y.

67013 Too few channel map data item were supplied for the indicated neutronic row.

User Recommendations

The channel map is used to overlay RETRAN-3D thermal-hydraulics channels onto the neutronics assemblies to obtain feedback data. Revise the input so a channel number is provided for each neutronic column for each neutronic row.

67014 The IPURDU option flag for 3D-kinetics is invalid.

User Recommendations

Revise the value of IPURDU to use one of the valid cross section models. It must be > 0.

67015 An invalid value for the Xenon, Iodine, Samarium, and Promethium fission product calculation flag XISP is invalid. It must be 0, 1, or 2.

User Recommendations

Review and revise the flag to use one of the valid option values.

67016 The frozen feedback option was specified via NFREEZ on data card 670021, but the 3 required reference parameters were no provided on the indicated data card.

User Recommendations

Either deactivate the frozen feedback option by setting NFREEZ = 0, or provide the 3 required reference feedback parameters.

67017 The 3-D kinetics cross section file TAPE68 is missing or has an incorrect format.

User Recommendations

Review the input to the execution script, batch file or interface program (execution procedure) to insure that the cross section file, TAPE68, is provided. Revise the input as

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Error Description

The file will generally have a name other than TAPE68 and the execution procedure will take the necessary steps to make sure that a TAPE68 file is provide to the RETRAN-3D program. The cross section file is a binary file.

67018 The number of cross-section variables read from TAPE68 NXSEC exceeds the number allowed.

User Recommendations

The cross-section data file can only contain a maximum of 53 cross-section variables. The cross-section preparation program used to create TAPE68 is in error and needs to be corrected.

67019 The number of independent variables NINDP read from TAPE68 is incorrect.

User Recommendations

The cross-section data file can only contain 12 independent variables. The cross-section preparation program used to create TAPE68 is in error and needs to be corrected.

67020 The cross-section data file (TAPE68) does not contain the XISP number densities required for IFXISP=0.

User Recommendations

If IFXISP = 0 is the desired input option, insufficient or incorrect XISP number density data is present. The cross-section file must be revised. It may be possible to turn the XISP option off or set IFXISP=2 to allow use of the current cross-section data file.

67021 The rod position search flag NSERCH is invalid. It must be 0 for no search or it must be equal to a rod group number that will be the rod search group.

User Recommendations

Revise the value of NSERCH to refer to a valid rod group number that also is the group the search will be applied to. For no search, set NSERCH=0 as indicated above.

67022 The boron search flag NBORON is invalid because both rod position search and boron search are specified. Only one search is allowed.

User Recommendations

Either set NSERCH or NBORON to 0 so the remaining nonzero flag will activate the desired search.

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Error Description

67023 The value of the frozen feedback flag given by NFREEZ is invalid. It must be between 1 and 7, or -1 or -2 for reflector regions.

User Recommendations

Review and revise the value to use one of the valid options or turn the frozen feedback option off by setting NFREEZ=0.

67024 The indicated integer edit control flag is invalid. It must be between 0 and 2.

User Recommendations

The integer edit control flags are also included in the CDI file. There is some overlap between input values and those in the CDI file. In general, values specified in the base deck take precedence over values in the CDI file. Revise the input value as necessary to resolve the error.

C.3.21.2 CDI File Related Input Errors

CDI files are generally created by a computer program that combines information from multiple data files. Any CDI file format or content errors that are identified below are generally due to an error in the CDI file creation program, although directions are given for the user to review and revise the content of the CDI file.

Error Description

68001 The symmetry flag value calculated from the CDI file data is invalid. It must be 1, 2, or 4 and it is different from input flag ISYM

User Recommendations

The symmetry flag is calculated based on row and column data specified in the CDI file. Check the input data in the CDI file for row, column and plane data for T-H and neutronics

68002 The normalized flow for all channels given in the CDI file does not sum to 1.0.

User Recommendations

This may require revising the initial channel flows given in the CDA file so they sum to 1.0. In the event that the sum is very close to 1.0, adjust the bypass flow to make normalized flow sum to 1.0.

Error	Description

68003 An end of file was encountered while reading the CDI file for the thermal hydraulic data. The 'CTHD' text header was not found in the CDI file.

User Recommendations

The thermal Hydraulic data is supplied following the 'CTHD' header. It is required when using the CDI file to provide T-H and neutronic data. Review and revise the content of the CDI file as necessary. Check the Programmer's Manual - Volume 2 for more information on content and format of the CDI file (TAPE78).

68004 Multiple fuel geometries are being mapped onto the indicated RETRAN-3D channel. Only one fuel geometry can be mapped into a channel.

User Recommendations

Review and revise the channel fuel geometry specification in the CDI file as necessary.

68005 Multiple volume geometries are mapped onto a single RETRAN-3D channel. Only one volume geometry can be specified for a channel.

User Recommendations

Review and revise the volume geometry specifications in the CDI file so a single geometry is associated with a volume.

68006 Multiple junction geometries are mapped onto a single RETRAN-3D channel. Only one junction geometry can be specified for a channel.

User Recommendations

Review and revise the junction specifications in the CDI file so single junction geometry is associated with a channel.

68007 Multiple leakage path definitions are mapped into a single RETRAN-3D channel. Only one leakage path specifications can be specified for a channel.

User Recommendations

Review and revise the leakage path specifications in the CDI file so single leakage path is associated with a channel.

68008 Multiple water tube geometries are mapped onto a single RETRAN-3D channel. Only one water tube geometry can be specified for one channel.

Error Description

User Recommendations

Review and revise the water tube geometry specifications in the CDI file so single water tube geometry is associated with a channel.

68009 A thermal-hydraulic channel maps to more than one neutronics channel, one to one correspondence is required

User Recommendations

Review and revise the thermal-hydraulics channel map specifications in the CDI file so single thermal-hydraulics channel is associated with a given neutronics channel.

68010 The dynamic gap model is invoked by the channel model, but insufficient gap model descriptions were provided.

User Recommendations

Either modify the CDI file to use only the dynamic gap model descriptions included in the base model or provide additional dynamic gap model descriptions in the base deck.

68011 The values for the number of columns in assembly mesh ID and the number of nodes in X direction for neutronics mesh NCOL specified in the CDI file are inconsistent with the symmetry flag IXSYM for the in X direction.

User Recommendations

Review and revise the CDI file as necessary since ID and NCOL must be equal when IXSYM is for a full assembly.

68012 The values for the number of rows in an assembly mesh JD, the number of nodes in the Y direction for the neutronics mesh NROW and the symmetry flag in the Y direction IYSYM given in the CDI file are inconsistent.

User Recommendations

Review and revise the CDI file as necessary since JD and NROW must be equal when IYSYM is for a full assembly.

68013 Inconsistent data specified in CDI file for planes. The values for the number of planes in the assembly mesh KD and the number of planes in the Z direction for the neutronics mesh NPLN are not equal, but should be.

Error Description

User Recommendations

Current version of RETRAN-3D requires same number of planes on neutronics and assembly mesh.

68014 An error was encountered while reading the CDI file. The indicated keyword was expected, but another was encountered. Incorrect header flag encountered while reading the CDI file

User Recommendations

The CDI file is read sequentially and it requires that data be in fixed order and identified with specific header information, which can be found in the Programmer's Manual - Volume 2. Review and revise the file as necessary.

68015 The limiting range for the power nodes specified in the RETRAN-3D channel model (NYAT1 and NYTA2) are inconsistent with corresponding values (NYLIM1 and NYLIM2) specified in the CDI file.

User Recommendations

Review and revise the values for NYAT1 and NYAT2 as necessary. It is possible that NYLIM1 and NYLIM2 from the CDI file are in error and need to be revised; however, the content of the CDI should be correct in most instances.

68016 The number of rows, columns, and planes obtained from the CDI file and the cross-section file are different, but must be the same.

User Recommendations

Review and revise the values for the number of columns, rows, and planes in the CDI file to match the values in the cross-section file. If the CDI file values are correct, a different cross-section file is required.

68017 The value of NLEAKS in the PARM block of the CDI file is invalid. Allowable values are 1, 2, or 3.

User Recommendations

Review and revise the value of NLEAKS in the CDI file as required to satisfy the requirements above.

Error Description

68018 The value of NLEAKT in the PARM block of the CDI file is invalid. Allowable values range from 1 to 7.

User Recommendations

Review and revise the value of NLEAKT in the CDI file as required to satisfy the requirements above.

68019 The value of EIGUES in the PAR1 block of the CDI file is out of range. It must be > 0.0 and < 2.0.

User Recommendations

Revise the value of EIGUES in the CDI file as required to satisfy the requirements above.

68020 The initial total power POWRIN given in the on PAR1 block of the CDI file is invalid. It must be > 0.0.

User Recommendations

Revise the value of POWRIN in the CDI file as required to satisfy the requirements above.

68021 The flux equation time differencing coefficient THETAF in the PAR1 block of the CDI file must be between 0.5 and 1.0.

User Recommendations

Revise the value of THETAF in the CDI file as required to satisfy the requirements above.

68022 The precursor equation time differencing coefficient THETAP in the PAR1 block of the CDI file must be > 0.0 and < THETAF.

User Recommendations

Revise the value of THETAP in the CDI file as required to satisfy the requirements above.

68023 Based on the value of NLEAKS in the CDI file, the value included for NLEAKT is incorrect.

Error Description

User Recommendations

Review and revise either the value of NLEAKS in the CDI file, or the value of NLEAKT as necessary.

68024 The number of delayed neutron groups NDNEUT in the DIMN block of the CDI file is invalid. There can be no transient solution without delay neutrons. NDNEUT must be > 0.

User Recommendations

Review and revise either the value of NDNEUT in the CDI file to be the desired number of delayed neutron groups (typically 6).

68025 The number of nodes specified for the X, Y or Z direction in CDI file is incorrect.

User Recommendations

Revise the node specification to the correct value.

68026 The dynamic gap model is invoked by the channel model, but not specified for all channels.

User Recommendations

If the dynamic gap model is used it must be used for all channels: otherwise, do not use the dynamic gap model.

C.3.22 CONTROL SYSTEM RELATED INPUT ERRORS

Input errors associated with the control system model are discussed below.

Error Description

70001 The control system solution convergence criteria specified is negative. CNTEPS must be greater than zero.

User Recommendations

If a value on CNTEPS is provided on the control system solution data card, it must be >= 0. If it is omitted or input as 0, the default value will be used.

Error Description

70002 Insufficient control input data cards 702XXX were supplied. When a control system description card 701000 is provided and the number of control inputs NCI is > 0, NCI control input data cards are required

User Recommendations

Either revise the value of NCI to match the number of control inputs defined in the input, or provide the additional control input descriptions so the number of inputs matches the value of NCI.

This error will not occur if the 701000 card is not used or if NCI is set to zero on the 701000 card, in which case the code will determine the value of NCI based on the number of 702XXX cards in the input deck.

70003 Insufficient control block description data cards 703XXX were supplied. When a control system description card 701000 is provided and the number of control block descriptions NCB is > 0, NCB control block description data cards are required

User Recommendations

Either revise the value of NCB to match the number of control block descriptions defined in the input, or provide the additional control block descriptions so the number of control blocks matches the value of NCB.

This error will not occur if the 701000 card is not used or if NCB is set to zero on the 701000 card, in which case the code will determine the value of NCB based on the number of 703XXX cards in the input deck.

70004 An invalid control block type was specified.

User Recommendations

Revise the block type specified to be one of the valid block types. Note that they must be entered as upper case.

70005 The control block is a super block (super max, super min or super sum), but the additional the super block description data card 704XXX specified by the value of IC1 was not found in the input deck. Note that the value of IC1 corresponds to the value of XXX for the corresponding 704XXX data card.

User Recommendations

Add the necessary 704XXX data card or revise the value of IC1 to refer to a card that is included in the input deck.

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Error Description

70006 An incorrect number of data items were provided on the indicated super block data card.

User Recommendations

Revise the data card so the correct number of data items is provided.

70007 Too few data items were provided on the control block data card. At least 8 values are required.

User Recommendations

Add the addition input data to the data card.

70008 The input value of INC1 is invalid. It must be either a valid control input (INC1 > 0) or a valid control block (INC1 < 0).

User Recommendations

Revise the value of INC1 to refer to the desired control input or control block number. If the desired control input or control block is not defined, use the control input description data card 702XXX or control block description data card 703XXX to define the given input. Note: The card number displayed with the error message is not an actual card number but an indication of the type of control card, such as control input or control block. The user may be required to locate the actual card using INC1 or INC2.

70009 The input value of INC2 is invalid. It must be either a valid control input (INC2 > 0) or a valid control block (INC2 < 0).

User Recommendations

Revise the value of INC2 to refer to the desired control input or control block number. If the desired control input or control block is not defined, use the control input description data card 702XXX or control block description data card 703XXX to define the given input. Note: The card number displayed with the error message is not an actual card number but an indication of the type of control card, such as control input or control block. The user may be required to locate the actual card using INC1 or INC2.

70010 The control block specified via CP2 for a variable delay control block is invalid.

User Recommendations

Revise the value of CP2 to refer to a valid control block ID, or if the desired ID has not be defined, define is using a control block description data card 703XXX. Note: The card number displayed with the error message is not an actual card number but an indication of the type of control card, such as control input or control block. The user may be required to locate the actual card using INC1 or INC2.

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Error Description

70011 The general data table specified via INC2 for the function generator does not exist.

User Recommendations

Either revise the value of INC2 to refer to the correct general data table, or define the desired data table using a general data table description data card 12XXYY. Note: The card number displayed with the error message is not an actual card number but an indication of the type of control card, such as control input or control block. The user may be required to locate the actual card using INC1 or INC2.

C.3.23 AUXILIARY DNB MODEL RELATED INPUT ERRORS

Input errors associated with the auxiliary DNB model are discussed below.

Error Description

80001 An incorrect number of data items were supplied for DNB problem dimension data card.

User Recommendations

Add the required input to the DNB problem dimension data card.

80002 N1, on the DNB problem dimension data card, volumes must be specified for the DNB model, but a different number were provided.

User Recommendations

Provide the required number of volumes ordered from the bottom to the top of the core.

80003 The axial power profile must sum to 1.00 but does not.

User Recommendations

Revise the profile values so they sum to 1.00 + or – 0.05.

80004 NOA, on the DNB problem dimension data card, axial power data points are required for the axial power profile, but a different number of data points were provided.

User Recommendations

Either adjust the value of NOA to match the number of axial power profile points supplied or revise the power profile input to provide the indicated number of points.

Error Description

80005 Core volumes must be given in sequence with first volume being bottom of the core and last volume being the top of the core.

User Recommendations

Revise the volumes given such that they satisfy the requirements given above.

C.3.24 PROGRAMMING AND MODEL LIMITATION RELATED ERRORS

Many of the errors discussed below are included to detect and notify code a user that a logic path has been taken that is in error. Most of these errors will require assistance from the maintenance support provider. Other errors are due to code limitations.

Error Description

90001 Space has been allocated for a fixed number of junction chains, but space is required for more chains.

User Recommendations

This is a model limitation.

90002 No junction chains are specified in the input model. At least one chain is required by the matrix solver.

User Recommendations

Specify at least three dummy volumes and two dummy junction connections to form a chain.

90003 Subroutine CONMAT is called with wrong argument. Valid arguments are 1 or 2.

User Recommendations

This is a programming error. Contact the maintenance support provider for assistance.

90004 The array size is not sufficient for the sparse matrix solution. This is a programming error.

User Recommendations

This is a programming error. Contact the maintenance support provider for assistance.

Error Description

90005 No normal (non-time-dependent) volumes are specified in the input model. At least 2 normal volumes are required.

User Recommendations

Specify at least three dummy normal volumes and two dummy junction connections to form a chain.

90006 The number of normal (non-time-dependent) volumes identified in subroutine CONMAT are different than those identified in subroutine CHAIN2.

User Recommendations

This is a programming error. Contact the maintenance support provider for assistance.

90007 An error while opening the trip summary file TRIPSUM on unit is 3. The file may exist as a "read only" file or it may be open (and locked) by another application.

User Recommendations

Make sure that the file does not exist as a "read only" file if it does, remove the file. If it exists, it may be open by another application. This may require closing the file or running the code in a different directory.

90008 Errors were encountered during processing for the 3-D kinetics input. Execution will be terminated.

User Recommendations

Resolve the errors identified in the ERRLOG file.

C.3.25 RESTRT AND REEDIT RELATED INPUT PROCESSING ERRORS

The following error descriptions are for input errors detected while processing input for the RESTRT and REEDIT options.

Error Description

95001 The indicated word is negative, but cannot be.

User Recommendations

Revise the input to satisfy the requirement for the indicated word.

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Error	Description

95002 An incorrect number of data items were supplied.

User Recommendations

Revise the input to supply the correct number of data items.

95003 The RESTRT problem specified too many trip cards. The maximum number of trips that can be supplied is the number of trips supplied with the original problem.

User Recommendations

Revise the input so the number of trip cards provided does not exceed the number of trips used in the original problem.

95004 A generalized RESTRT case is indicated by the value of IRTYP on the problem control and description data card, but no generalized restart cards were provided.

User Recommendations

If the intension was to run a generalized restart problem, supply the generalized restart deck following the case terminator (/) for the base restart deck. Otherwise, revise the value of IRTYP to 0 or omit it from the problem control and description data card.

95005 The heat transfer map option flag IHTMAP on the original problem control and description data card cannot be changed during a generalized RESTRT run.

User Recommendations

Either remove the problem control and description data card 01000Y from the generalized restart input, or revise the value of the IHTMAP flag to match the original problem.

95006 For a generalized restart, the matrix solution option NUMRCS cannot be changed from the value used for the original run.

User Recommendations

Either remove the problem control and description data card 01000Y from the generalized restart input, or revise the value of the NUMRCS flag to match the original problem.

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Error Description

95007 For a generalized restart, the Purdue iterative thermal-hydraulics solver option ITHSLV cannot be changed from the value used for the original run.

User Recommendations

Either remove the problem control and description data card 01000Y from the generalized restart input, or revise the value of the ITHSLV flag to match the original problem.

95008 A generalized restart case is indicated based on the value of IRTYP on the problem control and description data cards, but not enough space is available to store generalized restart input.

User Recommendations

The length of the array used to store the generalized restart input file (the original input plus the generalized restart input that serve as replacement cards) is inadequate. This is a code limitation. If large data tables have be added, it might be possible to eliminate the error by reducing their size. Otherwise, contact the maintenance support provider.

95009 The problem dimension input on the original and generalized restart input is different. Both cases must specify either long format input or short format input but not mixed input for the problem dimension card.

User Recommendations

Modify the restart input for generalized restart and change problem dimension input format (long or short) to match original problem input.

95010 An error occurred while opening the restart file for writing. Additional information is edited about file unit, block lengths, and I/O status.

User Recommendations

The file may be open for use by another program or the file may have a read-only attribute. The I/O status flag gives the cause of the error. The flag values differ between compiler vendors, so it may be necessary to contact your IT support. The maintenance support provider may be able to provide assistance.

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Error	Description

95011 Error writing a record to the RESTRT file. Either the file is not opened correctly i.e., with write privileges or inadequate space is available to write RESTRT file. This error may occur while writing RESTRT header records, data records or trailer records. Additional information about record numbers, block lengths, block name, and I/O status may be helpful in resolving the error

User Recommendations

The file may be open for use by another program or the file may have a read-only attribute. The I/O status flag gives the cause of the error. The flag values differ between compiler vendors, so it may be necessary to contact your IT support. The maintenance support provider may be able to provide assistance.

95012 An error was encountered while inquiring about the RESTRT file's status.

User Recommendations

The I/O status flag gives the cause of the error. The flag values differ between compiler vendors, so it may be necessary to contact your IT support. The maintenance support provider may be able to provide assistance.

95013 An error occurred while opening a restart file for reading. Additional information is edited about file unit, block lengths, and I/O status.

User Recommendations

The cause for this error may be that the file is already open by another application or the file does not. The I/O status flag gives the cause of the error. The flag values differ between compiler vendors, so it may be necessary to contact your IT support. The maintenance support provider may be able to provide assistance.

95014 An end-of-file was encountered while reading the restart file. This error also occurs when trying to access more data than is available on the RESTRT file. Additional information edited may provide more help in resolving this error

User Recommendations

This error may indicate that the original problem was run on a different version of RETRAN-3D than is being used for the restart problem and the restart file content has changed. If this is the case, run the restart using that same code version as was used create the restart file.

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Error Description

It is also possible that the restart file has been corrupted and has a bad record. Try restarting a record earlier to see if the error goes away. If restarting earlier doesn't satisfy your needs, recreate the record that is needed by restarting earlier and recreate a restart file that covers the period past where the desired restart record is. Then retry the original restart with the new restart file.

95015 The header record read from the RESTRT file indicates that this file is not a RETRAN-3D RESTRT file.

User Recommendations

Check to make sure that the file supplied as a restart file is actually a RETRAN-3D restart file and that is has not been over written by another application. Restart files are binary, making it difficult to view their contents with text editors. Some additional information is edited to help identify the content of the restart file.

95016 The first 16 characters of the title card provided with the RESTRT input file do not match those for the title obtained from the RESTRT file.

User Recommendations

Revise the first 16 characters of the RESTRT title card so they match those for the original problem title.

95017 An error was encountered while reading a RESTRT file. This error may occur while reading RESTRT header records, restart records or trailer records. Additional information about record numbers, block lengths, block name, and I/O status may be helpful in resolving the error

User Recommendations

The file may be open for use by another program or the file may have a read-only attribute. The I/O status flag gives the cause of the error. The flag values differ between compiler vendors, so it may be necessary to contact your IT support. The maintenance support provider may be able to provide assistance.

95018 The restart file trailer label was encountered while attempting to read a data record. This error can occur when the RESTRT file is not compatible with current RETRAN-3D version.

User Recommendations

Insure that the restart file is compatible with the version of RETRAN-3D being used for the RESTRT run. If it is, it may be necessary to contact the maintenance support provider.

Error Description

95019 A block mismatch occurred while reading the RESTRT file. This indicates that the RESTRT file was created with code version with a different restart file structure.

User Recommendations

A restart file for the current version will have to be used, or use the code version that was used to create the restart file

95020 An incorrect number of data items were specified in the problem control and description data card for REEDIT.

User Recommendations

Four data items must be specified on the 010001 data card for a REEDIT problem.

95021 The number of edit frequency data cards NEDF is invalid. It must be >= 1.

User Recommendations

Revise the value of NEDF so it satisfies the requirement given above. Note that NEDF edit frequency data cards 03XXX0 must also be provided.

95022 The beginning record number for the first edit NRREC is invalid. It must be >= 0.

User Recommendations

Revise the value of NRREC so it satisfies the requirement given above. Time = 0.0 corresponds to restart record 1. If NRREC is omitted or entered as 0, it defaults to 1. The record number corresponding to a given major edit time is listed in the original problem output.

95023 The edit interval end times specified on the edit frequency cards 03XXX0 are not in ascending order.

User Recommendations

Revise the end times on the edit frequency data cards so they are in ascending order.

95024 Revised input is provided for trip ID, which is already activated.

User Recommendations

Either remove the revised trip data for the indicated trip, or change the restart record to an earlier time so the trip is not activated.

Error	Description

95025 There is a mismatch between the data specified in the RESTRT deck and original input deck for the given trip ID. The input signal IDSIG, and the monitored values IX1 and IX2 in the RESTRT deck must match the trip data in the original deck.

User Recommendations

Revise the restart input to match the original input. The values that can be changed are the signal setpoint, delay time, and alphanumeric trip label.

C.4 MEMORY ALLOCATION ERROR MESSAGES

When the memory allocation routines detect an error condition while allocating or deallocating space for pointers and/or arrays, a status flag is returned that indicates the cause of the error. The value of the status flag is dependent on the compiler used to create the executable program. Four separate errors pertaining to memory allocation are described below.

The corrective action for all of the memory allocation errors is to contact the RETRAN-3D maintenance support provider for assistance.

Error	Description

100 An error occurred while allocating memory for the specified array. The error can occur while allocating real, integer or logical arrays. The information regarding the module name, subroutine name, length of array, compiler status error number, array name etc are displayed. A detail compiler status error number description can be obtained from compiler guidelines for the Fortran compiler used for your installation.

Some of the errors could be due to allocating an array already allocated or it may be due to insufficient space.

101 The size of an array specified for allocation is either zero or less than zero. Current compiler configuration does not allow allocating zero size arrays. Also size cannot be negative. The printed error description includes the array name and type, subroutine name and associated module name. These may aid the maintenance support provider in investigating and identifying the cause of the error.

102 This error is probably due to a programming error. Some related memory allocations are divided across several routines as per the input processing scheme. For these, the first set of arrays must be allocated and data stored in these arrays. Based on data stored in the first set of arrays, the second set of arrays is allocated when a subsequent allocation routine is called. This error will occur if the second or dependent allocation routine is called before the first allocation routine is called.

Error	Description
103	An error occurred while deallocating an array. This error occurs when attempting to deallocate an array that currently is not allocated. The subroutine name, module name, and value of the status flag help in evaluating the cause of the error.

C.5 TRANSIENT SOLUTION-RELATED ERRORS

Error messages that occur in the RETRAN-3D transient solution scheme have been revised. They have been grouped into one of the following eight categories.

100	Numerical Solution
200	Pressure Search Failure
300	Model Limitation
400	Heat Transfer
500	Kinetics
600	Utility Routine or Problem Control

Each error is assigned a unique error number within the category. This information is written to both the standard output file and an error log file. In some instances additional information is also written that will help aid the user in diagnosing the problem. Each unique error number is associated with a description of the situation or conditions that cause the error, along with recommendations that can be used to mitigate or avoid the error in the future. The summary of individual errors is present below for each category.

C.5.1 NUMERICAL SOLUTION FAILURES

The following errors result from one of the many numerical solution algorithms failing to converge. Another cause occurs when the solution converges but the conditions are not consistent with the model assumptions.

Error	Description
101	The computed junction enthalpy is outside the range of 0.0 to 2000 Btu/lbm. There are a number of potential causes for this error. Some may be due to model limitations, while others may be due to modeling options that are used. In general, the junction enthalpy will be a function of the donor volume enthalpy, but it can be somewhat different depending on the junction enthalpy model used.

Error Description

User Recommendations

1. To determine the cause of the problem, identify the model used to define the junction enthalpy. This can be pure donor, enthalpy transport, bubble rise, temperature transport delay, or method characteristics. Next determine if flow reversals are occurring. The 'Descriptive Information" printed with the error message should indicate if the flow reversed during the failed time-step advancement. You may need to look at detailed printed edits or plots of the problematic junction to determine if the behavior is reasonable prior to the failure. The behavior may give you a clue as to the cause of the problem. Flow reversals can introduce significant nonlinearities into the solution, particularly for the enthalpy transport and bubble rise volumes.

2. If the enthalpy transport model is used, the junction enthalpy error may be to due flow reversals. If this is the case, try deactivating the enthalpy transport model either on a time trip or when a flow reversal occurs.

3. Examine the behavior of the upstream and downstream volume to determine if their behavior is the direct cause of the error. For example, the enthalpy in the donor may be approaching either the upper or lower limit of the range of applicability. When this value is adjusted according to the particular junction model being used, the junction value goes out of range. If this is the case, determine why the volume enthalpy is behaving as it is, e.g., are the heat sources and sinks reasonable, or are there some incorrect boundary conditions being applied.

4. Another possible solution to the problem is to reduce the maximum time-step size prior to the time when the error occurs.

102 The flow reversal time-step selection algorithm computed a time-step size smaller than the minimum value allowed. Examine the results to determine if the flow reversal(s) are physically realistic. There are situation where some of the junction enthalpy models can introduce significant nonlinear behavior. For example, as a level passes through a junction connected to a bubble rise volume, there can be step changes in the enthalpy that range from saturated liquid to saturated vapor. These nonlinear changes can introduce flow reversals.

User Recommendations

1. If the flow reversal is associated with a bubble rise volume and there are step changes in the junction enthalpy, try smoothing the enthalpy by revising the modeling to use overlapped volumes with vertically distributed junctions located at the center of the overlapped region.

Error Description

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2. Flow reversals due to changes in the pressure gradient, which can be affected by convective energy transfer or by mass transfer. There are a number of things that can affect mass and energy transfer. They include slip models, interphase mass and energy exchange models and boundary conditions. Examine the detailed behavior in the vicinity of the junction where the failure occurred to determine if a particularly model is responsible for the error.

3. Reducing the time-step size prior to the time when the problem occurs might help; however, there is generally something else that is the direct cause.

103 No longer used - available for future use.

104 This error occurred while the pressure was being determined for the indicated volume. The code took and invalid path in subroutine PRESUR that skipped all of the legitimate pressure search options. Variables used to control the logic flow probably have been corrupted by an earlier (and possibly undetected) code error.

User Recommendations

The probability of encountering this error should be very small. If it is encountered, contact the appropriate code maintenance support organization.

105 A failure occurred in the iterative solution scheme time-step size selection. The time-step size was reduced to a value smaller than the minimum allowed value. This error is indirectly caused by one of the time-step size selection algorithms that initiates an advancement at half of the current time-step size.

User Recommendations

See the error description and corresponding recommendations for the preceding pressure search failure.

106 The enthalpy transport model computed a junction enthalpy that is outside the range 0.0 to 2000.0 Btu/lbm.

User Recommendations

This error is typically due to flow reversals in junctions connect to the volumes associated with the problematic junction. Try turning the enthalpy transport model off using either the enthalpy transport deactivation card 080000.

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Error Description

107 The control system numerical solution scheme failed to converge. This error is generally caused by feedback loops. A Gauss-Seidel iterative scheme is used to solve the coupled system of equations and the feedback loops cause the system of equations to be nondiagonally dominant. This leads the solution failing to converge.

User Recommendations

1. In some instances, it is possible to increase the number of iterations used by the Gauss-Seidel scheme. This is done on the 701000 data card.

2. Another approach to resolve the problem requires modification of the control system model. Rather than connecting downstream signals directly to the feedback input, use an input signal that is connected to the output for the block, e.g., COUT -xxx. This will hold the feedback at the old time level and greatly improve the convergence for the solution scheme.

C.5.2 PRESSURE SEARCH FAILURES

The following errors result from one of the many pressure search algorithms failing to converge, or the search converges but the conditions are not consistent with the model assumptions.

Error Description

202 An accumulator volume pressure search failed to converge. The error was the result of the pressure failing to converge in the allowed number of iterations. This error will only be encountered if the fixed time-step size option (noniterative solution) is being used.

User Recommendations

See User Recommendations for Error 201.

203 An accumulator volume pressure search converged, but the liquid region enthalpy exceeds the saturated liquid enthalpy at the total pressure. The accumulator pressure model assumes that the liquid will remain subcooled. This error will only be encountered if the fixed time-step size option (noniterative solution) is being used.

User Recommendations

See User Recommendations for Error 201.

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Error	Description

204 A two-region nonequilibrium volume (pressurizer or separator) pressure search failed to converge. The particular error was the result of the liquid region volume not converging during the outer iteration of the pressure solution where the liquid volume is determined. This error is only encountered when the explicit form of the pressurizer solution is used. When this error is encountered, the pressurizer should be filling or emptying. The normalized liquid region volume will indicate if the volume is emptying (~0) or filling (~1).

User Recommendations

1. It might be possible to eliminate this error by using a smaller time-step size during the time period where the volume empties or fills.

2. An alternate approach would be to use the implicit pressurizer solution rather that the explicit form.

3. Determine if there are any control actions occurring at or just prior to the failure, or control actions that should occur but aren't happening that might be causing the failure. An example would be pressurizer heaters remaining on when there is very little liquid present in the volume. Correct any improper control behavior that might be affecting the failure.

205 A two-region nonequilibrium volume (pressurizer or separator) pressure search failed to converge. A pressure solution was not obtained for the given region mass and energy values. The energy values are approximate, since the liquid volume has not converged at this point. This error is only encountered when the explicit form of the pressurizer solution is used. When this error is encountered, the volume should be draining or filling. The normalized liquid region volume will indicate if the volume is draining or filling (~0 or ~1).

User Recommendations

It might be possible to eliminate this error by using a smaller time-step size during the time period where the pressurizer empties or fills.

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Error	Description

206 A two-region nonequilibrium volume (pressurizer or separator) pressure search failed to converge. This error is only encountered when the implicit form of the pressurizer solution is used. When this error is encountered, the volume should be emptying or filling. The normalized liquid region volume will indicate if the volume is emptying or filling (~0 or ~1).

User Recommendations

It might be possible to eliminate this error by using a smaller time-step size during the time period where the volume empties or fills.

207 A failure occurred while attempting to evaluate the saturation properties for a two-region nonequilibrium volume. This error is the result of using a bad pressure or quality to evaluate the saturation properties. It generally will occur as the result of a pressure that exceeds the critical point or is less than the lower range of the water property curve fits.

User Recommendations

1. This error may result from a previous pressure search error for this control volume. Examine the error log for a prior and related error.

2. If the error is not related to a prior error, there may be a coding error.

208 A failure occurred while attempting to evaluate the homogeneous equilibrium model derivatives for use in the explicit solution for a two-region nonequilibrium volume.

User Recommendations

1. Notify the code maintenance organization if you encounter this error.

2. The error might be avoided by revising the time-step size for the period prior to the occurrence of the error.

209 A failure occurred while evaluating the water properties for a time-dependent volume (TDV) using a pressure enthalpy equation of state call. Either the pressure or enthalpy (or both) are outside the range of the water property curve fits.

User Recommendations

This error typically occurs as the result of an error in the input conditions, or those computed by interpolating data input by the user. Check the tabular TDV data being used for this volume.

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Error Description

210 A failure occurred while evaluating the saturation properties for a time-dependent volume (TDV). The pressure is outside the range of the saturation property curve fits.

User Recommendations

This error can occur when the pressure exceeds the critical point, but the TDV data indicates that the mixture level ZM is >0 and < ZVOL, where ZVOL is the volume height. Check the tabular TDV data being used for this volume.

211 The fluid properties for a time-dependent volume (TDV) indicate that the volume is either single-phase liquid or single-phase vapor, while the mixture level ZM is >0 and <ZVOL (ZVOL is the volume height), indicating two-phase fluid conditions.

User Recommendations

This error is typically due to errors in either the specification data for the fluid properties or the mixture level Check the tabular TDV data being used for this volume.

212 The fluid properties for a time-dependent volume (TDV) indicate that the volume is either single-phase liquid or single-phase vapor, while the mixture level ZM is >0 and <ZVOL (ZVOL is the volume height). Such a mixture level specification requires two-phase fluid conditions.

User Recommendations

This error is typically due to errors in either the specification data for the fluid properties or the mixture level. Check the tabular TDV data being used for this volume. The Programmer's Information section of the error message includes an enthalpy or mixture level that should eliminate the problem. Revise the input with one or the other value (not both).

213 An error occurred while evaluating the fluid properties for a time-dependent volume (TDV). The saturation temperature and quality are defined by control systems and one or both are outside the allowable ranges, (33 < Tsat < 714.36) and (0 < X < 1).

User Recommendations

The saturation temperature and quality are included in the error message. Identify the offending parameter and make the necessary changes to the appropriate control system so the parameter is kept in the valid range.

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Error Description

214 An error occurred while evaluating the fluid properties for a time-dependent volume (TDV). The saturation pressure and quality are defined by control systems and one or both are outside the allowable ranges, (0.1 < Psat < 3208.2) and (0 < X < 1).

User Recommendations

The saturation pressure and quality are included in the error message. Identify the offending parameter and make the necessary changes to the appropriate control system so the parameter is kept in the valid range.

215 An error occurred while evaluating the fluid properties for a time-dependent volume (TDV). The pressure and temperature for single-phase conditions are defined by control systems. The pair of values does not define a single-phase liquid of vapor state.

User Recommendations

The pressure and temperature are included in the error message. Identify the offending parameter(s) and make the necessary changes to the control system(s) so the parameters are kept in the valid range for single-phase liquid or vapor.

216 The homogeneous equilibrium pressure search for water failed to converge. The mixture mass and energy do not allow a valid pressure to be determined.

User Recommendations

1. When using the fixed time-step size option (NCHK=1), this error generally indicates that the time-step size needs to be reduced. You will generally have fewer failures using the iterative time-step control option (NCHK=0)

2. If the failure occurred when the volume crossed from two-phase to single-phase liquid conditions, the error may be due to water packing. Re-run of restart with a different time-step size. In some instances, a larger time-step size will avoid the water packing failure. Others may require a smaller time-step size.

3. When the iterative time-step control option is used, the code will attempt to adjust time-step size to avoid code failures. In some instances, water packing may occur, but the code will not fail. On subsequent time advancements, the pressure will try to increase because of the inertial affects of the flow. The result is that the code fails subsequently as the pressure exceeds the upper limit. Reducing (or increasing) the maximum time-step size, will generally avoid the error.

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Error	Description

217 The homogeneous equilibrium pressure search for a water/noncondensable gas volume failed to converge. The pressure cannot be determined uniquely from the mixture mass and energy, and noncondensable gas mass inventories.

User Recommendations

1. When using the fixed time-step size option (NCHK=1), this error generally indicates that the time-step size needs to be reduced. You will generally have fewer failures using the iterative time-step control option (NCHK=0).

2. If using the iterative time-step control option (NCHK=0), try reducing the maximum time-step size for a period of time prior to the failure.

218 A negative mass or energy indicates that the numerical solution has produced anomalous results. A pressure solution is not possible for this condition so a failure occurs.

User Recommendations

This is generally corrected by reducing the time-step size prior to the time where the error occurs. You may want to subsequently perform a time-step sensitivity study by running cases with reduced time-step sizes to ensure that the solution is converged.

219 The pressure search for the five-equation model (constrained nonequilibrium) failed to converge to a valid pressure solution.

User Recommendations

See User Recommendations for Error 217.

220 The pressure search for the six-equation model failed to converge to a valid pressure solution. This option currently is not available.

User Recommendations

See User Recommendations for Error 217.

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Error Description

221 The pressure for the appropriate pressure equation of state converged to a solution that is beyond the range of the water property functions. For a low pressure, the mass, energy, or both are too low. For a high pressure, the mass, energy, or both are too high. These can be caused by model problems or code errors.

User Recommendations

1. Obtain more detailed output edits prior to the failure. Determine if the pressure is changing continuously over a number of time-step advancements rather than in a single time-step advancement.

2. If the change occurs over a single (1 to 3) time step, reducing the maximum time-step size for a short period prior to the failure may help resolve the error.

3. If the change is over many time steps, the error is probably related to one of the situations discussed below.

4. In some instances, user models may be causing the mass and/or energy in the volume to deplete or pack. Examine junctions, heat conductors, and nonconducting heat exchangers and determine if their behavior is causing the problem. Make any necessary modifications to the model to resolve problem.

5. For more complicated modeling, e.g., use of two-region nonequilibrium or five-equation options in the offending volume, examine the interregion or interphase mass and energy exchange rates to determine if they might be causing the problem. It may be possible to modify model parameters or option use to resolve the problem.

6. In some instances, this error may be due to a code error or model limitation. If you think this might be the case, please contact the organization responsible for performing code maintenance.

C.5.3 Model Limitation Failures

The following errors result from model limitations that are encountered during execution of RETRAN-3D problems. These errors often occur when the range of conditions or duration of a simulation are changed and the new conditions take the model outside its limited range of applicability.

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Error Description

301 An error occurred while evaluating the choked mass flow rate using the choking model requested by the user. The specified choking model is indicated in the error message. This error will only be encountered if the fixed time-step size option (noniterative solution) is being used.

User Recommendations

1. This error is encountered when either the Moody or Extended-Henry models are used. Generally, the stagnation pressure and enthalpy used to evaluate the critical flow are correct, but they are outside the function (table) boundaries. First examine your problem to see is choking should be allowed in the offending junction. If not, turn choking off. Otherwise, select a choking model that has a wider range of applicability. The isentropic expansion homogeneous expansion model (HEM) is recommended.

2. Reducing the time-step size generally will not eliminate this error, especially when using the iterative solution scheme where an error condition for a time step less that the minimum allowed value will usually terminate problems that encounter pressures or enthalpies outside the boundary of the functional fits (tables).

302 An error occurred while preparing to evaluate the water properties for the indicated fill boundary condition. The fill table either contains an enthalpy value that is outside the valid range, or extrapolation is allowed and the extrapolated value is out of range.

User Recommendations

This error is eliminated by revising the fill table to contain valid values or by changing it so extrapolated values will remain in the valid range.

303 An error occurred while preparing to evaluate the water properties for the fill identified. The fill table either contains a pressure value that is outside the valid range, or extrapolation is allowed and the extrapolated value is out of range.

User Recommendations

This error is eliminated by revising the fill table to contain valid values or by changing it so extrapolated values will remain in the valid range.

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Error Description

304 The error occurred during steady-state initialization. It resulted from the use of an input option that is not valid for steady-state initialization. For steady-state initialization, any fills that are active at time zero must specify a fixed flow rate (or mass flux), not a volumetric flow (GPM). The mass flow is a function of the upstream volume enthalpy and pressure for a negative fill that uses the volumetric flow option because it is affected by the density.

User Recommendations

Use one of the input options for the negative fill that specifies a fixed mass flow rate or flux to eliminate the error.

305 The error occurred while evaluating the junction enthalpy using the enthalpy transport model. The computed enthalpy is either less than or equal to zero or greater than 2000 Btu/lbm. This situation can be cause by flow reversals or an anomalous slip velocity.

User Recommendations

1. When it appears that the error is caused by flow reversals in the offending junction, or junctions adjacent to the offending junction, it may be necessary to use the enthalpy transport deactivation option (card 080000) to turn enthalpy transport off before the error is encountered.

2. A less probable cause can be a bad energy source term resulting from the kinetic and or heat transfer model. If there is an anomalous reactivity insertion, the resulting power increase can vaporize all liquid and lead to excessively superheated vapor. If this appears to be the cause, check the reactivity insertion to see if it is in error. If it is correct, this may be a situation where smaller time steps will resolve the problem. If they don't, try deactivating enthalpy transport as described above.

3. In some situations where the enthalpy transport model may be applied, such as bypass volumes where the heat addition has a small affect on the junction enthalpy, the model can be turned off without significantly affecting the results. This will avoid problems that can occur when flows reverse.

306 The error occurred in the generalized transport model. The junction mixing efficiency was computed by a control system, which returned a negative efficiency. The offending control block is identified in the error message.

User Recommendations

Examine the control system that is identified in the error message and make the necessary changes to prevent calculation of negative efficiencies.

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Error Description

307 The error occurred in the generalized transport model. The junction concentration was computed by a control system, which returned a negative concentration. The offending control block is identified in the error message.

User Recommendations

Examine the control system that is identified in the error message and make the necessary changes to prevent calculation of negative concentrations.

308 The iteration numerical solution scheme used by the generalized transport model failed to converge.

User Recommendations

1. Examine the efficiencies and/or concentrations provided to the model as boundary conditions to see if they are changing rapidly. If they are, is the behavior correct. If not, correct the behavior.

2. If there doesn't appear to be a problem with the boundary conditions, try using a smaller maximum time-step size during the period where the solution failed to converge.

309 The generalized transport model failed due to a negative impurity mass being computed for a control volume. .

User Recommendations

See User Recommendations for Error 308.

310 A centrifugal pump has reversed but the model option to prevent reversal is active. This is probably due to a code error.

User Recommendations

An alternative would be to use a pump speed versus time boundary condition for the offending pump.

Error Description

311 The pump performance curves for the centrifugal pump model were not supplied for all four quadrants. During the transient simulation, the pump speed/flow characteristics moved to a quadrant for which curves were not supplied.

User Recommendations

1. Examine the pump flow and speed response to determine if it is reasonable for the transient being simulated. This will allow you to determine if the pump should be in the undefined quadrant. There may be something wrong with the simulation that results in the error.

2. If the simulation appears to be correct, you will need to add the pump head and/or flow characteristics for the undefined quadrant that is causing the error condition.

312 An error occurred in the control system model where a referenced block is not a valid control block type. Block types are checked during the input processing, so this error is probably due to a code error.

User Recommendations

Check to make sure that the indicated control block was specified as a valid control block type. Contact technical support if the control block type is valid.

313 The divisor for the identified division control block is zero. This error is trapped to prevent an overflow error.

User Recommendations

Modify the input associated with the block that provides the divisor signal to insure that a zero output value is not allowed.

314 The input for the identified logarithm control block is less than or equal to zero. This error is trapped to prevent a FORTRAN math error.

User Recommendations

Modify the input associated with the block that provides the signal to the logarithm block to insure that a zero or negative output value is not allowed.

Error Description

315 The calculated value for junction inertia is less than or equal to zero. This error is trapped to prevent anomalous results.

User Recommendations

Check the control block used to calculate the junction inertia to insure that a zero or negative value is not allowed.

316 An intermediate term used to evaluate the junction enthalpy for the enthalpy transport model is less than 0 and in used as an argument to the Log function. There is a low probability of encountering this error. It may be due to a bad estimate of the junction enthalpy (prior to applying the enthalpy transport correction) or the pressure may be approaching the critical point.

User Recommendations

There are several possible corrections. The error could be caused by a poor solution due to a time-step size that is too large. If the junction flows in the vicinity of the error are oscillating or changing rapidly, using a small time-step size for the affected time period may resolve the problem.

Otherwise, it may be necessary to turn enthalpy transport off at the time (or just before) the error occurs. This can be done in either a RETRAN-3D or RESTRT-3D run using the enthalpy transport deactivation data card 080000 discussed in Section IV.8.4 of the User's Manual – Volume 3.

C.5.4 HEAT TRANSFER SOLUTION FAILURES

The following errors result from one of the many heat transfer correlations that use numerical solution algorithms to iteratively solve for the wall heat flux and surface temperature simultaneously.

Error Description

401 The failure occurred while evaluating fluid properties used to evaluate the particular heat transfer correlation. A pressure/temperature entry to the water properties was used. The resulting error is the result of either the pressure/temperature entry giving a two-phase condition or the resulting single-phase condition is out of range for the water property routines.

Error Description

User Recommendations

1. A bad temperature is often the cause of this error. The temperature is equal to the previous surface temperature for the heat conductor. When this error condition occurs due to a bad temperature, the code might have run beyond the range of applicability for the heat transfer correlation. The cause can be due to a bad heat generation rate, or it might be due to inadequate cooling. In the later case, the simulation may have reached the limit of applicability.

2. If the temperature appears to be reasonable, but the pressure is not, the cause of the error may be due to something other than the heat generation rate or cooling. A problem with the pressure search or something that has a detrimental affect on the pressure could be the cause. Try to identify the cause of the bad pressure. Often, using smaller time-step sizes will mitigate problems with the pressure solution.

3. As a last resort, you may be able to select use of an alternate heat transfer correlation that will not encounter this error.

4. Another alternative is to try using a smaller time-step size.

402 The iterative solution of the heat conduction and surface heat transfer equations failed to converge in the maximum number of iterations allowed. For some correlations, the material properties use to evaluate the heat transfer correlation are a function of the surface temperature. Rapid changes or discontinuities in these properties due to changes in the surface temperature can lead to nonconvergence.

User Recommendations

1. Examine the results just prior to the failure to determine if the surface temperature is being driven by a poor heat generation rate. If so, correct the cause of that problem.

2. There may be rapid changes in heat transfer, including regime changes. Use of smaller time-step sizes during the period when the error occurs might mitigate the problem.

3. There may be an alternate heat transfer correlation that could be used to avoid the error condition.

Error Description

403 The failure occurred while evaluating fluid properties used to evaluate the particular heat transfer correlation. A pressure/enthalpy entry to the water properties was used. The resulting error occurred because one of the input values was out of range for the water property routines.

User Recommendations

1. A bad enthalpy is often the cause of this error. The enthalpy is a function of the wall surface temperature for the heat conductor being evaluated. When this error condition occurs due to a bad enthalpy, the code might have run beyond the range of applicability for the heat transfer correlation. The cause can be due to a bad heat generation rate, or it might be due to inadequate cooling. In the later case, the simulation may have reached the limit of applicability.

2. If the enthalpy appears to be reasonable, but the pressure is not, the cause of the error may be due to something other than the heat generation rate or cooling. A problem with the pressure search or something that has a detrimental affect on the pressure could be the cause. Try to identify the cause of the bad pressure. Often, using smaller time-step sizes will mitigate problems with the pressure solution.

3. You may be able to select use of an alternate heat transfer correlation that will not encounter this error.

4. Another alternative is to try using a smaller time-step size.

404 The iterative solution of the heat conduction and surface heat transfer equations failed to converge in the maximum number of iterations allowed. This particular correlation also solves for the interfacial temperature, which is a function of the local concentration of noncondensable gas. The material properties use to evaluate the heat transfer correlation are a function of the interfacial temperature. Rapid changes or discontinuities in these properties due to changes in the interfacial temperature can lead to nonconvergence.

User Recommendations

1. Examine the results just prior to the failure to determine if the surface temperature is being driven by a poor heat generation rate. If so, correct the cause of that problem.

2. There may be rapid changes in heat transfer, including regime changes. Use of smaller time-step sizes during the period when the error occurs might mitigate the problem.

Error	Description
405	Surface temperatures less than 0.0 were obtained for heat transfer modes 25 and 28. This is likely due to a code error. Please contact the organization responsible for code maintenance.

C.5.5 KINETICS MODEL FAILURES

The following errors result from one of reactor kinetics models used by RETRAN-3D. The error descriptions identify the particular model where the failure occurred and additional information will identify parameters that may be in error.

Error	Description
501	The Runga-Kutta numerical integration scheme used in the point reactor kinetics model failed to converge. User Recommendations This error condition is generally caused by an excessive reactivity insertion rate. Examine the reactivity models, particularly the control reactivity models, to ensure that they are behaving as intended. Correct any incorrect behavior.
502	Failure to open an output file on Unit 6. The error occurs when reduced output is requested. User Recommendations Review the directory where RETRAN-3D is running for file name OUTPUT and verify it is not opened by any other program.

C.5.6 UTILITY ROUTINE AND PROBLEM CONTROL FAILURES

The following errors result from one of the utility subroutines or problem control functions used by RETRAN-3D. The error descriptions identify the model or control function where the failure occurred and additional information will identify specific parameters that may be in error.

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Error Description

601 An error occurred in subroutine POLATE while performing linear interpolation. The error is due to the independent variable being outside the boundaries of the table. For this error to occur, the table use must have precluded use of extrapolation. Errors of this type are associated with the valve model. Function CHKV is identified as is the specific function being performed, e.g., interpolation of a "VALVE CLOSING" table, when the call to subroutine POLATE failed. Detailed information is provided as part of the error message to allow the specific table to be identified.

User Recommendations

Examine the value of the independent variable included with the error message. Identify the variable that it represents by distinguishing the table on which interpolation was being performed. If the value of the independent variable is not physically reasonable, try to identify what might be causing it to be so. The independent variable will generally be time, but it can also be area, or angle. When time is the independent variable, the error generally indicates that the range of the associated table is inadequate. An inadequate range is also indicated for area and angle independent variable tables. Identify the offending table and extend the range.

602 An error occurred in subroutine POLATE while performing linear interpolation for a model (not a valve). The error is due to the independent variable being outside the boundaries of the table. For this error to occur, the table use must have precluded use of extrapolation. The offending table can be either a user-supplied or built-in table. The subroutine that called POLATE is identified as is the specific function being performed, e.g., interpolation of a "VOLUMETRIC HEAT CAPACITY -- MATERIAL = IIII" table. Detailed information is provided as part of the error message to allow the specific table to be identified.

User Recommendations

1. Examine the value of the independent variable included with the error message. Identify the variable that it represents by distinguishing the table for which interpolation was being performed. If the value of the independent variable is not physically reasonable, try to identify what might be causing it to be so. Identify the model that is causing the bad value to be computed, and then try to identify what is causing the model to behave poorly. For example, if the independent variable is a heat conductor temperature and it is too large, check to see if the power is reasonable. If it isn't, look at the reactivity or other driving functions.

2. If the value of the independent variable is reasonable, the problem may be with the table. Examine the range of data corresponding to the independent variable to determine if it is adequate for the current problem. You may need to add additional data to the table, or it may be possible to simply allow extrapolation by setting the number of points negative.

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Error Description

3. If the value of the independent variable is reasonable, and the built-in table cannot be extended or replaced, file a trouble report and try to use an alternate way of modeling the situation.

603 An error occurred in subroutine POL2 while performing a two-dimensional linear interpolation for a model. The error is due to one of the independent variables being outside the boundaries of the table. The offending table can be either a user-supplied or built-in table. The subroutine that called POL2 is identified as is the specific function being performed, e.g., interpolation of a "TWO-PHASE FRIC MULT GCB (BUILT-IN) - SUB. TFFM" table. Detailed information is provided as part of the error message to allow the specific table to be identified.

User Recommendations

1. Examine the value of the independent variables included with the error message. Identify the specific variable that it represents by distinguishing the table for which interpolation was being performed. If the value of the independent variable is not physically reasonable, try to identify what might be causing it to be so. Identify the model that is causing the bad value to be computed, and then try to identify what is causing the model to behave poorly. For example, if the independent variable is for a control system 2-D function generator table and it is too large, check to see if the independent variable magnitude is reasonable. If it isn't, look at the behavior of the model that defines it.

2. If the value of the independent variable is reasonable, the problem may be with the table. Examine the range of data corresponding to the independent variables to determine if they are adequate for the current problem. You may need to add additional data points to the table.

3. If the value of the offending independent variable is reasonable, and the built-in table cannot be extended or replaced, file a trouble report and try to use an alternate way of modeling the situation.

604 The problem elapsed (simulation) time exceeds the end time (TLAST) for the final time-step control data set.

User Recommendations

Either extend the end time on the final time-step control data card or add another time-step control card that extends the end time beyond the time at which the problem simulation will be terminated.

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C.6 STEADY-STATE WARNINGS AND FAILURES

Errors and warnings written by the RETRAN-3D steady-state solution scheme are discussed below. The error/warning messages are written to the output file and the ERR_LOG file. They identify the model or control function where the failure occurred. In some instances additional information will identify specific parameters that may be in error. User recommendations provide suggested corrective action to remove the error.

Error Description

801 The bubble velocity is zero for the indicated bubble rise volume. This will prevent separation in the volume and the mixture level will move to the top of the volume and remain there for the duration of the simulation.

This warning is only written if the steady-state solution does not converge on the final iteration, so it is rarely encountered.

User Recommendations

The code calculates the bubble rise velocity to obtain steady-state mass balance for the saturated vapor region above the mixture level. A zero bubble velocity indicates that no bubble mass will move from the mixture region to the vapor region. This warning message indicates the mixture level may change when the transient solution scheme is run, e.g., the level may change from its steady-state value during a null transient used to test the validity of the steady-state solution.

If the bubble mass in the mixture region is zero, there is no vapor to transport to the vapor region. Make revisions to the initial conditions, i.e., the input enthalpy, recirculation flow, or flow splits to increase the quality for the mixture region so vapor is available to flow into the vapor region.

The bubble gradient, whether computed or the input value, affect the partial vapor density at the mixture interface and thus the bubble velocity.

802 The bubble rise constants that were computed by steady-state to ensure mass and energy balances in the bubble rise volumes may result in anomalous behavior for some transient situations.

User Recommendations

The computed constants should be reviewed and engineering judgment exercised before they are used for transient calculations. Note that bubble velocities > ~500.0 will result in essentially all vapor being instantly transported to the vapor region, leaving the mixture region with a very low quality. On the other hand, small velocities, <~.05 will result in limited vapor transport to the vapor region. Consequently, vapor will accumulate in the mixture region, causing the level to swell.

Error Description

The bubble gradient will affect the enthalpy of junctions residing below the mixture level and will also affect vapor transport to the vapor region. Higher gradient values will decrease the affected junction enthalpies, but will increase the vapor transport to the vapor region.

803 The volume pressure for the indicated volume was adjusted during steady-state initialization to match the total flow specified for the flow splits paths.

User Recommendations

When the flow split feature is used and total flow is specified as the core flow boundary condition, the code adjusts the inlet boundary volume pressure to force the total flow to agree with the total core flow given by the sum of the split paths.

The user should review and evaluate the calculated inlet pressure to anticipate its effect on transient.

804 More than one junction resides below the mixture level for the indicated separated volume. This may cause steady-state to not converge for the indicated volume. This warning is only written if the steady-state solution does not converge on the final iteration, so it is rarely encountered, but if it is, follow the recommendations below.

User Recommendations

Bubble rise volumes get special treatment by the steady-state initialization feature. The steady-state volume energy equation is solved locally for the bubble rise volume to define the enthalpy of junctions exiting below the mixture level. If these junctions are at different elevations the energy balance may not be satisfied.

If possible, move one or more of the junctions above the mixture level or combine them into a single junction. Otherwise, specifying the enthalpy in the separated volume may resolve convergence problems.

Review the input flow specifications to ensure that negative flow through the junction connected below mixture does not occur, when multiple junctions are connected below the mixture level.

805 The indicated junction uses the vertical junction option (JVERTL=1), but the top or bottom elevation of the circular junction area is outside the region occupied by one or both of the volumes it connects. The region or domain occupied by each volume ranges from ELEV to ELEV+ZVOL. The effective diameter of the junction will be reduced to keep the area within the region occupied by the volume, which can adversely affect the results. Otherwise, follow the recommendations given below.

Error Description

User Recommendations

1. Compare the junction elevation (ZJUN) minus its radius with the elevation (ELEV) of the volume. Also compare ZJUN plus its radius with the elevation (ELEV) plus the height of the volume (ZVOL). Adjust either the junction elevation or the junction hydraulic diameter so the vertical area remains within the bounds of the volume.

2. When a vertically oriented junctions junction is used to smooth the junction enthalpy when a level passes out of an upper volume or when a volume fills the vertical junction must reside within the overlap region created by two connected volumes. Adjust the junction elevation (ZJUN) and/or diameter (DIAMJ) as necessary so that the sum (and difference) of the junction elevation and radius falls within overlapped region common to both volumes.

806 The slip model is limiting the flow in the indicated junction to liquid only because there is no vapor available to the junction. This may cause steady-state to not converge for the affected volumes.

User Recommendations

The first thing to look at is the cause of the single-phase conditions in the liquid only volume. If they are the desired condition, an option is to eliminate slip in the junction using IFRJ=-99 on the junction data card 08XXY.

807 The pressurizer steady-state initialization option is activated, but either the pressurizer heater is not turned on, or the heater capacity is not adequate to overcome the heat losses. The pressurizer initialization may not converge.

User Recommendations

Pressurizer heaters are required and must be turned on during steady state when the pressurizer steady-state initialization option is used. The heater power must be adequate to overcome any heat losses and to flash enough liquid to balance steam condensed on the spray and vessel walls (if heat losses are modeled).

Error Description

808 The calculated control block output is different from the user-supplied value of initial output. Without making adjustments, a null transient may drift because of feedback from a control system that is not initialized to a true steady-state initial condition.

User Recommendations

Depending on the use of the control block elsewhere in the input model, the required action varies. Some corrective action follows.

1. If the block defines an initial condition for steady-state, e.g., a fill mass flow rate or an enthalpy, the gains and/or other constants will need to be adjusted so the calculated value matches the specified initial value.

2. For blocks where the output is not used as an initial condition, the initial output can be changed to the calculated output.

809 An enthalpy has been specified for a two-phase volume that is altered by use of the automatic overlap option (JVERT = 3).

User Recommendations

When the automatic overlap option is used, a volume's height is increased. This can cause problems when the enthalpy is specified by the user because the increase in volume height increases the height of the vapor region since the mixture level is already specified by the user.

The enthalpy calculated by the code should be evaluated by the user to determine its acceptability for a given analysis. If an exact enthalpy is desired for the two-phase volume, a manual overlap and use of the JVERT = 1 option may be required.

900 Steady-state initialization failed during the specified iteration.

User Recommendations

This error message and associated problem termination is a result of previous error message. During steady-state initialization, an error may occur during evaluation of any one of many calculation models.

A previous error message should identify the cause of the problem. Follow the user recommendations for that error.

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Error	Description

901 Unable to reach steady-state convergence within the specified number of iterations.

User Recommendations

Examine the volume and junction data actually being used to identify the volumes and junction that are causing the nonconvergence. If the error is due to a continuity (mass flow) imbalance, an error message will be issued and the problem terminated before the momentum and energy equations are solved. Any volumes and junctions not satisfying the convergence criteria are flagged as not converged.

When steady-state does not converge, the JSST option on the problem description data card 01000Y is useful in turning on output edits for each steady-state iteration. This allows evaluation of what is changing from one iteration to the next.

1. In some instances, increasing the number of steady-state iterations may resolve the error, but generally only when two-phase regions are not converging.

2. If the momentum equation is not converging, also examine the energy equation convergence especially for adjacent volumes with two-phase regions where the hydrostatic head and wall friction are dependent on the enthalpies. If one or both of the volume enthalpies is not converged, try to correct the energy equation errors first.

3. If the enthalpy error is in the volume where the enthalpy is input, this error is the sum of all other enthalpy errors around the loop(s). Consequently, the focus should be on correcting these errors.

4. If one of the errors is in a bubble rise volume, correct this error by increasing the inlet enthalpy. Otherwise revise the steam and recirculation path flow split.

5. When slip is used, two-phase regions may not converge if flow regimes change, or if a boiling boundary changes between iterations. This may require a flow regime to be hardwired, or slightly adjust the input enthalpy to prevent the boiling boundary from moving between volumes.

6. Junctions that do not converge may be due to an under specified system. Review the location of specified enthalpies and loss coefficient that are calculated by steady-state initialization, particularly those that are related to the region that affects the nonconverged junction. It may be necessary to have another loss coefficient computed.

902 For the current use of the bubble rise volume, the enthalpy is calculated to obtain a steady-state energy balance even though the enthalpy was specified. This calculated enthalpy does not match the input enthalpy.

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Error Description

User Recommendations

A local solution of the steady-state volume energy equation is solved for the bubble rise volume, to define the enthalpy of junctions exiting below the mixture level. Using the required junction(s) enthalpy, the volume enthalpy is computed given the bubble gradient.

1. Review the parameters associated with the bubble rise model and related junctions and evaluate if the calculated enthalpy is reasonable. If so, remove the input enthalpy and allow the computed value to be used.

2. Otherwise, make adjustments to the bubble rise model input or related junction input.

903 The calculated pressure for the indicated volume, does not match the input pressure.

User Recommendations

Evaluate the difference between the calculated and input pressure and then determine if the input pressure should be set to the calculated value. Otherwise determine what can be revised to allow the calculated value to be essentially the same as the input value.

904 More steam is flowing into the vapor region of the bubble rise volume than is leaving from junctions residing above the mixture level. This may cause the mixture level to drift during a null transient.

User Recommendations

Review the related input such as the bubble rise model mixture level, the junction elevations and flows and the bubble velocity, which can be affected by the local energy balance. Revise the input as necessary to resolve the error.

905 The pressurizer steady-state solution did not converge in the specified number of iterations.

User Recommendations

The error occurs during separate evaluation of pressurizer steady-state initialization model. The model requires initial flow through pressurizer and heater power to balance mass and energy during steady state.

1. Review thermodynamic initial condition specified for the pressurizer. Initial spray or surgeline flow may be too high to balance by the heater power. Increasing spray/surgeline flow may eliminate the error. Review heater power and revise as applicable.

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Error Description

2. Heat loss through the liquid region may be more than the heater power. Review relevant input data for the pressurizer such as mixture level, bubble velocity, bubble gradient, input pressure, and conductor data if applicable. Review and revise the heater power as applicable

906 The steady-state initialization error occurred while initializing a steam generator. Energy flow is reversed for the specified conductor. It is caused by the primary-side temperature being lower than the secondary-side temperature.

User Recommendations

Energy flow from secondary side to primary side is not appropriate for steady state. If the maximum number of steady-state iterations, LCOUNT specified on steady state convergence data cards 230000 is negative, a warning is issued instead of an error and the problem continues with the transient.

The overall temperature or enthalpy change from the inlet to exit of the steam generator is known. However, the change associated with each volume is not known and here the heat transfer process is used to obtain the individual changes. The sum of these changes generally does not equal the overall change, so the heat conductor areas are adjusted. For full power situations, slight error in the actual heat transfer does not result in the primary temperature being less than that for the secondary. However, for low power cases, slight errors cause the primary temperature to drop below that for the secondary side, which then gives reverse energy flow. For this reason, the error generally occurs for low power cases.

The following suggestions are made to help eliminate the error.

1. Review the power removal fraction (POWF) on the steady-state power removal data card 230XXY and determine if it is correct. Make any necessary adjustments. Also examine the tube mass flow rate and inlet temperature to ensure they are as desired.

2. For U-tube steam generators, the secondary side is at the saturation temperature, which defines the temperature gradient across the steam generator tubes. Adjusting the secondary pressure, will affect the temperature gradient across the steam generator. Adjusting the secondary pressure is an effective means of eliminating the error. The resulting surface area changes that will be made by the steady-state initialization feature may still be large. Further adjustment to the pressure can reduce the area change, which should typically be less than ~3%.

3. The off-rated power initialization option (see 23600Y data card) has a feature that automatically adjusts the secondary pressure. It will adjust the pressure to minimize the change in the conductor surface area required to obtain an overall energy balance.

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Error Description

4. For once through steam generators, it may be necessary to adjust the aspirator flow rate to eliminate the error.

5. The low power, or implicit steam generator initialization option (see the 2350XY data card), can be used for all power levels. It eliminates the reverse energy flow problem and also adjusts the secondary-side pressure as necessary to obtain an overall energy balance.

907 The steady-state initialization error occurred while initializing a feed water heater. A reverse energy flow occurs for the specified conductor, where the primary-side temperature is lower than the secondary-side temperature.

User Recommendations

Energy flow from secondary side to primary side is not a correct steady-state condition. If the maximum number of steady-state iterations, LCOUNT specified on steady-state convergence data cards 230000 is negative, a warning is issued instead of an error and the problem continues with the transient.

1. Review the initial condition specified for the feed water heater system to ensure they are the desired values. Make any necessary revisions.

2. Review the conductor specifications for the feed water heater. Large conductor surface areas may cause reverse energy flow. Make any necessary adjustments. Note that steady state does not adjust the conductor areas for feed water heater.

3. Review the tube flow and inlet condition to determine if they are correct. Make revisions as necessary.

908 The initial enthalpy for the indicated volume used to begin steady-state initialization cannot be computed from the initial conditions supplied. The volume is probably isolated from the rest of the system and/or it has no flow from or to a volume with a known enthalpy.

User Recommendations

Each independent flow “loop” must have one enthalpy defined to satisfy the minimum requirements of the energy equation. If a valve in a junction is closed at time zero, a known enthalpy will not be propagated across the junction. Review the time-dependent junction area in the steady-state summary edit to determine if areas are as desired for steady state. If they are not, revise the valve and/or trip settings as necessary.

The volume initial condition summary edit should also be reviewed to determine if the necessary enthalpies have been supplied. Otherwise, supply an additional enthalpy initial condition.

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Error	Description

909 An error occurred while evaluating vapor partial pressure for the indicated bubble rise volume. The total pressure, temperature, and total noncondensable quality are shown. They are generally quantities that are determined by the steady-state solver. The error occurred while evaluating the partial pressure for vapor and noncondensable. Total pressure is a sum of partial pressure of vapor and noncondensable.

User Recommendations

This error occurs when total number of iteration exceeds the maximum number of iterations allowed for evaluating partial pressures of vapor and noncondensable. This indicates the possibility of improper thermodynamic conditions being input for the volume. Review the thermodynamic properties for this volume and revise the specification for the initial state as necessary.

The independent state variables may have been computed from input for other volumes rather than being input. If this is the case, it may be necessary to determine the cause of the independent variable values that did not converge to a consistent state. Other input or model parameters may have to be revised.

910 The liquid region properties just evaluated for the indicated bubble rise volume are not for single-phase liquid, but must be. The indicated phase was determined by subroutine WAT3 using the shown pressure and temperature. They may be calculated values rather than input values. The volume contains noncondensable gas.

User Recommendations

A bubble rise volume containing noncondensable gas should contain subcooled liquid below the mixture level and a superheated steam/noncondensable gas mixture above the mixture level. Examine the values of the temperature and pressure and phase flag (1=liquid, 2=two-phase, 3=vapor) included with the error message.

1. If the pressure and temperature are input, revise them as necessary to give valid subcooled liquid conditions.

2. If the pressure and temperature are computed values determined by steady-state initialization, review and evaluate the conditions in adjacent volumes to aid in determining the cause of the error. Make adjustments to initial conditions or model parameters as necessary to resolve the error.

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Error Description

911 The vapor region properties just evaluated for the indicated bubble rise volume are not for single-phase vapor, but must be. The indicated phase was determined by subroutine WAT3 using the shown pressure and temperature. They may be calculated values rather than input values. The volume contains noncondensable gas.

User Recommendations

A bubble rise volume containing noncondensable gas should contain superheated vapor above the mixture level and subcooled liquid mixture below the mixture level. Examine the values of the temperature and pressure and phase flag (1=liquid, 2=two-phase, 3=vapor) included with the error message.

1. If the pressure and temperature are input, revise them as necessary to give valid superheated vapor conditions.

2. If the pressure and temperature are computed values determined by steady-state initialization, review and evaluate the conditions in adjacent volumes to aid in determining the cause of the error. Make adjustments to initial conditions or model parameters as necessary to resolve the error.

912 An error was returned from subroutine WAT3 while attempting to determine single-phase liquid properties for the indicated separated volume using the pressure and temperature shown. They may be calculated values or input values, but they do not correspond to a valid single-phase (liquid or vapor) state. The volume also contains noncondensable gas.

User Recommendations

1. If the pressure and temperature are input, revise them as necessary to give valid subcooled liquid conditions.

2. If the pressure and temperature are computed values determined by steady-state initialization, review and evaluate the conditions in adjacent volumes to aid in determining the cause of the error. Make adjustments to initial conditions or model parameters as necessary to resolve the error.

913 An error was returned from subroutine WAT2 for the indicated bubble rise volume while determining two-phase properties. The pressure and quality used in the call to WAT2 are shown. They may be calculated values rather than input values.

User Recommendations

When a bubble rise model contains liquid and vapor only, subroutine WAT2 is called to evaluate saturation temperature for a given pressure and quality. The error occurs when

Error Description

pressure is outside the water property limits. The pressure must be greater than 0.01 and less than 6000.0 psi (or the overridden maximum) and the quality must satisfy $0.0 \leq x \leq 1.0$. Review the shown pressure and quality and revise them it as necessary.

914 The pressure for the indicated volume is above the critical point.

User Recommendations

The pressure for the volume must be below the critical value. Review the volume initial conditions summary edit to determine where the pressures are supplied for steady-state initialization. If the pressure was specified for a bubble rise or separator volume and it is greater than the critical value, make the necessary adjustments. If the pressure is a calculated value, determine what is causing the elevated pressure and make the appropriate revisions so the computed separator pressure is in range.

915 An error occurred for the indicated volume while evaluating water properties for a separator volume during steady-state initialization. It occurred for a call to subroutine WAT5 which determines single-phase or two-phase properties using pressure and enthalpy (p and h). The error message includes information indicating where the properties would have been used, which may provide some additional insight into the cause of the error.

User Recommendations

The enthalpy is a user input value, in which case the input should be reviewed and a determination made if it is correct or if it needs revision. It is also possible that the error is due to a bad pressure or combination of pressure and enthalpy. The pressure can either be an input value or one that is computed from an input pressure somewhere else and pressure drops (or rises) between that volume and the separator. Review the pressures and pressure drops. Input pressures are shown in the volume initial condition summary edit.

It is possible that the pressure is the cause of the error, but examination of the printed value should provide an indication of whether or not the pressure is the cause. If the pressure is the problem, make the necessary adjustments to correct the error.

916 An error occurred for the indicated volume while evaluating water properties for a separator volume during steady-state initialization. It occurred for a call to subroutine WAT2, which determines two-phase properties using pressure and quality (p and x). The error message includes the subroutine used and the values used in the failed call. It also contains information indicating where the properties would have been used, which may provide some additional insight into the cause of the error.

Error Description

User Recommendations

Saturation properties are used for three different purposed when initializing a separator volume. Each is discussed below.

1. The quality is the probable cause for the error. The quality is computed for the liquid region based on a local energy balance. It may be necessary to adjust the inlet enthalpy or the flow split between the steam and recirculation paths to eliminate the error.

2. If the quality is associated with the vapor region, the error may be the result of the carryover model being used. Review the carryover modeling and make any necessary changes.

3. For the volume average conditions, both the pressure and quality should be evaluated to determine the cause of the error. More than likely they are not directly input, but are computed quantities and the offending quantity will have to be traced back to the real cause somewhere else in the model.

917 An energy balance was not obtained for the indicated bubble rise volume. The enthalpy error corresponds to the subcooling that is shown for the recirculation path junction (exiting below the mixture level). Due to the bubble rise model assumptions, the minimum value for an exit junction enthalpy residing below the mixture level is that for saturated liquid as shown.

User Recommendations

One way to eliminate this error is to raise the inlet enthalpy to the separated volume. This can be accomplished by raising the reference input enthalpy (usually specified in the lower plenum). If it is not acceptable, another approach can be used.

When it is not acceptable to raise the inlet enthalpy, is will be necessary to adjust the flow split between the steam and recirculation flow paths. The steam flow will have to be reduced and the recirculation flow increased.

It is also possible, but unlikely, that the power is too low so the increase in the flowing enthalpy from the reference enthalpy (typically at the lower plenum) to the inlet of the separated volume is inadequate. If the power is incorrect, increasing it may help resolve the problem.

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Error Description

918 Steady state was unable to estimate the pressure for the indicated volume from the input data when making the initial control volume pressure estimate. The scheme being used is to simply move known pressures to adjacent volumes if the flow area is greater than zero. It is not affected by the location of computed form loss coefficients.

User Recommendations

Each independent "loop" must have at least one pressure defined to satisfy the minimum requirements of the momentum equation. If a valve is closed at time zero, a known pressure will not be propagated across the junction. Review the time-dependent junction area in the steady-state summary edit to determine if areas are as desired for steady state. If they are not, revise the valve and/or trip settings as necessary.

The volume initial condition summary edit should also be reviewed to determine if the necessary pressures have been supplied. Otherwise, supply an additional pressure initial condition.

The error occurs when the code cannot calculate all volume pressures from the input data specified.

919 An enthalpy specification was not provided for the indicated energy equation set comprised of the volumes listed. Each independent flow loop requires at least one enthalpy specification.

User Recommendations

The error occurs when the code cannot calculate the volume enthalpy from the give input data or no enthalpy is specified for any of the volumes.

Review the volume initial conditions summarized in the volume initial condition summary edit. Correct any input errors that lead to the error above. It may be that a valve is closed that needs to be open or an additional enthalpy may need to be supplied. Make revisions as necessary.

920 The total flow entering the lower plenum does not equal the FIBWR total core flow boundary condition specified on the junction initial condition data card 232XXX, resulting in a mass imbalance for the lower plenum volume.

User Recommendations

The lower plenum inlet flow could be specified directly via input or computed from other flow specifications, e.g., it could be determined from the sum of the loop flows. If the total core flow specified on a junction initial condition data card is correct, other flow specifications that affect loop flow must be adjusted so the resulting lower plenum inlet flow matches the specified total core flow.

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Error Description

If the loop flows are correct, it will be necessary to adjust the core flow initial condition to match the lower plenum inlet flow.

921 The total flow leaving the upper plenum does not equal the FIBWR total core flow boundary condition specified on the junction initial condition data card 232XXX, resulting in a mass imbalance for the upper plenum volume.

User Recommendations

The upper plenum outlet flow could be specified directly via input or computed from other flow specifications, e.g., it could be determined from the sum of the loop flows. If the total core flow specified on a junction initial condition data card is correct, other flow specifications that affect loop flow must be adjusted so the resulting upper plenum outlet flow matches the specified total core flow.

If the loop flows are correct, it will be necessary to adjust the core flow initial condition to match the upper plenum outlet flow.

922 The indicated volume has a steady-state mass flow imbalance that exceeds the convergence criteria for the mixture continuity equation. The normalized error (time rate of change of mass) is shown.

User Recommendations

Typically, the flows entering and leaving the offending volume are computed, or inferred from junctions that may not be physically near the volume.

1. Review and evaluate the junction initial condition summary to determine where the problem may originate. Care must be taken to ensure that adequate significant figures are used with the initial condition specifications to satisfy the convergence criteria requirements.

2. Several potential problems can arise as the result of using fills, which are flow boundary conditions. For a fill to define a flow initial condition, it must be activated at time zero. This requires that any trip associate with the fill must be true at time zero since trips not only activate the fill flow but also valves that may be present in a fill junction.

3. Several fill junction options are possible. One is a fill flux, which requires that the fill mass flux to be multiplied by the time zero valve area to obtain the mass flow rate. The number of significant figures used for the fill table and area table can affect the resulting flow. If inadequate significant figures are supplied for either, a mass balance can be introduced. Additional significant figures may have to be added to either the fill table or area table for this situation.

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Error Description

4. Another commonly used resolution to the above is to set the fill table to the desired mass flow rates and then set the junction area to 1.0.

923 The enthalpy computed for the indicated volume is out of range. It must be greater than zero and less than or equal to 2000.0 Btu/lbm.

User Recommendations

If this error is encountered, it will be useful to active the steady-state debug output. This is done using the JSST variable on the problem description data card 01000Y. Turn the debugs on a few iterations prior to where the error occurs and review how the enthalpy for the troublesome volume and others in its vicinity behave for a few iterations prior to the failure. Also examine the slip velocity and void fraction. This should provide some insight into the behavior leading to the error.

1. One of the most commonly encountered problems that can lead to this error is the poor behavior of the slip model, particularly for highly voided systems. If the slip velocity is changing drastically from one iteration to the next and the flow regime is in the annular or transition regimes, it may be necessary to fix the flow regime using IFRJ on the junction data card 08XXXY, to bubbly flow. Other options would be to use either the Chexal-Lellouche τ_{gl} form of the dynamic slip model or to use the Chexal-Lellouche algebraic slip model.

2. This error can also be caused if the power addition is too high for the flow through the volume. It may be necessary to increase the flow or reduce the power.

3. If the error is for a core volume, make sure the power is correct. This includes the power fraction for the core section, which may be computed for either the one-dimensional or three-dimensional kinetics options. Make the necessary revisions if it is not correct.

4. Review and evaluate any energy sources to ensure they are correct.

924 The submerged area (area below the mixture level) for the indicated junction is less than or equal to zero. This is likely a code error.

User Recommendations

Review the description for the indicated vertical junction. If no input discrepancies are found, contact the maintenance contractor.

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Error Description

925 Countercurrent flow typically is not encountered in reactor systems for steady-state conditions. Consequently, the necessary logic to handle countercurrent flow is not included in the steady-state initial condition solver. The code is attempting to calculate derivatives for the countercurrent flow, which is not allowed during steady-state.

User Recommendations

The problem may be with the input specifications. Review the steady state or time zero output to evaluate the junction properties for which counter-current flow is occurring. Revise the initial conditions to prevent countercurrent flow or set IFRJ = -99 on the junction data card 08XXXY to turn slip off in the offending junction.

926 The enthalpy cannot be computed for a volume with no flow.

User Recommendations

The mixture energy equation is used to compute the volume enthalpies. To do so however, requires that there be flow through the volume. If a volume has no flow, but is connected to a volume whose enthalpy is known, the enthalpy will be propagated to the zero flow volume if the area of the junction connecting the volumes is greater than zero. This was not possible for the offending volume.

1. The enthalpy was not supplied for the volume but must be specified using the volume initial condition data cards 231XXX or the volume data cards 05XXXY (not recommended).

2. Another possibility is that there should be flow through the volume. If so, review the time-dependent junction areas and the junction initial condition summary edit to make sure that the area is open. Make any necessary revisions to the flow initial conditions. If the time-dependent area is incorrectly zero, review and revise as necessary the setting for valves and trips.

927 When steady-state initialization is not used (JSST = 1 on the problem dimension card 01000Y), all volume pressures must be correctly specified. Additionally, an additional quantity must be specified to allow the state of the volume to be defined, e.g., enthalpy, temperature, or quality.

User Recommendations

If the JSST = 1 option is desired, supply the initial pressure (and other state variable) for all volumes. Otherwise, revise the value of JSST on the problem dimension card (01000Y) to use steady state, JSST = 0.

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Error Description

928 The form loss coefficient for the indicated junction cannot be calculated since the junction flow is zero flow.

User Recommendations

If the loss coefficient is to be computed, review the junction initial condition summary edit and make sure that there is a flow specification that gives a nonzero flow for the junction. It may be necessary to check the status of valves and trips to ensure that the junction has a nonzero area for steady state.

In the event that the junction should have zero flow, revise the input to define FJUNF and FJUNR as appropriate for the junction geometry by setting them to values greater than or equal to zero. If present, remove the JESTW = 1 specification of the junction initial condition data card 232XXX for the indicated junction.

929 The forward form loss coefficient for the indicated junction cannot be computed because the flow is negative or zero.

User Recommendations

Form loss coefficients cannot be calculated for junctions with zero flow.

1. If the flow specification is correct and negative, flag FJUNR for calculation by steady state by setting JESTW = 1 on the junction initial condition data card 232XXX (or FJUNR = -1.0 on the junction data card 08XXXY --- obsolete). Also define FJUNF as appropriate. If it is input as zero, it will be set to FJUNR after it is calculated by steady state.

2. If the flow is incorrect, revise the flow specification to obtain a positive flow in the junction.

930 The reverse form loss coefficient for the indicated junction cannot be computed because the flow is positive or zero.

User Recommendations

Form loss coefficients cannot be calculated for junctions with zero flow.

1. If the flow specification is correct and positive, flag FJUNF for calculation by steady state by setting JESTW = 1 on the junction initial condition data card 232XXX (or FJUNF = -1.0 on the junction data card 08XXXY --- obsolete). Also define FJUNR as appropriate. If it is input as zero, it will be set to FJUNF after it is calculated by steady state.

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Error Description

2. If the flow is incorrect, revise the flow specification to obtain a negative flow in the junction.

The error usually occurs when both FJUNF and FJUNR are set to -1 to calculate loss coefficient on 08XXXY data cards. FJUNF must be set to 0 for this negative flow junction. It is recommended to use the steady-state junction initial condition data cards 232XXX. When 232XXX cards are used, based on the flow, the code determines which loss coefficient to calculate.

931 The junction flow cannot be computed for the indicated junction using the flow initial conditions that were provided. The problem is under specified.

User Recommendations

Each "loop" and flow split (if used) must have a mass flow rate defined. Review the junction initial conditions summary edit to determine where mass flow rates are specified. Then review the nodalization diagram for the model to determine what additional flow specifications are necessary to eliminate the error.

Another possible problem could be related to closed valves that should be open. If the flow initial conditions appear to be adequate, review the time-dependent areas for junctions with valves to ensure they are in the correct state for steady-state conditions. A nonzero flow would also indicate that a valve in the open state.

932 The noncondensable pressure search failed to converge within the indicated number of iterations for the indicated volume.

User Recommendations

Review the volume pressure, temperature, quality, and non condensable quality to determine if they are unreasonable. Make adjustments as necessary to the volume initial conditions.

933 Due to an inconsistency in the vapor and noncondensable gas qualities, the pressure search was unable to locate the correct state path for evaluating the thermodynamic properties for the indicated volume.

User Recommendations

Review volume thermodynamic properties, particularly mass of air, vapor, and liquid to ensure that the five-equation option is appropriate and properties represent adequate thermodynamic state.

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Error Description

934 The loss coefficient cannot be calculated for the indicated junction because the flow area is zero. The valve in the junction is closed at time zero.

User Recommendations

Review and evaluate the valve associated with the troublesome junction.

1. The valve may have an area table associated with it that could be producing a zero area.

2. Valves can be closed and opened under trip control. Check to make sure the valve type and associated trip are set up correctly.

3. Another possibility is that the trip used to activate that valve is not functioning properly. The trip associated with the valve should also be reviewed and evaluated.

4. If the valve is required to be closed during steady state, revise the junction loss coefficient calculation flag (JEST = 1 on the junction initial condition data card 232XXX or FJUNF = -1.0 on the junction data card 08XXXY) so that code does not attempt to calculate loss coefficient at this junction.

Make necessary changes to the valve settings, area table or trip settings.

935 The loss coefficient cannot be computed for the indicated junction because the junction flow is zero.

User Recommendations

The initial (time zero) junction flow for the indicated junction is zero. If this is the desired initial flow, the form loss coefficient must be given and cannot be computed by steady-state initialization. Either remove the FJUNF = -1.0 specification on the junction data card (08XXXY) or remove the JESTW = 1 specification for the junction on the associated junction initial condition data card 232XXX.

This may be a secondary error if the junction flow was intended to be nonzero. If so, correct the mass flow distribution so the affected junction flow is not zero, which will allow the form loss coefficient to be calculated.

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Error Description

936 A negative loss coefficient was calculated for the indicated junction. This implies that there is too much pressure drop somewhere in a flow loop, a parallel flow path, or that the pump head is inadequate to compensate for the pressure drops due to friction and hydrostatic head.

User Recommendations

The junction major edit contains individual pressure drop information for each junction. It includes the velocity (momentum flux) head, the elevation head, the wall friction and form losses, and the pump head if present. It will be useful to review these terms.

Making corrections to eliminate negative loss coefficients can be complicated because of complex model nodalization and the flexibility allowed for specifying initial conditions. For this reason, it is necessary to evaluate how this affects the junction where the negative loss is computed.

1. If the error is in a loop, the indication is that there is too much pressure drop. This means that the pressure drop must be reduced by reducing the wall friction or form loss. The wall friction can be reduced by reducing the volume flow length. Form losses are proportional to the loss coefficient, which can be reduced. Finally, the pump head may be increased by adjusting the pump model constants.

2. If the error is in a parallel path such as the core, e.g., the bypass and the active core channel, one has too much pressure drop and must be adjusted. For situations like this it is useful to use available data to determine if the pressure drops need revision. Since the core pressure drop is part of the loop pressure drop, the pump head may be part of the problem (generally not the case). These pressure drops are affected by the wall friction and form losses as described above. Similar adjustment can be made here also.

3. For open systems such as BWR models and PWR detailed steam generator models, errors occurring in the separator/downcomer regions can be the result of inadequate level. It may be necessary to raise a level in the downcomer to achieve adequate hydrostatic head to overcome the elevation change and friction effects through the heated region.

These should provide direction that will help focus on the area where revisions must be made to eliminate the negative loss coefficient.

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Error Description

937 Flow for the indicated junction was specified on either a junction data card (08XXXY) or on a junction steady-state initial condition data card (232XXX) but is also defined by implication with an upstream or downstream junction with its flow being calculated via the steady-state flow calculation. This combination is incompatible.

User Recommendations

If the flow for the path containing the junction is to be determined using the flow split option, remove the flow specification for the junction. A specification cannot be present on either a 08XXXY or 232XXX data card.

If the flow specified on a 08XXXY or 232XXX card is the desired initial condition, review the input to determine why the junction is also part of a flow split path, and then make the necessary changes so the junction is not in a flow split path.

938 The pressure for the indicated volume cannot be computed from the initial conditions provided.

User Recommendations

Various situations can lead to this error. Some of the most common problems are summarized below.

1. This situation may arise from a valve being closed, preventing the pressure from being propagated across the junction. Review the junction areas in the steady-state summary edit to determine if this could be the cause of the problem. Correct any valve states that may be incorrect.

2. Another cause for this error is the result of too many requests to compute junction loss coefficients. A request to compute a junction loss coefficient stops pressure propagation at the junction until pressures are known on both sides of the junction. If too many loss coefficients are computed, there will be regions in the system where the pressure does not have a path to allow the pressure to be propagated. Review the junction initial condition summary edit to aid in determining if too many loss coefficient calculations have been requested.

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Error Description

939 The loss coefficient for the indicated junction cannot be computed. This is due to not having pressures (either specified or computed) on both sides of the junction, which means the problem is underspecified.

User Recommendations

Several possible causes are explained below.

1. Review the junction areas in the steady-state summary edit to determine if a valve may be closed and preventing the pressure from being propagated into one or more affected volumes. If there is a problem revise the input as necessary.

2. It may be that too many loss coefficient calculation requests have been included. Review the volume initial condition summary to determine where pressures are input and where they should be propagated to. Then review the junction initial condition summary edit to determine if the calculated losses are causing the error.

940 The pressurizer steady-state initialization option is activated, but a surge line junction was not found.

User Recommendations

A surge line junction must be connected to the pressurizer below the mixture level. Review the junction input data and revise as necessary.

941 The pressurizer steady-state initialization option is activated, but a spray junction was not found. A spray junction is required.

User Recommendations

First make sure that a spray junction is present in the input deck. Next, make sure that the spray junction is identified by setting ISP = 1 on the junction data card.

942 The pressurizer steady-state initialization option is activated, but too many spray junctions were found. A maximum of two spray junctions are allowed.

User Recommendations

Review the junction input and identify the junctions for which the spray option, ISP = 1 on the junction data cards, 08XXXY, is set. Make the necessary revisions to limit the number of spray junctions to two.

Error Description

943 The indicated junction is not a flow definition junction, but was incorrectly identified by the code as a flow definition junction during steady-state initialization.

User Recommendation

This error indicates a probable code error. For assistance with this problem, contact the engineering contractor providing code maintenance.

944 The indicated junction was tagged more than once as a flow definition junction. For the flow split option, a junction must be tagged only once as a flow definition junction.

User Recommendation

This error is a probable code error. For assistance with this problem, contact the engineering contractor providing code maintenance.

945 The FIBWR total flow boundary condition requires that the total core flow must either be specified or inferred from other specified flows, but neither has be done in the current input specification.

User Recommendation

Review the junction flow specifications in the junction initial condition summary.

1. Define the total core flow on the 232XXX junction initial condition data card if it hasn't already been defined, or

2. Revise the core and bypass flow specifications so the total core flow is known.

946 The Off-Rated Power Initialization Procedure (ORPIP) was unable to reach a converged steady-state condition.

User Recommendations

1. One possibility that is worth trying is to increase the number of iterations. This is not a high probability solution, but is quick and easy to try. If it does not help, try the following.

2. Since the ORPIP is an outer iteration around the standard steady-state initialization feature that is used to adjust certain specified target parameters, there can be numerous causes for the failure. There should be other error messages that will identify the underlying cause of the failure to converge. In all likelihood, one or more of the target parameters is probably failing to converge. Review them and make adjustment to the input as necessary.

Error Description

947 The Off-Rated Power Initialization Procedure (ORPIP) was unable achieve the target mass or level even with the maximum lower downcomer enthalpy and maximum upper downcomer level adjustment.

User Recommendation

1. Confirm that the target value is correct. Make any adjustment if it is not correct.

2. Review the magnitude of the error between the target mass or level and the actual value. Then review the other model parameter to determine if the initial conditions can be adjusted to allow the target value to be achieved.

948 An input option was requested to have steady-state initialization compute the form loss coefficient for the indicated junction. This is not a valid option when JSST = 1 on the problem dimension card (01000Y) (the option to bypass steady-state initialization). No form loss coefficients can be computed for this option so they must be provided in the input (FJUNF and FJUNR must be ≥ 0.0).

User Recommendations

If the JSST = 1 option is desired, remove the requests to compute the form loss coefficient (FJUNF = -1.0 on the junction data card 08XXXY or JESTW=1 on card 232XXX). Otherwise, revise the value of JSST on the problem dimension card (01000Y) to use steady state, which will allow the loss coefficient to be computed.

949 The saturation temperature and related properties cannot be calculated for given pressure and quality.

User Recommendations

The error occurs when WAT2 is called to evaluate the saturation temperature, where the quality is assumed to be 0.5. The pressure may be out of bounds. The pressure must be less than the critical pressure. There is no lower limit.

Evaluate the pressure in the indicated volume and nearby volumes to determine why it is out of range.

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Error	Description

950 Either the liquid or vapor properties cannot be evaluated for the indicated volume given the pressure and temperature.

User Recommendations

The error occurred when WAT15 was called to evaluate the single-phase properties for liquid or vapor at given pressure and temperature. This property call allows superheated liquid or subcooled vapor in addition to the normal stable states. The error may be due to the pressure being less than 0.01 psia or greater than 6000.0 psia (or other defined maximum value). The temperature can also be out of range. Typically it would be greater than 32.2 F and less than the critical temperature.

Examine the conditions in the volume and determine which are causing the error. Then make the necessary changes to the initial condition specifications to remove the error.

951 The saturation pressure and related properties cannot be calculated for the given temperature and quality.

User Recommendations

The error occurs when WAT1 is called. The quality is typically fixed at 0.5 so the error occurs when temperature is outside the limit. Temperature must be greater than ~0.0 and less than the critical temperature.

Evaluate the temperature in the indicated volume and nearby volumes to determine why it is out of range.

952 The water property evaluation failed while evaluating single-phase liquid properties for the indicated volume. Either the given pressure and/or temperature are out of range.

User Recommendations

The error occurs when WAT3 is called to evaluate single-phase liquid properties. The error may occur because the pressure is outside the property limits. It must be greater than of 0.01 psia and less than 6000.0 psia (or other specified maximum). The error may also occur if the temperature is less than ~33 F or greater than ~1450 F. Review the pressure and temperature to determine which is unreasonable and revise as necessary. It is possible that the problem is really in a nearby volume so it may be necessary to revise the conditions in neighboring volumes.

Error Description

953 The water property evaluation failed while evaluating single-phase liquid properties for the indicated volume. Either the given pressure and/or enthalpy are out of range.

User Recommendations

The error occurs when WAT5 is called to evaluate single-phase liquid properties. The error may occur because the pressure is outside the property limits. It must be greater than of 0.01 psia and less than 6000.0 psia (or other specified maximum). The error may also occur because the enthalpy is less than ~0 Btu/lbm or greater than ~20050 Btu/lbm. Review the pressure and enthalpy to determine which is unreasonable and revise as necessary. It is possible that the problem is really in a nearby volume so it may be necessary to revise the conditions in neighboring volumes.

954 Not used.

955 The liquid enthalpy failed to converge while searching for the vapor partial pressure for the indicated volume.

User Recommendations

Examine the pressure and temperature (liquid) for the indicated volume and make any necessary revisions.

956 The calculation option flag (iopt) is invalid. This is probably a coding error.

User Recommendations

For assistance, contact the engineering contractor that is providing code maintenance and support.

957 The steady-state pressure calculated using the momentum equation is out of range for the indicated volume and junction.

User Recommendations

The steady-state initialization scheme either solves for a junction loss coefficient or adjacent volume pressure using the junction momentum equation. Review steady-state initialization input for adjacent volumes and junction. Make adjustments as necessary.

Review the steady-state edits and evaluate the pressure drop's computed loss coefficients.

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Error Description

958 The indicated volume contains vapor and noncondensable gas. The calculated vapor pressure is greater than total pressure.

User Recommendations

When a volume contains air and vapor, the humidity must be between zero and one. A humidity of one indicates saturated air and any humidity less than one indicates superheated vapor. The temperature is used to evaluate the saturation temperature, which is multiplied by the humidity to obtain the vapor pressure.

1. If the temperature is input, correct it or the total pressure such that the total pressure exceeds the vapor pressure.

2. Adjust the total input pressure if it is necessary. It is possible that the total pressure is a computed value, in which case adjustments may be necessary to give a reasonable total pressure.

959 The scratch space used to store the matrix for the energy equation solution is not adequate. This is a programming error.

User Recommendations

Contact the engineering contractor for user support and code maintenance issues.

960 The indicated volume has no out flow. This is a probable programming error.

User Recommendations

Contact the engineering contractor for user support and code maintenance issues.

961 At least one computed enthalpy is out of range. Enthalpies must be greater than zero and less than or equal to 2000.0 Btu/lbm. Review the volume data actually being used to determine the volume(s) causing the problem. The error is triggered by subroutine HAVG, which is only used the first two steady-state iterations.

User Recommendations

If this error is encountered, it will be useful to active the steady-state debug output. This is done using the JSST variable on the problem description data card 01000Y. Turn the debugs on a few iterations prior to where the error occurs and review how the enthalpy for the troublesome volume and others in its vicinity behave for a few iterations prior to the failure. Note that slip is not active when subroutine HAVG is used to solve the mixture energy equation (turned off for first two iterations if it was active in the model). This should provide some insight into the behavior leading to the error.

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Error Description

1. This error can also be caused if the power addition is too high for the flow through the volume. It may be necessary to increase the flow or reduce the power.

2. If the error is for a core volume, make sure the power is correct. This includes the power fraction for the core section, which may be computed for either the one-dimensional or three-dimensional kinetics options. Make the necessary revisions if it is not correct.

3. Review and evaluate any energy sources to ensure they are correct. They are printed in the volume major edit for all volumes.

962 There is a probable coding error in subroutine XANDH. Logic has transferred the code to a location where there is no code to execute.

User Recommendations

Contact the engineering contractor and provide them with the diagnostic information that is included with the error message.

963 There is a probable coding error in subroutine XANDH. The error is related to the flow split model where inadequate space was reserved for the junction that references a flow definition junction.

User Recommendations

Contact the engineering contractor for assistance.

964 There is a probable coding error in subroutine XANDH that is related to the FIBWR leakage model flow. The required off-diagonal connections were not located. This is probably due to a code error.

User Recommendations

Contact the engineering contractor for assistance.

Error	Description
965	There is a probable coding error that has selected an invalid combination of surface boundary conditions while obtaining a heat conduction solution. User Recommendations Contact the engineering contractor for assistance.
966	The two-surface simultaneous boundary solution failed to converge for the given conductor. User Recommendations Examine the thermodynamic conditions for the adjacent volumes to ensure that they are realistic and that they are consistent with the heat correlations used by RETRAN for each side of the given conductor. Specify correct thermodynamic conditions for the volumes as appropriate or select a different heat transfer correlation for use via IMCL or IMCR on the conductor cards (15XXXY).
967	No power is available for removal by use of a steam generator. User Recommendations A power source must be supplied in order for the steady state power removal option to function. Either add a power source to the system, or remove the steady-state power removal system cards (230XXY).