Combustion Efficiency Analyzer

709

Rev. 6.x Analyzers



The Value Leader™

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Introduction

Thank you for purchasing TPI brand products. The TPI 709 Flue Gas Analyzer is a state of the art, easy to use analyzer designed not only to display and calculate the required readings from a flue but also to cover most of the other measurements associated with combustion. The instrument is ruggedly constructed and comes with a 3 Year unit and 2 Year sensor Guarantee.

General Overview

The TPI 709 combustion analyzer uses state of the art electrochemical sensors. This sensor technology provides the longest lasting, most accurate and reliable means for performing combustion tests. The sensors in your analyzer will need to be replaced periodically and calibration is recommended once every year. The 709 will remind you when calibration is due by flashing “CAL DUE Err” for three seconds at start up.

Electrochemical sensors by nature are always active. Therefore the time the analyzer is off and not being used must be taken into account when determining sensor life. The sensors in your analyzer are warranted for two years. This warranty does not cover sensors damaged through misuse of the analyzer.

You should keep the batteries of your 709 fresh so power is constantly being supplied to your sensors.

The following guidelines will help prevent damage to your sensors:

Always use the mini pump filter when testing flue gases.
Always periodically check and replace the mini pump filter as needed.
Always make sure the in-line filter / water trap is installed properly.
Always periodically check and replace the in-line filter as needed.
Always remove water or condensation from the inside of the in-line filter / water trap assembly prior to performing tests.
Always use the optional oil filter (p/n A773) when performing tests on oil burning equipment.

General Overview (Continued)

Never over saturate your sensors by performing tests on equipment with gas levels beyond the capability of you analyzer.

Always keep the A794 water trap / filter assembly clean and replace the filter as necessary. Replacement filter part number is A794F.

This manual will guide you through the functions of the TPI 709 which will give you many years of reliable service.

Your TPI 709 Flue Gas Analyzer comes complete with the following standard accessories:

- TPI 709 Instrument
- Rubber Boot (A765)
- Soft Carrying Case (A768)
- Flue Sampling Probe (A770)
- In-Line Filter assembly installed on Flue probe (A794)
- Temperature Probe (GK11M)
- Mini Pump Protection Filter Assembly and spare filters (A763)
- Exhaust Spigot (removable) (A764)
- Instruction Manual

( ) Denotes part number

Your TPI 709 Flue Gas Analyzer has the following options available:

- Infrared printer (A740)
- Spare In-Line Filter (A794F is a package of 5 filters)

Instrument Overview

Front View



Rubber Boot	Protects the instrument from accidental damage
Display	Large 3 Parameter Backlit LCD Display
Battery Condition Icon	Shows condition of batteries.
Keypad	Selects all available functions
Selected Fuel Type	N GAS, LPG, LIGHT OIL, HEAVY OIL, OPT 1 (Bituminous Coal), OPT 2 (Anthracite Coal), OPT 3 (Coke), OPT 4 (Butane), OPT 5 (Wood), OPT 6 (Bagasse)

NOTE: When selecting oil as fuel be sure to use the optional oil filter (A773) or readings could become erratic. See Appendix E for installation instructions.

Keypad



Scrolls through selectable fuels (see page 8)
Switches between Gross and Newt Efficiency (see page 17)
Switches between ºC and ºF (see pages 18 & 21)
Moves up through the Stored Data Addresses



Zeroes pressure reading (See page 21)
Moves down through the Stored Data Addresses



Scrolls through Combustion Analysis Displays (See 17& 18)
Scrolls through Function Screens
Turns temperature differential calculation ON/OFF (see 20)
Turns ch2 temperature ON/OFF (see page 20)
Allows you to change the Date and Time (see page 22)
Allows you to choose a Stored Data Address



Sends stored data to a separate infrared printer (see pg 25)



Allows you to view stored data on the display (see pg 24)



Stores readings to memory (see pg 23)

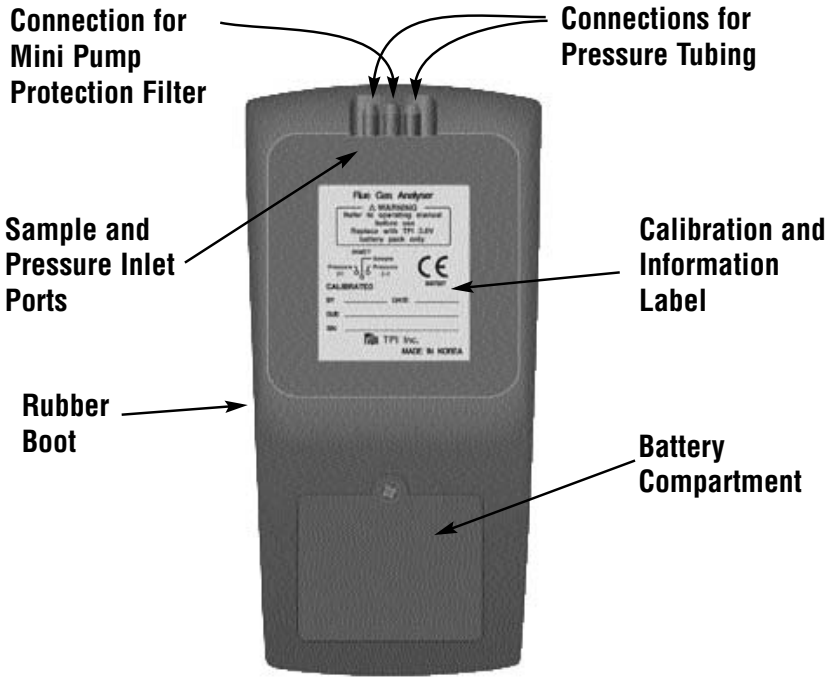


Scrolls through and selects analyzer functions (see 20~22)
Turns Backlight ON and OFF (see 9)



Turns the instrument ON and OFF (see pages 8 & 9)

Back View



Sample and Pressure Inlet Ports: Connection for Flue Probe (see pages 7 & 11)

Connection for Mini Pump Protection Filter (see pages 7 & 11)

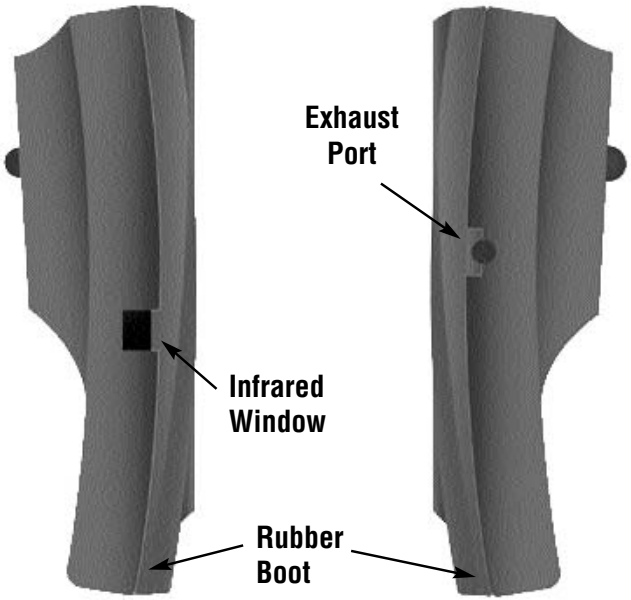
Connection for pressure tubing (see pages 7 & 21)

Calibration and Information Label: Displays calibration information and serial number

Battery Compartment: Holds 3 AA Alkaline Batteries

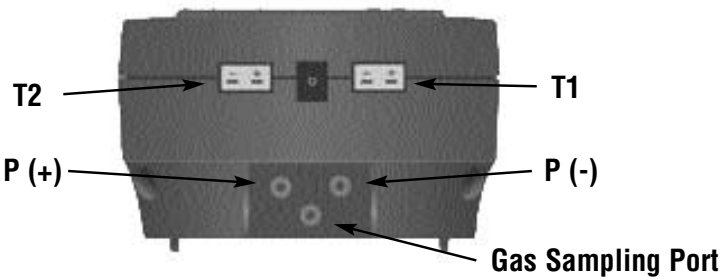
Rubber Boot Protects the instrument

Side Views



Exhaust Port	Port for connection of Exhaust Adapter
Infrared Window	Window for sending stored data to IR Printer (see page 25)
Rubber Boot	Protects the instrument from accidental damage

Top View



T1 Socket	Connection for thermocouple plug on flue probe (see page 11) Connection for any 'K' type thermocouple probe (see page 20)
T2 Socket	Connection for ambient 'K' type thermocouple probe (see page 11) Connection for any 'K' type thermocouple probe (see page 20)
Gas Sample Port	Connection for Mini Pump Protection Filter and Flue Probe (see pages 7 & 11)
P (+) Port **P (-) Port**	Connections for Pressure Tubing (see page 21)

BASIC ANALYZER FUNCTIONS

Analyzer Batteries

Your combustion analyzer is fitted with three AA size 1.5V alkaline batteries. It is important to keep battery power to the sensors in your analyzer even when it is not in use.

Your analyzer has a battery status indicator in the lower right corner of the display. Battery status is determined as follows:


Indicates batteries are at full capacity.


Indicates batteries are at 2/3 capacity.


Indicates batteries are at 1/3 capacity. Replacement of batteries should be considered soon.


Indicates batteries are very low and in need of replacement immediately. See Appendix J for battery replacement instructions.

Turning The Analyzer On & Fuel Type Selection

Always: - ***Before turning on please ensure that the Mini Pump Protection Filter assembly and the Temperature Sampling Probe complete with In-Line Filter or the Tubing & In-Line Filter fare not connected to the Gas Sample Port (see page 7)***

The instrument MUST be turned on in a clean air environment as the initial purge will set the Carbon Monoxide level to Zero and the Oxygen to 20.9%. Press and hold down the Power Key and the TPI 709 will start its 30 second countdown 'PURGE' will be displayed.

During the last 20 seconds of the 30 second purge time the type of fuel can be selected. Use the Up Arrow key to scroll through the following Fuels: - Natural Gas, LPG, Light Oil*, Heavy Oil*, OPT1 : Bituminous Coal, OPT 2 : Anthracite Coal, OPT 3: Coke, OPT 4: Butane, OPT 5: Wood (Dry), OPT 6: Bagasse. When the desired fuel is displayed release the key and the displayed fuel is now selected.

Unless a fuel is selected the analyzer will start up using the last fuel selected.

After start up, several tests can be performed to ensure proper function of the analyzer and flue probe. Please refer to Appendix A.

***NOTE: When selecting oil as fuel be sure to use the optional oil filter (A773) or readings could become erratic. See Appendix E for installation instructions.**

After the 30 second countdown the instrument is ready to take Flue, Temperature, Pressure or Leak Detection readings and the default combustion display will be displayed.

The 709 will auto power off if no keys have been pressed for 10 minutes and the CO level is below 15ppm. Auto off can be disabled (see Appendix D). The auto power off feature is always enabled upon power up.

The Scroll/Enter Key allows you to scroll through the combustion displays as outlined on pages 17&18. The Func Key is used to select the 709 function mode and allows you to set it to be a combustion analyzer, manometer, or thermometer. In addition, the Func Key is used to access the date and time display. See pages 20 through 24 for more information on the Func Key.

Turning The Analyzer Off

Always: - Before turning off return the instrument to a clean air environment and allow the Carbon Monoxide level to return to below 15ppm and the Oxygen level to return to 20.9% (± 0.3%) Press the Power Key to turn the instrument off:- NOTE Should you attempt to turn the instrument Off and the CO reading is above 15ppm then the instrument will remain On and a short Beep will be heard. The Instrument can only be switched off if the CO is below 15ppm

The instrument has an auto shut off after 10 minutes should no keys have been pressed for this period and as mentioned above that the CO is below 15ppm. Should the CO be above 15ppm then the 10 minute auto shut off countdown will not begin till the CO has gone below 15ppm. The auto power off feature can be disabled. Please see Appendix D. The auto power off feature is always enabled upon power up.

Activating the Backlight

The display backlight can be activated at any time by pressing and holding down the Func Key for approximately 2 seconds. The backlight will automatically shut off after approximately 20 seconds to preserve battery life.

COMBUSTION ANALYSIS OVERVIEW

Performing combustion analysis is very important to the overall safety and efficiency of heating equipment. The following guidelines and descriptions are generic and meant to provide you with a basic understanding of combustion testing. TPI always recommends you contact the manufacturer of the device under test, obtain information specific to the device, and follow the procedures and safety guidelines for performing tests and affecting repairs.

In general, for most applications, flue gas samples should be taken prior to the draft diverter or any other opening that allows room air to enter the system. This prevents room air from mixing with gases in the flue and diluting the test sample. To ensure accurate and consistent combustion tests, it is important gas and temperature samples be taken at the same location. This is easy with the TPI flue probe because the temperature sensor is an integral part of the probe.

Prior to taking a sample, the device under test should be on and operating. Putting the flue probe in the sample area prior to starting the device may cause saturation of the sensors due to the higher initial concentration of carbon monoxide that may be encountered upon start up. If this happens, allow your analyzer to purge in fresh air until the carbon monoxide level returns to 0 ppm and the oxygen level returns to 20.9%. This may take more than an hour depending on how saturated the sensors are.

The figures on pages 13 through 15 show locations for performing tests on commonly encountered equipment. Remember to consult with the manufacturer of the device under test for specific test information.

Pressing the Func Key enables access to the different functions available on the 712. The default function is Combustion Analyzer. Other available functions are: Thermometer, Manometer/Tightness Test, Combustible Gas Leak Detector, and Date / Time display.

Refer to the Appendix G “Technical Notes” for additional information.

Combustion Analyzer (Default Start Up Mode)

COMBUSTION TEST PROCEDURE

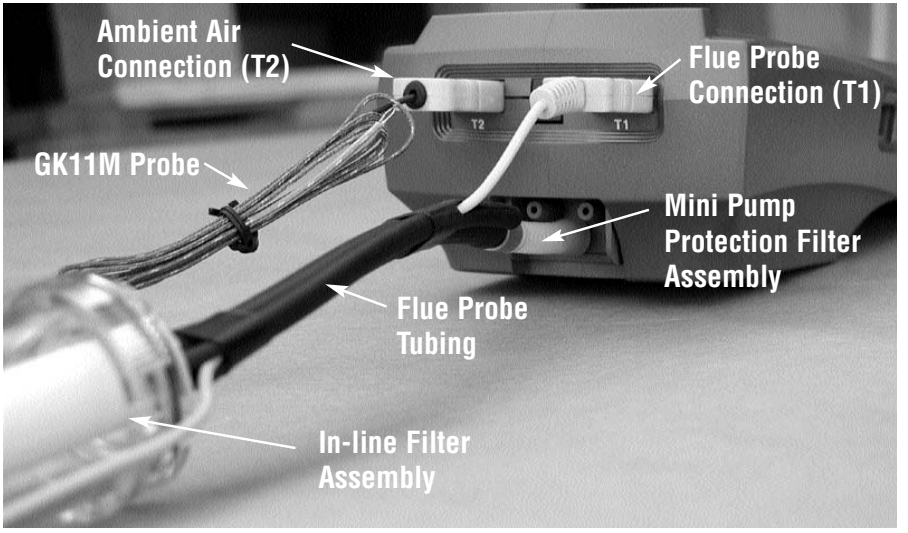
Note: It is recommended you perform routine general maintenance on your analyzer to ensure proper function. Please refer to Appendix A for general maintenance schedule and function tests.

1. Turn the 709 on in fresh air as outlined on page 8. After the initial purge cycle the 709 will default to combustion analyzer mode and combustion display 1 will be seen.



- **Combustion Display 1 (Default Start Up Display)**
- Displays Carbon Monoxide (CO) reading in parts per million (ppm)
- Displays calculated Carbon Dioxide (CO2) figure in percentage (%)
- Displays calculated CO/CO2 (Ratio) figure

2. Connect the Mini Pump Protection Filter assembly and Flue Probe Tubing complete with In-Line Filter to the Gas Sample Port and the 'K' Type Thermocouple Plug from the Flue Probe into Thermocouple (T1) Socket. The GK11M ambient air temperature probe is connected to the (T2) socket. (See below & page 7)



WARNING: - Ensure the 'K' type thermocouple probes are inserted into the sockets correctly (see page 7). The plugs are polarity marked and forcing the plug into the socket the wrong way may result in damage to the instrument.

IMPORTANT: Prior to taking a sample, the device under test should be on and at operating temperature. **Putting the flue probe in the sample area prior to starting the device may cause saturation of the sensors due to the higher initial concentration of carbon monoxide that may be encountered upon start up.** If this happens, allow your analyzer to purge in fresh air until the carbon monoxide level returns to 0 ppm and the oxygen level returns to 20.9%. This may take more than an hour depending on how saturated the sensors are.

3. Drill a 1/4 inch hole into the flue of the device under test. For most applications, flue gas samples should be taken prior to the draft diverter or any other opening that allows room air to enter the system. This prevents room air from mixing with gases in the flue and diluting the test sample.

It is important to use manufacturers recommended test locations whenever possible.

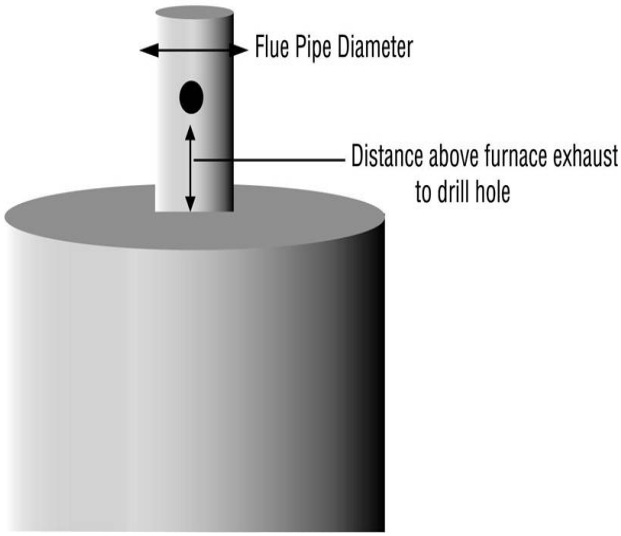
Refer to the figure below for calculating the sample hole location.

Flue pipe diameter x 1.5 = proper hole location

Example for a 4 inch flue:

4 inches x 1.5 = 6 inches

The hole should be drilled 6 inches above the furnace exhaust.



The figures on the following pages show typical test locations on commonly encountered equipment.

TYPICAL TEST LOCATIONS

Atmospheric Gas Fired Fan Assist Boiler / Furnace

Typical Test Locations

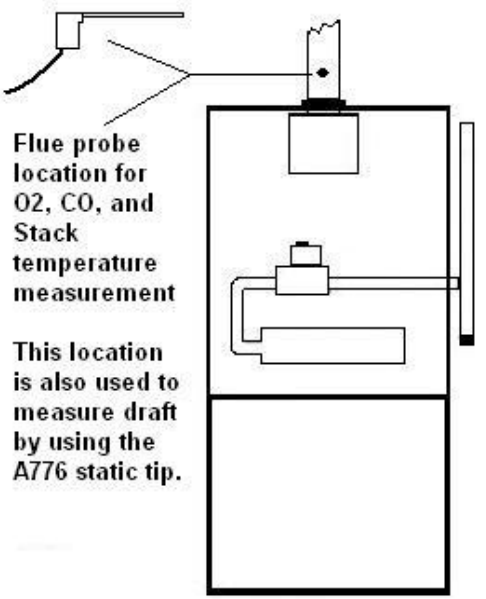


Figure 1

It is important to use manufacturers recommended test locations whenever possible.

TYPICAL TEST LOCATIONS

Condensing Boiler / Furnace

Typical Test Locations

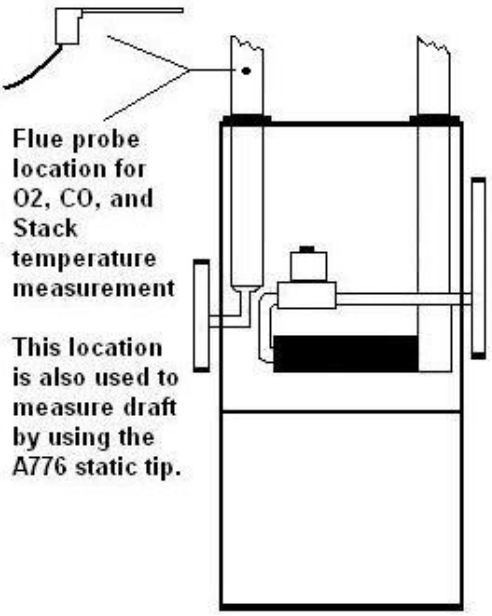


Figure 2

It is important to use manufacturers recommended test locations whenever possible.

TYPICAL TEST LOCATIONS

Atmospheric Forced Air Furnace

Typical Test Locations

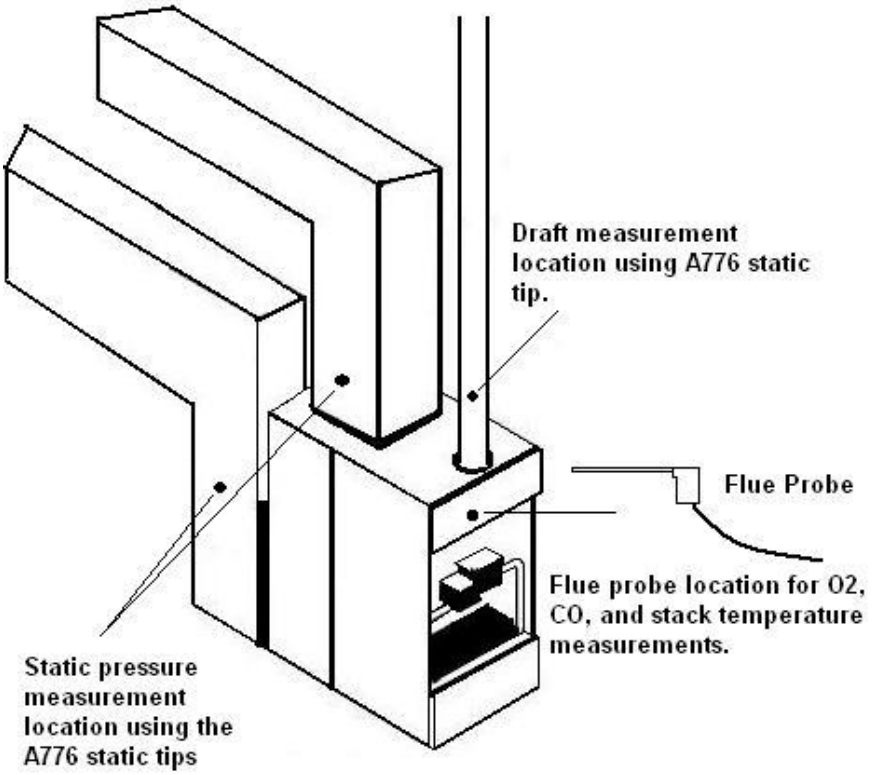
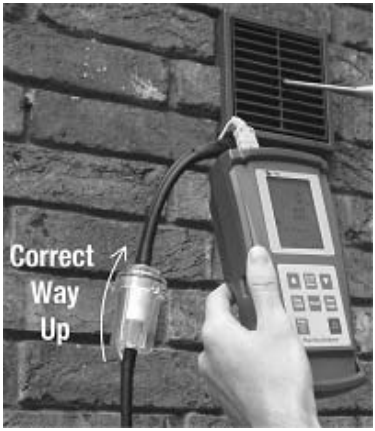


Figure 3

It is important to use manufacturers recommended test locations whenever possible.

4. Insert the flue probe into the sample hole of the device under test. The probe tip should be in the middle of the flue pipe or exhaust stream.

Ensure the In-Line Filter / Water Trap hangs below the analyzer in the proper vertical position when readings are being taken. Failure to comply reduces the effectiveness of the water trap and may result in damage to the instrument. Refer to the pictures below for correct and incorrect use.





WARNING: - Should the CO reading rise above 2,000ppm a continuous series of Alarm Beeps will be heard. The Probe should immediately be disconnected from the instrument and the instrument returned to a clean air environment. This Alarm alerts the user that there is a high concentration of CO, and this procedure will protect the sensors within the instrument. The alarm level can be changed. Please see Appendix D

Make sure to check the water trap periodically during testing to ensure it does not fill with condensate and empty it as necessary. If the filter begins to fill during a test, open the lid and empty out the condensate. After closing the lid, allow readings to stabilize again.

IMPORTANT: The water trap is fitted with a water block filter (p/n A794W) in the lid to prevent water from flowing down into the pump. If the water trap fills the water block filter will stop the flow to the analyzer and FLO ERR will display. The water trap should be emptied immediately if this happens. The water block filter may need to be dried out or replaced before testing can resume.

5. Allow the readings to stabilize. Multiple combustion analysis displays are available to provide the various test results. Use the Scroll/Enter Key to move through the various combustion displays.



- **Combustion Display 1 (Default Start Up Display)**
- Displays Carbon Monoxide (CO) reading in parts per million (ppm)
- Displays calculated Carbon Dioxide (CO2) figure in percentage (%)
- Displays calculated CO/CO2 (Ratio) figure. The 712 calculates this number by first converting the CO2 measurement from percentage to ppm. The formula for this conversion is: CO2ppm=(CO2%*10,000). This ratio is not used in any other calculations. 10,000ppm = 1%

Pressing the Scroll Enter key changes the display:



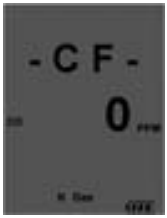
- **Combustion Display 2**
- Displays Oxygen (O2) reading in percentage (%)
- Displays calculated Excess Air (X Air) figure in percentage
- Displays calculated Efficiency (Eff.) figure in percentage
- Pressing the Up Arrow Key will toggle between Gross & Net Efficiency **(Note: Gross Efficiency is used in the USA)**

Pressing the Scroll Enter key changes the display:



- **Combustion Display 3**
- Displays Carbon Monoxide (CO) reading in parts per million (ppm)
- Displays Oxygen (O2) reading in percentage (%)

Pressing the Scroll Enter key changes the display: (Next Page)



• **Combustion Display 4**
• Displays CO air free (-CF-)

CO air free takes into account excess air (make up air) and factors this out of the displayed reading. Some systems inject extra air to ensure complete combustion. This can dilute the CO sample resulting in a low CO reading when the standard CO display is being read.

This display should be used if the manufacturer specifications are stated as CO air free. If it is used on a system that is not specified in CO air free the displayed reading may appear abnormally high as compared to the manufacturer specification.

The formula for CO air free is: COairfree = (20.9/20.9 - O2 meas.) x CO meas.

Pressing the Scroll Enter key changes the display:



• **Combustion Display 5**
• Displays Temperature reading of Channel 1 (T1)
• Displays Temperature reading of Channel 2 (T2)
• Displays the Differential Temperature (Diff.) between ch1 and ch2
• 'oPEn' will be displayed if no 'K' type probe is connected to the thermocouple socket
• Press the Up Arrow Key to switch between ºC and ºF

Pressing the Scroll Enter key again will make the display return to combustion display 1 (Default display)

6. During a combustion test you can save, print, and send data to a computer. See pages 25 through 31. Allow readings to stabilize before saving or printing the data. Refer to page 19 for typical test results.

7. Pressure measurements can be made during a combustion test if required. Refer to page21.

8. After the test is complete, remove the flue probe from the test location and allow the analyzer to purge in a fresh air environment with the probe attached. Make sure the analyzer purges to below 15ppm. Never remove the battery to turn the analyzer off before the purge is complete. Refer to page 9 for complete instructions.

Typical Test Results

Actual test results vary depending on the equipment under test. TPI recommends you check with the manufacturer of the equipment being tested to determine specific acceptable results.

Power Burners (Gas Fired)

Oxygen	3% to 6%
Carbon Monoxide	Less than 100ppm (air free)
Stack Temperature	300°F to 500°F
Draft	-0.15 inH2O

Power Burners (Oil Fired)

Oxygen	4% to 7%
Carbon Monoxide	Less than 100ppm (air free)
Stack Temperature	325°F to 625°F
Draft	-0.15 inH2O

Gas Fired Burners (Atmospheric / Fan Assist)

Oxygen	7% to 9%
Carbon Monoxide	Less than 100ppm (air free)
Stack Temperature	325°F to 500°F
Draft	-0.15 inH2O to -0.4 inH2O

Thermometer Mode

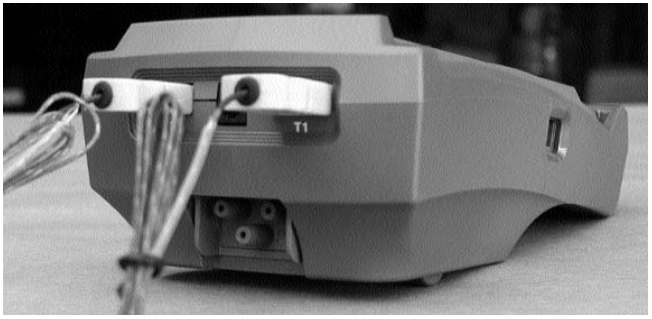
With the analyzer running, press the Func Key to access the thermometer function. In this mode the 709 functions like a K-Type thermocouple thermometer. The pump will stop running when in this function.

The thermometer function allows you to perform temperature tests.



Function Display 1 (Temperature)
T1 Temperature
T2 Temperature
Differential Temperature

1. Ensure you have a 'K' type probe connected to one or both of the thermocouple sockets T1 or T2 (refer to figure below)



WARNING: - There is ONLY one correct way to connect the 'K' type thermocouple plug into the socket (see page 7). Forcing the plug into the socket the wrong way may result in damage to the instrument.

2. Touch the temperature probe to the item under test and read the displayed temperature.
Other Features:

- Pressing the Up Arrow Key will toggle between ºC and ºF
- Pressing the Scroll/Enter Key will toggle the Differential Temperature ON and OFF
- Single Log Mode (S-Lg) can be activated to log temperatures. See section 10.
- 'oPEn' will be displayed if no 'K' type probe is connected to the thermocouple socket

Manometer Mode

With the analyzer running, press the Func Key repeatedly to access the thermometer function. In this mode the 709 functions like a differential manometer. The pump will stop running when in this function.

The pressure function allows you to perform draft and pressure tests.



Function 2 Display (Pressure)
Pressure reading

1. Ensure you have Pressure Sampling Tube connected to one or both of the Pressure Ports and there are no restriction in the tubing (see figure below)



2. Zero the display by pressing the Down Arrow Key.
3. Connect the tube(s) to the device under test and read the pressure on the display.

Other Features:

- Pressing the Up Arrow Key will scroll through mbar, kPa and inH2O
- Pressing the Down Arrow Key will Zero the Pressure reading
- Pressing the Scroll/Enter Key will toggle the ch2 temperature reading ON and OFF

The 709 incorporates a differential manometer. This means when a single hose is connected to the (+) port and pressure is applied, the 709 will read positive pressure. If a single hose is connected to the (-) port and pressure is applied, the 709 will read a negative pressure. If both ports are connected to a pressure, the 709 will read the difference (P1 - P2) between the two.

SETTING DATE AND TIME

With the analyzer running, press the Func Key repeatedly to access the date/time screen. From this function Time, Date and Year can be changed.



Function Display 4 (Date / Time)
Time
Date / Month
Year

If the Date and Time do not need to be changed, press the Func Key to bypass this function and return the 712 to combustion analyzer mode (Function 1).

1. Once the Time, Date, and Year screen is displayed, press the Scroll/Enter Key once to allow you to change the data.

2. Press the Up Arrow Key to Increase the Minutes.

3. Press the Down Arrow Key to Decrease the Minutes.

4. Press the Scroll/Enter Key to confirm the desired Minute and move onto the Hours.

5. Repeat steps 2 to 4 to change the Hour, the Day, the Month and the Year.

6. The unit will return to normal after the desired Year has been confirmed

STORING DATA

During testing data can be stored for later retrieval.

When data is saved, all data previously in the address will be overwritten.When saving pressure/draft readings, select an address different from the one used to save combustion readings.

1. Press the Store Key. *To cancel storing information press the Store Key and use the Up/Down Arrow Keys to select "Yes" and press the Scroll/Enter Key.*

2. "Addr" and an address location from 0 to 49 will flash on the display. Use the Up/Down Arrow Keys to select the desired location to store the data and press the Scroll/Enter Key. *To cancel storing information press the Store Key and use the Up/Down Arrow Keys to select "Yes" and press the Scroll/Enter Key.*

3. The data is stored and "End" will display. Use the Up/Down Arrow Keys to select "Yes" to stop storing data and return to normal operation or select "No" to store data again. Press the Scroll/Enter Key.

   You have just successfully stored a set of readings which can be reviewed on screen (see 8) or sent to the IR printer (see 9)

RECALLING DATA

The recall feature allows you to display stored data or retrieve the last date of calibration.

Recalling Saved Data or Calibration Date

1. Press the Recall button once.
2. The display will show “Stor” and “Cal”. Use the Arrow buttons to select the desired function. *To cancel recalling information press the Recall Key and use the Up/Down Arrow Keys to select “Yes” and press the Scroll/Enter Key.*

Stor - Selecting “Stor” allows you to display the information in a memory location.

1. Press the Recall button once. The display will show “Stor” and “Cal”. Using the Arrow buttons select “Stor” by making it blink. Press the Scroll/Enter button.
2. “Addr” will be displayed and a number from 0 to 49 will flash.
3. Using the up and down arrows, select the memory location of the readings you want to display.
4. Press the Scroll/Enter key once. The 709 will display the date and time screen showing when that reading was stored.
5. Use the up and down arrows to scroll through the data that was saved.
6. Press the Scroll/Enter button and “End” will be displayed and “Yes” will flash. Press the Scroll/Enter button if you are finished recalling data or use the Arrow buttons to select No to recall data from other locations.

CAL - Selecting “CAL” allows you to display the last date of calibration.

1. Press the Recall button once. The display will show “Stor” and “Cal”. Using the Arrow buttons select “Cal” by making it blink. Press the Scroll/Enter button.
2. “CAL” will blink and the last calibration date will be displayed in DD/MM.YYYY format.
3. Press the Scroll/Enter button, “End” will be display and YES will blink. Press the Scroll/Enter button to return to normal operation.

PRINTING DATA

WARNING: - To operate correctly there must be a clear line of sight between the Infrared Window on the instrument (see 3.3) and the Infrared Window on the IR Printer (see Printer instructions). Place the printer so it is no closer than approximately 6 inches from the analyzer.

1. Press the Print Key once 'rEAL', “Stor’, and “Cal” will be displayed and ‘rEAL’ will be flashing. *To cancel printing press the Print Key and use the Up/Down Arrow Keys to select “Yes” and press the Scroll/Enter Key.*

   Selecting ‘rEAL’ will cause the 709 to print the test data currently on the display (real time data). Selecting ‘Stor’ will cause the 709 to print data stored in memory. Selecting “Cal” will cause the 709 to print the last date of calibration. Use the Up and Down Arrow Keys to select the desired print mode and press the Scroll/Enter Key.

   REAL Print Mode - If rEAL print mode is selected, the analyzer will display ‘Wait’ ‘out’ and bars will change position on the LCD until printing is complete.

   STOR Print Mode - If Stor mode is selected, 'Addr' will be displayed on the top line along with 'SA ' and a location number from 0 to 49 will be flashing on the screen. Select the required address location that you wish to print data from by pressing the Up and Down Arrow Keys and press the ‘Scroll/Enter’ Key. The analyzer will display ‘Wait’, ‘out’ and bars will change position on the LCD until printing is complete.

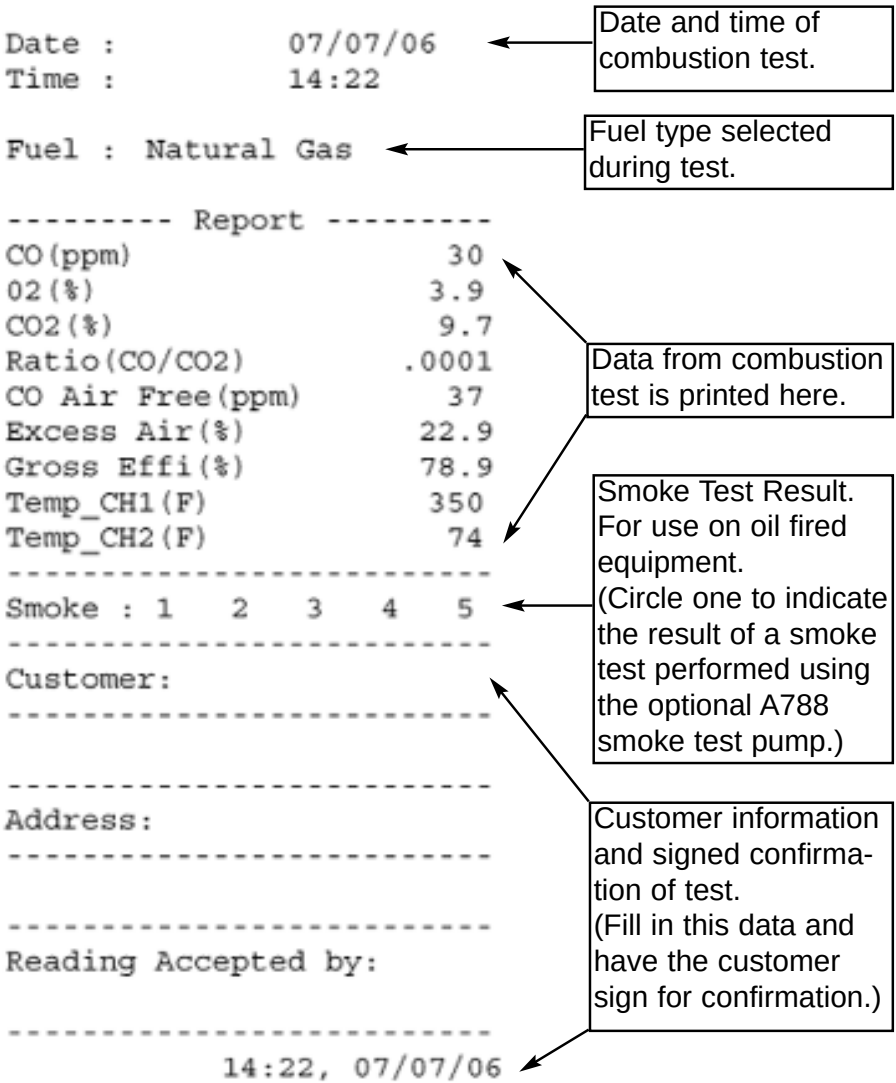
   CAL Print Mode - If Cal print mode is selected, the analyzer will display ‘Wait’ ‘out’ and bars will change position on the LCD until printing is complete.

   After printing is complete, ‘End’ will be displayed and ‘YES’ (or ‘no’) will blink. Selecting ‘YES’ will return the 709 to normal operation, selecting ‘no’ will return the 709 to the print selection screen so you can print again. Use the Up and Down Arrow Keys to make the selection and press the Scroll/Enter Key.

   Combustion and pressure/draft printouts must be performed separately. Perform a combustion test and save the data. Perform a pressure/draft test and save the data in a different address. Print each address separately.

PRINTING DATA (Continued)

Printout Interpretation



SPECIFICATIONS

Instrument

Operating Temperature Range	14°F to +122°F (-10°C to +50°C)
Battery	1.5V AA size (3)
Battery Life	> 6 Hours
Fuels	Natural Gas, LPG, Light Oil, Heavy Oil OPT 1 (Bituminous Coal), OPT 2 (Anthracite Coal), OPT 3 (Coke), OPT 4 (Butane), OPT 5 (Wood), OPT 6 (Bagasse)
Display	Backlit LCD
Data Storage	50 sets of readings
Time & Date	24 Hour Real Time Clock
Dimensions	200mm x 90mm x 60mm
Weight	500g
Casing	Rubber Boot as Standard
Switch Off	Failsafe
Exhaust	Safety Spigot
Conforms to	BS7927 (and the draft BS7967)

Flue Temperature Probe

Construction	Pistol Grip with Stainless Steel Shaft
Hose Length	2500mm
Insertion Length	200mm
'K' Type Thermocouple Accuracy	+/- 0.3%, +/- 1°C
Maximum Temperature	800°C

Gases

	Range	Resolution	Accuracy
Oxygen	0-25%	0.1%	+/- 0.3%
Carbon Monoxide	0-10,000 ppm	1 ppm	+/- 5 ppm or 5% Whichever is greater
Carbon Dioxide	0-25%	0.1%	Calculated
CO/CO2 Ratio	0-0.999	0.001	Calculated
Combustion Efficiency	0-100%	0.1%	Calculated

SPECIFICATIONS (Continued)

Pressure Measurement

Selectable Ranges	mbar, kPa and inH2O
Range	- 150 mbar to + 150 mbar -15 kPa to + 15 kPa -60 inH_2O to 60 inH_2O
Resolution	0.01 mbar, 0.001 kPa, 0.001 inH_2O
Accuracy	+/- 0.5% fsd

Temperature Measurement

Input Type	K-Type thermocouple
Range	-58°F to 1832°F (-50°C to 1000°C)*
Resolution	1°F (1°C)
Accuracy	+/- (0.3% of rdg + 2°F) or +/- (0.3% of rdg + 1°C)

* The thermocouple supplied (GK11M) has the ability to measure temperatures in the -50°F to 950°F range. The 712 accepts industry standard K-type thermocouple probes with sub-mini connectors.

CALIBRATION & SERVICE

It is recommended that your analyzer be calibrated every 12 months. When calibration is due the analyzer will remind you by flashing “CAL DUE Err” at start up and then return to normal operation. Please consult Test Products International for further details or send your analyzer to the address below for service.

TPI / Attn. Repair
9615 SW Allen Blvd. Suite 104
Beaverton, OR 97005

The following are consumable parts for the instrument:

In-Line Filter Element (pkg of 5)	User Replaceable	A794F
Mini Pump Protection Filter Assem.	User Replaceable	A763
**Oxygen Sensor	User / Factory Replaceable	A761
**Carbon Monoxide Sensor	User / Factory Replaceable	A760

***Sensor replacement requires calibration gas.*

WARRANTY

Your TPI 709 Flue Gas Analyzer is guaranteed free from defects in materials and workmanship for 3 Years from the date of purchase. This guarantee does not affect your statuary rights. For additional information please refer to the included warranty card or contact TPI at 800-368-5719.

To obtain warranty performance or maintenance on your analyzer: - Include with the product your name, address, phone number, written description of the problem and proof of purchase date. Carefully package and return to:

TPI / Attn. Repair
9615 SW Allen Blvd. Suite 104
Beaverton, OR 97005

Appendix A: General Maintenance

All combustion analyzers use consumable items such filters and probes. These items are user serviceable and can be taken care of by the operator.

The consumable items that will require operator attention are the water trap / filter assembly, flue probe, pump protection filter, and ambient temperature probe.

The recommended maintenance schedule for your analyzer is as follows:

Maintenance Performed	**Frequency**
Water trap Check	Once per week (Once per day for analyzers
Filter Check	that see heavy use or are used in oil fired
	applications)
Pump Operation Check	Once per month (More often for analyzers
Flue Probe Integrity Check	that see heavy use or are used in oil fired
Thermocouple Probe Check	applications)

Water Trap Check
Visually check the water trap for:

1. Cracks in the bowl.
2. Broken ears on the bowl where the lid locks on.
3. Broken ears on the lid.
4. Worn out o-ring on the lid.
5. Loose connection to the flue probe tubing.

Filter Check

Signs of dirty or water saturated filters are a slow pump, flow error displayed when the flue probe is connected, and measurements that take longer than normal.

TPI analyzers use three filters to protect the pump and sensors. The first filter to check is the A763 mini pump protection filter. (see picture below)



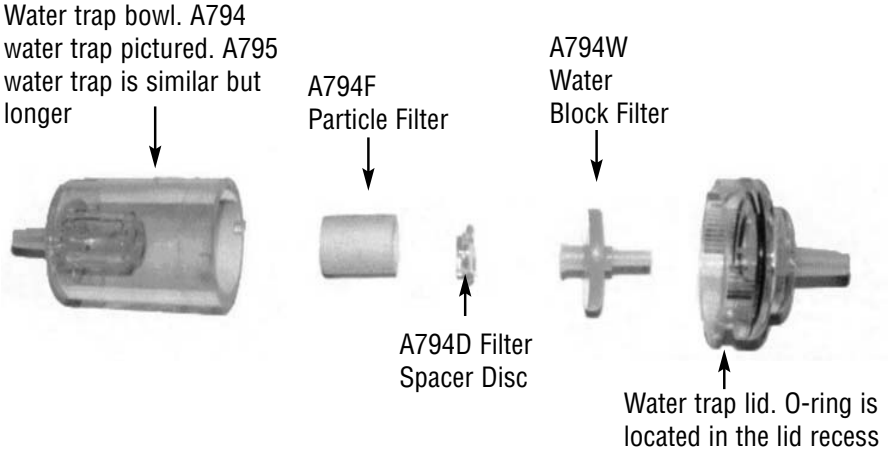
A763 Pump Protection Filter

Look in the inspection window to check the filter. When the filter material becomes dark, pull the black nose cone out of the tubing and replace the ball filter inside.

Appendix A: General Maintenance (continued)

Filter Check Continued

The other two filters are located in the water trap. The main filter is the A794F particle filter. This filter stops debris and dust from traveling down to the analyzer. The secondary filter is the A794W water block filter. This filter stops flow in the event the water trap fills with condensate. Refer to the picture below.



Open the water trap and look at the A794F particle filter. The filter will typically get dirty from the inside first. If the filter is dark on the inside a replacement filter should be installed.

If the A794F is clean but saturated with water a replacement should be installed to ensure proper flow. The saturated filter can be left to dry and reused later.

Pump Operation Check

1. Turn the analyzer on as outlined on page 8. Do not connect anything to the inlet. Wait until the analyzer has completed the initial purge and sensor check and is operating normally prior to proceeding to step 2.

2. Cover the analyzer inlet with your finger. The analyzer should display “FLO ERR” and a rapid beeping should be heard.

If the analyzer does not beep and display “FLO ERR” this may be an indication the flow sensor requires calibration, the pump is faulty, or there is an internal leak. The analyzer should be returned for factory service.

Appendix A: General Maintenance (continued)

Flue Probe Integrity Check

NOTE: Perform this check after performing the Pump Operation Check outlined on the previous page.

1. Turn the analyzer on as outlined on page 8. Do not connect anything to the inlet. Wait until the analyzer has completed the initial purge and sensor check and is operating normally prior to proceeding to step 2.

2. Connect the A763 mini pump protection filter and flue probe assembly to the inlet of the analyzer and the yellow thermocouple connector to input T1.

3. Repeatedly press the Scroll/Enter key until temperature is displayed. If the displayed temperature is approximately the ambient temperature the thermocouple is operating properly and you may proceed to the next step to continue the test. If the displayed temperature is "OL" the thermocouple is open and the probe is in need of factory service.

4. Cover the end of the flue probe with a small piece of tube and pinch the end close. After a short period of time the analyzer should display "FLO ERR" and a rapid beeping should be heard. If this happens the flue probe his operating properly and the integrity test is complete. If the analyzer does not display "FLO ERR" this is an indication of a possible leak somewhere in the flue probe and you may proceed to the next step for further tests.

5. Pinch the hose below the handle of the flue probe. If the analyzer displays "FLO ERR" there is a leak in the handle assembly and the probe needs to be factory serviced. If the analyzer does not display "FLO ERR" proceed to the next step for further tests.

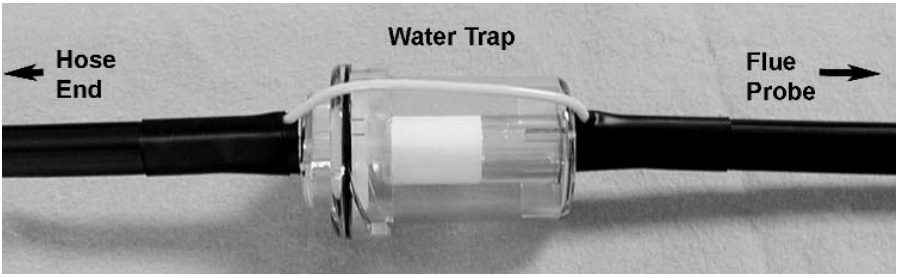
6. Pinch the hose between the analyzer and the water trap. If "FLO ERR" still does not display there may be an internal leak, pump problem, or other issue and the analyzer needs to be factory serviced. If "FLO ERR" is displayed there is a leak in the water trap assembly and the water trap assembly should be checked as outlined on page 39 & 40.

Appendix B: A773 SULFUR FILTER INSTALLATION & MAINTENANCE

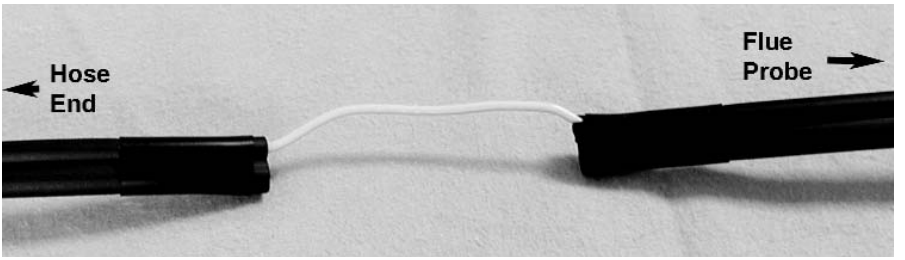
When performing combustion tests on oil fired equipment it is important to use the optional A773 sulfur filter. Failure to do so can result in incorrect and readings. This filter also protects the sensors from the affects of sulfur. The A773 does not have to be removed when working with other types of fuels.

PROCEDURE

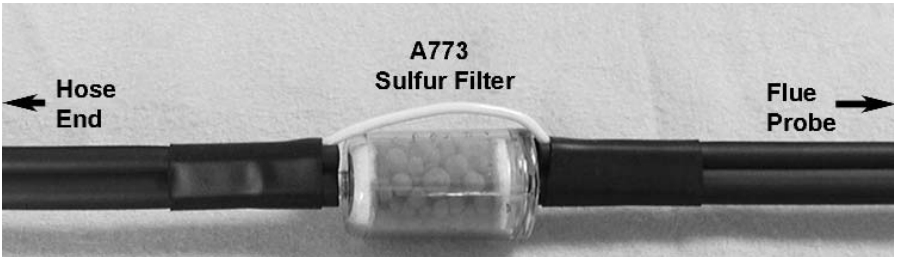
1. Begin with the water trap section of the flue probe oriented as shown in the picture below.



2. Remove the water trap from the flue probe hose. (See picture below)



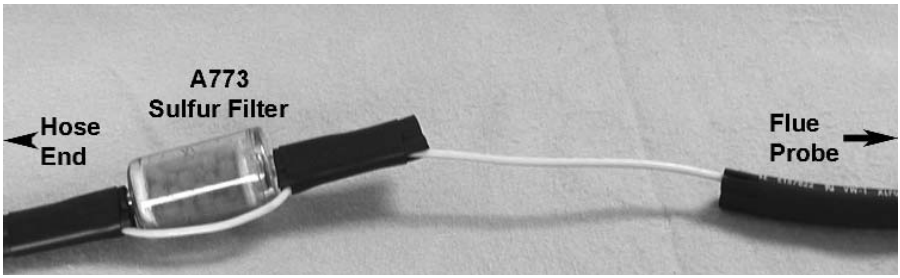
3. Insert the A773 sulfur filter flue probe tube where the water trap was removed..



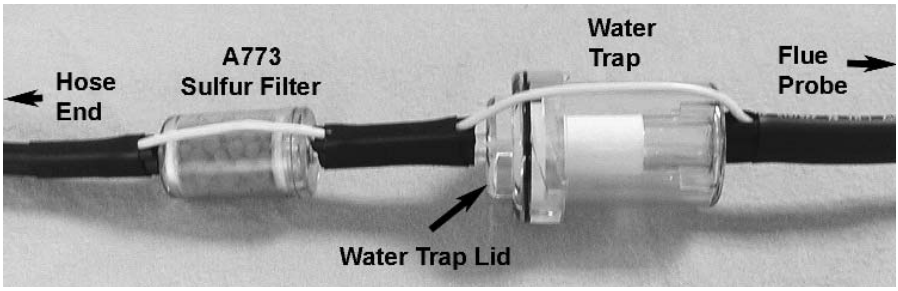
Appendix B: A773 SULFUR FILTER INSTALLATION & MAINTENANCE

4. Beginning on the "Flue Probe" side of the A773 sulfur filter, pull the yellow thermocouple cord out of the channel of the flue probe tube. Pull out approximately the length of the water trap that was removed.

5. Being careful not to cut the yellow cord, cut out a section of the flue probe tubing the length of the water trap on the "Flue Probe" side of the A773 sulfur filter. (See picture below)



6. Install the water trap in the flue probe hose where the piece was cut out. Make sure the water trap is positioned correctly. The water trap lid should face the "Hose End" side of the hose.



A773 SULFUR FILTER MAINTENANCE:

The A773 should be replaced when most of the pellets become discolored, usually white or black.

If the A773 begins to trap condensate and fill with water but the pellets are not discolored to the point replacement is required, it should be removed and allowed to dry. Once it is dry it can be reused.

Appendix C: ERROR CODES & TROUBLESHOOTING

The 709 analyzer will display certain codes to let you know of a malfunction.

Code Displayed	Code Definition	Possible Causes	Corrective Action
CAL DUE Err	Annual calibration is due.	Last calibration was performed over one year ago.	The analyzer will perform properly after this message displays but should be returned to TPI when possible for annual calibration.
Flo Err	Pump not drawing sample at correct flow rate.	Blockage / kink in flue probe hose. Dirty or blocked filter(s). Worn pump.	Check and rectify. See Appendix A. Replace filter(s). See Appendix A. Return to TPI for service.
InIt O2 Err	Oxygen sensor failed to initialize	Flue probe connected to 709 prior to power up. 709 did not purge completely from last sample. Worn or defective oxygen sensor.	Disconnect probe and restart. Purge for 20 minutes and restart. Return to TPI for sensor replacement or install new sensor.* Try manually initializing the sensor. See Appendix E.
InIt CO Err	Carbon monoxide sensor failed to initialize.	Flue probe connected to 709 prior to power up. 709 did not purge completely from last sample. Worn or defective carbon monoxide sensor.	Disconnect probe and restart. Purge for 20 minutes and restart. Return to TPI for sensor replacement or install new sensor.* Try manually initializing the sensor. See Appendix E.
Lo bat	Low battery.	Batteries needs to be changed.	Charge batteries. (See Appendix J.
oFL	Overflow indication. The pressure being measured is outside the maximum measurement capability.	Pressure being measured is too high or low. Pressure sensor damaged or defective.	Remove pressure source. Return to TPI for service.
oFL	Overflow indication. The temperature being measured is outside the maximum measurement capability.	Temperature being measured is too high or low.	Remove pressure source.
oPEn	Unable to read thermocouple (temperature).	Temperature probe not connected to input. Worn temperature sensor.	Connect temperature probe to analyzer. Replace temperature probe or flue probe.

*Sensor replacement requires calibration gas.

Appendix C: ERROR CODES & TROUBLESHOOTING (Continued)

Problem	Possible Cause	Corrective Action
Efficiency reading incorrect	NET efficiency selected. Ambient temperature probe not plugged in to T2. Incorrect fuel selected.	Select GROSS efficiency. See page 17. Plug ambient probe into T2. See page 11. Select the proper fuel for the equipment being tested. See page 8.
Readings are erratic when working on oil fired equipment.	A773 oil filter not installed or installed incorrectly.	Make sure the optional oil filter (A773) is installed. See Appendix B.
One or all of the following parameters; Ratio, CO air free, excess air, and efficiency read and print dashes.	Measured values are such that the calculated values of these parameters are out of range.	Redo combustion test. Since these are calculated values, the measure values must be within certain levels for these to display. If the measured oxygen level is above 19.9% these parameters won't read. These parameters might not display or be applicable in some tests.
Analyzer won't turn off	Oxygen and/or carbon monoxide levels outside limits.	Allow the analyzer to purge longer.

Appendix D: CO ALARM & AUTO OFF SETTINGS

Setting the Carbon Monoxide Alarm Point and/or Auto Power Off Mode

The CO alarm and auto power off settings can be changed as necessary by performing the following procedure.

WARNING : Changing parameters in field calibration mode can adversely affect the operation of your analyzer. Follow the instructions carefully.

1. With the analyzer running, press and hold the FUNC and Down Arrow keys for approximately 5 seconds until a beep is heard. Press and hold the Scroll/Enter Key down until 'FILD CAL' is displayed. The 709 will cycle through a 30 second countdown then display 'CAL', Air', gAS'.

2. Use the Up Arrow Key to select 'Air' by making it blink. Press the Scroll/Enter Key to accept the selection.

3. 709 Display: 'CAL', 'FLo', 'oPEn'. Action : Press the Func Key to bypass.

4. 709 Display: 'CAL', 'FLo', 'CLos'. Action : Press the Func Key to bypass.

5. 709 Display: '0ppm', 'Co', 'rEF'. Action : Press the Func Key to bypass.

6. 709 Display: '20.9%', 'o2', 'rEF'. Action : Press the Func Key to bypass.

7. 709 Display: '2000', 'A-r', 'SEt'. Action : If you are not changing the CO alarm point press the Func Key. Otherwise press the Up and Down Keys to set the ppm level the alarm will sound at. Factory default is 2000ppm. Press the Scroll/Enter Key to accept the selection.

8. 709 Display: 'Auto', 'oFF', 'En'. Action : If you are not changing the auto power off mode press the Func Key. Otherwise press the Up and Down Arrow Keys to enable (En) or disable (dis) the auto off function. Factory default is enabled (En). Press the Scroll/Enter Key to accept the selection.

9. 709 Display: 'CAL', 'StoP', 'go'. Action : Press the Up Arrow Key to select 'StoP' by making it blink and press the Scroll/Enter Key to accept the selection. The 709 will return to normal operation

Appendix E: MANUALLY INITIALIZING SENSORS

If the CO or O2 sensor fails to initialize, this procedure can be performed to try and manually initialize the sensor(s).

WARNING : Changing parameters in calibration mode can adversely affect the operation of your analyzer. Follow the instructions carefully.

1. Turn the analyzer on. When the countdown reaches 26, press and hold down the Up Arrow, Scroll/Enter, and Down Arrow keys together for approximately 5 to 7 seconds. The analyzer will beep and "Fact Cal" will be displayed. Release the keys. The analyzer will cycle through a 30 second countdown then display 'CAL', Air', gAS'.
2. Use the Up Arrow Key to select 'Air' by making it blink. Press the Scroll/Enter Key to accept the selection.
3. 709 Display: 'CAL', 'FLo', 'oPEn'. Action : Press the Func Key to bypass.
4. 709 Display: 'CAL', 'FLo', 'CLos'. Action : Press the Func Key to bypass.
5. 709 Display: '0ppm', 'Co', 'rEF'. Action : Press the Scroll/Enter Key. After the 10 second countdown is complete press the Scroll/Enter Key twice.
6. 709 Display: '20.9%', 'o2', 'rEF'. Action : Press the Scroll/Enter Key. After the 10 second countdown is complete press the Scroll/Enter Key twice.
7. 709 Display: '0.0mbar', '0.0', 'oFS'. Action : Press the Func Key to bypass.
8. 709 Display: "0C", "rEF". Action : Press the Func Key to bypass.
9. 709 Display: "900C", "rEF". Action : Press the Func Key to bypass.
10. 709 Display: "120mbar", "rEF". Action : Press the Func Key to bypass.
11. 709 Display: "-120mbar", "rEF". Action : Press the Func Key to bypass.
12. 709 Display: '2000', 'A-r', 'SEt'. Action : Press the Func Key to bypass.
13. 709 Display: 'Auto', 'oFF', 'En'. Action : Press the Func Key to bypass.
14. 709 Display: 'CAL', 'StoP', 'go'. Action : Press the Up Arrow Key to select 'StoP' by making it blink and press the Scroll/Enter Key to accept the selection. The 709 will return to normal operation

If the 709 continues to fail to automatically initialize or this procedure fails to initialize the sensors, return your analyzer to Test Products International.

Appendix F: RESETTING PRESSURE SENSOR ZERO

Manually resetting the pressure sensor zero point

If the pressure sensor will not zero as described in section 6.2 use the procedure below to reset the zero point of the sensor.

WARNING : Changing parameters in field calibration mode can adversely affect the operation of your analyzer. Follow the instructions carefully.

1. With the analyzer running, press and hold the FUNC and Down Arrow keys for approximately 5 seconds until a beep is heard. Press and hold the Scroll/Enter Key down until 'FILD CAL' is displayed. The 709 will cycle through a 30 second countdown then display 'CAL', Air', gAS'.

2. Use the Up Arrow Key to select 'Air' by making it blink. Press the Scroll/Enter Key to accept the selection.

3. 709 Display: 'CAL', 'FLo', 'oPEn'. Action : Press the Func Key to bypass.

4. 709 Display: 'CAL', 'FLo', 'CLos'. Action : Press the Func Key to bypass.

5. 709 Display: 'CAL', 'LEAK', 'rEF'. Action : Press the Func Key to bypass.

6. 709 Display: '0ppm', 'Co', 'rEF'. Action : Press the Func Key to bypass.

7. 709 Display: '20.9%', 'o2', 'rEF'. Action : Press the Func Key to bypass.

8. 709 Display: '0.0mbar', '0.0', 'oFS'. Action : Press the Func Key to bypass.

9. 709 Display: '2000', 'A-r', 'SEt'. Action : Press the Func Key to bypass.

10. 709 Display: 'Auto', 'oFF', 'En'. Action : Press the Func Key to bypass.

11. 709 Display: 'CAL', 'StoP', 'go'. Action : Press the Up Arrow Key to select 'StoP' by making it blink and press the Scroll/Enter Key to accept the selection. The 709 will return to normal operation

If the 709 continues to fail to automatically initialize or this procedure fails to initialize the sensors, return your analyzer to Test Products International.

Appendix G: Technical Notes

Note 1: When performing a pressure or draft test during a combustion test, the pump can be turned on to provide a continuous sample to the sensors. This enables pressure adjustments to be made and the affect to the combustion process can be seen by returning to combustion analyzer mode. Use the FUNC Key to activate manometer mode. Press and hold the Up Arrow Key until the pump reactivates. Perform a pressure test and then use the FUNC key to activate combustion analyzer mode. Repeat this process until pressure adjustments are complete.

Note 2: Several factors affect combustion efficiency. Dirty or clogged air filters reduce the amount of air available for combustion therefore reducing efficiency. Obstructions in the flue block exhaust gases and alter the air mixture in the combustion chamber which reduces efficiency. Air leaks in the combustion chamber also alter the mixture causing decreased efficiency.

Note 3: The primary way to affect change in combustion efficiency when working with modern gas fired equipment is through gas manifold pressure adjustment. Confirm manifold pressures are within maufacturers specifications prior to performing a combustion test. Once manifold pressures are within limits a combustion test can be performed to provide information regarding any adjustments that may be needed.

Appendix H: Testing for Carbon Monoxide in Ambient Air

The 712 can be used to test for carbon monoxide in ambient air. For example tests can be performed in work spaces and living areas like offices and houses to ensure safety.

1. Following the steps outlined on page 8, turn the analyzer on in a clean air environment away from the area to be tested,

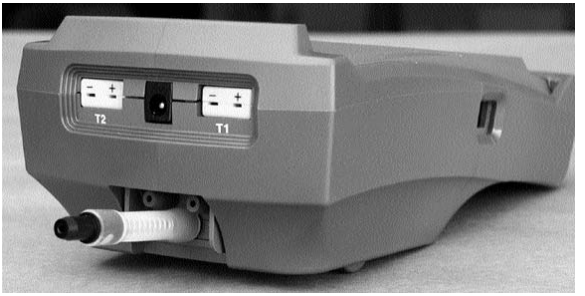
2. After the purge cycle is complete combustion display 1 will be seen. This is the default start up display and is the display to use when performing this test. Please see below.



The top display shows the carbon monoxide level.

For this test, ignore the middle and bottom displays.

3. Connect the Mini Pump Protection filter to the analyzer. See picture below.



4. Begin testing for carbon monoxide. Move from space to space to detect any CO that may be present. The CO reading will be seen in the top part of the display.

5. If necessary, the flue probe can be attached to test in ducts and plenums.

6. Refer to the chart on page 42 for a list of exposure times and levels of carbon monoxide in ambient test applications

7. When testing is complete, turn the analyzer off as outlined on page 8.

Appendix I: Carbon Monoxide in Ambient Air Chart

This chart contains maximum exposure levels and times for carbon monoxide. This is a general guidline only. It is recommended you check with your local government for guidelines in your area.



Concentration of CO in air	Exposure times and toxic symptoms
9ppm	The maximum allowable concentration for short term exposure in a living area according to ASHRAE
35ppm	The maximum allowable concentration for continuous exposure in any 8 hour period, according to federal law. (US federal law)
200ppm*	Maximum concentration allowable any time according to OSHA. Slight headaches, fatigue, dizziness, nausea after 2-3 hours.
400ppm*	Frontal headaches within 1-2 hours, life threatening after 3 hours. Maximum allowable limit in flue gas according to EPA and AGA.
800ppm*	Headache, dizziness, nausea, and convulsions with 45 minutes. Unconsciousness within 2 hours. Death within 2-3 minutes.
1600ppm*	Headache, dizziness, and nausea within 20 minutes. Death within 1 hour.
3200ppm*	Headache, dizziness, and nausea within 5-10 minutes. Death within 30 minutes.
6400ppm*	Headache, dizziness, and nausea within 1-2 minutes. Death within 10-15 minutes.
12800ppm*	Death within 1-3 minutes.

Appendix J: CARBON MONOXIDE FACTS

Carbon Monoxide (CO) is invisible, odorless, and tasteless. It is the byproduct of combustion and levels are elevated when there is incomplete combustion.

Sources of CO include:

Unvented kerosene and gas space heaters
Leaking chimneys & furnaces
Gas water heaters
Back drafting from furnaces
Wood stoves& fireplaces
Gas Stoves
Automobile exhaust
Tobacco smoke

Carbon Monoxide is picked up quickly in the body by red blood cells. At high levels of CO the body replaces oxygen with carbon monoxide.

The most common symptoms of CO poisoning are headache, dizziness, weakness, nausea, vomiting, chest pain, and confusion. High levels of CO inhalation can cause loss of consciousness and death. Unless suspected, CO poisoning can be difficult to diagnose because the symptoms mimic other illnesses.

People who are sleeping or intoxicated can die from CO poisoning before ever experiencing symptoms.

Please see the next page for a list of exposure times and symptoms.

Appendix K: Battery Replacement

When the battery status indicator is empty the batteries should be changed immediately. For optimum performance replace the batteries with 3 AA size alkaline batteries. The procedure for replacing batteries is as follows:

1. Turn the analyzer over and locate the phillips head battery cover screw. See picture below.



2. Loosen the screw. Pull out on the screw to remove the battery cover.

3. Remove the old batteries and observing the polartiy markings in the battery compartment, install the new batteries.

4. Re-install the battery cover by fitting the bottom part in first.

5. Tighten the battery cover screw.