Agilent G3163A
Real-Time Gas Analyzer

Getting Started

Agilent Technologies

Notices

Manual Part Number

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Contents

Getting Started

The Agilent G3163A Real-Time Gas Analyzer (RTGA) monitors gaseous process streams and produces trend plots and Excel-compatible data files.

The hardware consists of:

- An Agilent Technologies 5973N Mass Selective Detector, with the Real-Time Gas Analyzer hardware interface
- An Agilent 19265B Temperature Controller/thermal jacket
- An MKS PDR2000 Pressure Gauge/Controller
- A sample inlet valve
- Associated plumbing
- A personal computer (PC), as described on the next page

The analyzer is controlled by Agilent 5973 MSD ChemStation software. Method creation and data processing are done by MS Sensor 2.0 (Diablo Analytical, Inc.) software. Both programs run on a personal computer (PC).

Installation

Hardware and software are installed by Agilent Technologies personnel, who also check out the entire system. The information on this page is provided for the user for future reference.

Minimum computer requirements

- 300 MHz Pentium PC with a minimum of 128 MB system memory
- 2 Gbyte hard drive
- Windows 2000

MSD ChemStation

See the MSD ChemStation documentation for the installation procedure. MSD ChemStation software, including BootP and the SICL drivers, must be correctly installed before running Real Time Gas Analyzer software. Software revision must be G1701 DA (D.00.00.38) or higher.

Real Time Gas Analyzer

Before installing the Real Time Gas Analyzer software, read the document **release notes.htm** in the root directory of the Real Time Gas Analyzer CD-ROM. This document contains installation and usage information that may not be included in the software manual or help file.

Install Real Time Gas Analyzer on the same drive as MSD ChemStation. To begin installation, run the program **setup.exe** in the root directory of the Real Time Gas Analyzer CD-ROM. Follow the on-screen instructions.

Theory of operation

The sample interface for the Real Time Gas Analyzer is shown in Figure 1.

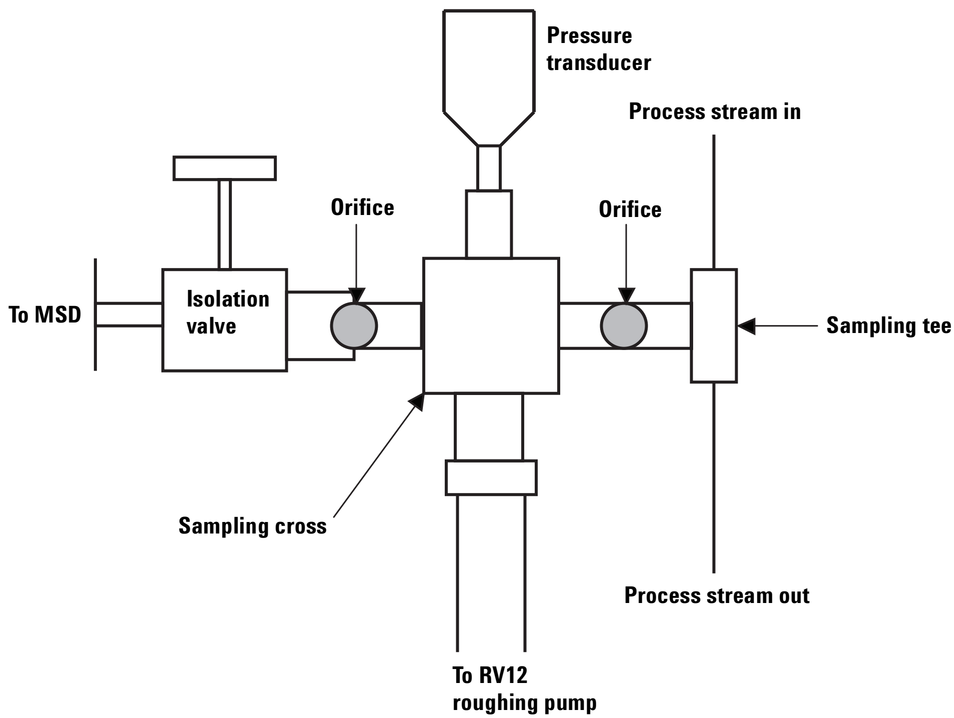


Figure 1 The sample interface

The interface consists of a sampling *tee* and a sampling *cross*. Sample input tubing is connected to the top of the sampling tee. One branch of the tee is connected to the sampling cross while the other is a vent line for excess sample. Since only a small fraction of the sample input will flow into the sampling cross, the bulk of the sample can be routed back into the process, if desired, or vented.

A fixed orifice (30 µm i.d.) limits the amount of sample that is drawn. The first orifice is in between the sampling tee and the sampling cross. One branch of the cross connects to the large vacuum pump (RV12). This pump reduces the pressure in the cross and pulls the majority of the sampled stream out to waste.

A second leg on the cross allows a precision pressure transducer to read the cross pressure. This signal can be used to adjust the data for changes in sample pressure.

The final branch contains a second orifice that further limits the amount of sample reaching the mass spectrometer and allows the mass spectrometer to maintain the necessary vacuum. The default restrictor size is 50 µm for this stage.

Flow then passes through a vacuum isolation valve that is useful for troubleshooting and maintenance. The outlet of the isolation valve connects to the mass spectrometer interface and directs the sampled stream to the ionization region in the mass spectrometer.

The two orifices and the large vacuum pump allow the high vacuum mass spectrometer to directly sample a gaseous input with minimal dwell time. A thermal jacket envelopes the sampling tee and the cross to maintain the desired sample temperature until high vacuum is encountered. The Agilent 19265B Temperature Controller regulates this temperature to the user-selected setpoint.

If excess sample is to be vented, it is recommended that some length of tubing be attached to the outlet of the sample tee to limit back diffusion of air into the cross.

Setting up the hardware

Connecting sample lines to the sample tee after temperature and pressure controllers

The sample input and output connections are standard 1/16-inch Swagelok fittings. By using 1/16-inch tubing, the dwell time of the sample line can be minimized without introducing a large pressure drop. The sample input is connected to the top of the interface and the vent or process return is connected to the bottom of the interface. To make a new fitting connection, make sure the tube is fully inserted into the fitting body. Finger-tighten the fitting and then tighten ¾ of a turn with a 5/16-inch wrench on the compression nut and a 5/16-inch wrench on the adapter body.

If necessary, user-supplied fittings can be used to adapt process lines to the 1/16 inch required for the interface. Heating the sample lines is the responsibility of the user.

Temperature controller operation and maintenance

Changing the interface temperature

The control panel of the 19265B temperature controller is shown in Figure 2.

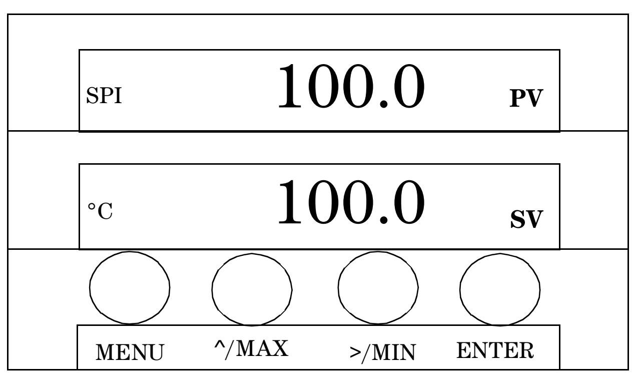


Figure 2 Thermal controller interface

While the controller is running, it should flash SPI intermittently in the Process Value (PV) window. This is normal.

On the 19265B controller, the setpoint can be changed with the following keystrokes.

1 Press **MENU** once. The SetPoint Value (SV) lower display flashes in the hundreds place.
2 Press **^/MAX** to increase this value. Then press **>/MIN** to move to the next place. Repeat until the value desired is loaded.
3 Then press **ENTER** to load the new value.

NOTE Maximum temperature for the interface is 200 °C. Do not enter values higher than this into the controller.

Pressure sensor operation and maintenance

To connect the pressure sensor to the cross:

The pressure sensor is connected to the sampling cross with standard VCR4 fittings. To install a new pressure sensor, loosen the cap fitting with a 5/8- and 3/4-inch or adjustable wrenches.

Use the lint-free gloves included with the MSD ship kit to handle the VCR4 gasket. Carefully place the gasket on top of the cross fitting and place the pressure sensor on top of the gasket. This is best done if the female fitting on the pressure sensor is slid back to allow the sealing surfaces to meet.

Finger-tighten the male and female nut assemblies. Using the wrenches, tighten the fittings an additional 1/8 of a turn.

To connect the pressure sensor controller to the PC:

Two cables are included with the pressure sensor controller. One (part no. CB628S-3-10) is for connecting the sensor to the controller while the other (part no. CBPDR-1-10) is for connecting the controller to the PC. An appropriate power cord is also included for the sensor controller.

To configure the pressure sensor controller:

The controller has no On/Off switch so, once it is plugged in, the LED display will light and begin to flash. To obtain accurate readings, the PDR 2000 Controller needs to be configured for the sensor in terms of *units*, *full scale*, and *zero*.

1. To begin configuration, press the [**Select**] button on the controller. The display will flash **OFF** and the LED indicator will be on **SetPt1 Hi**.
2. Press **[Select]** four times so that **Units** is indicated. Use the [**Raise**] and [**Lower**] buttons to scroll through the options until **torr** is shown. Press [**Select**] to choose **torr**; the controller will advance to the **Calibrate** option.
3. Press [**Select**] again to move to the **Full Scale** option. Make sure that the controller is set to the pressure sensor channel (CH1 or CH2, CH1 preferred), then use [**Raise**] and [**Lower**] to set the full scale value to that of the sensor. For the sensor supplied with the RTGA interface, this value is 10 torr.

The controller is now configured and ready to be zeroed.

To zero the pressure sensor:

The sampling pressure sensor needs to be zeroed initially and periodically. To check the current zero setting, make sure that the roughing pump for the interface is on. Close the isolation valve to the mass spectrometer and plug the sample input and output branches on the sampling tee. Allow the roughing pump to run for at least 15 minutes.

The pressure sensor can be zeroed in two places. A zero adjustment is located on the transducer itself and can be turned with a small flat-blade screwdriver. Zeroing can also be done on the controller front panel. Make sure that the channel selection is on the pressure sensor to be zeroed (typically CH 1). Press the **[Select]** button until the Zero LED is lit. Using the **[Raise]** and **[Lower]** buttons, adjust the readout to 0.000 torr.

NOTE If either component (pressure sensor or power supply) is replaced, the system will need to be rezeroed.

If the sensor still cannot be zeroed, please refer to the MKS manual included with your system.

System options

NOTE

MSD ChemStation software must be installed and configured before starting the MS Sensor software. Refer to the MS Sensor manual for more information on advanced topics such as the Method Wizard, a simplified user interface for routine operation.

1 To start the software, double-click the MS Sensor icon on the desktop or run **C:\MSSensor\MSSensor.exe**. The top screen and the current event log appear (Figure 3).

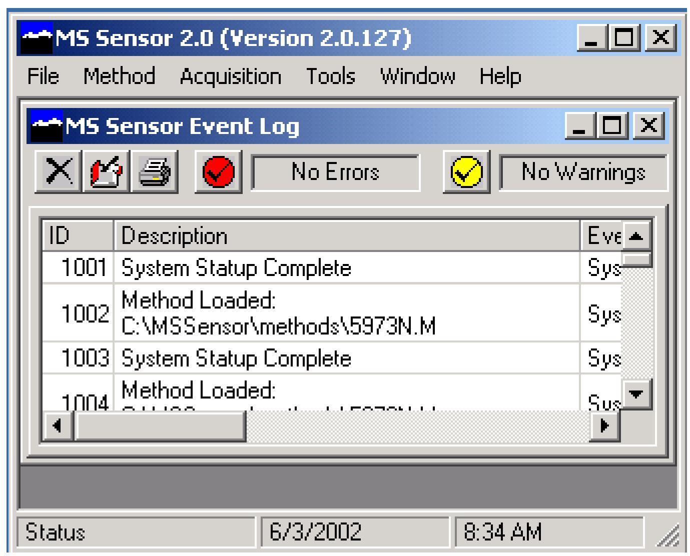


Figure 3 Top screen

2 Select **Tools/Options** from the menu at the top of the screen. The Options dialog box appears (Figure 4).

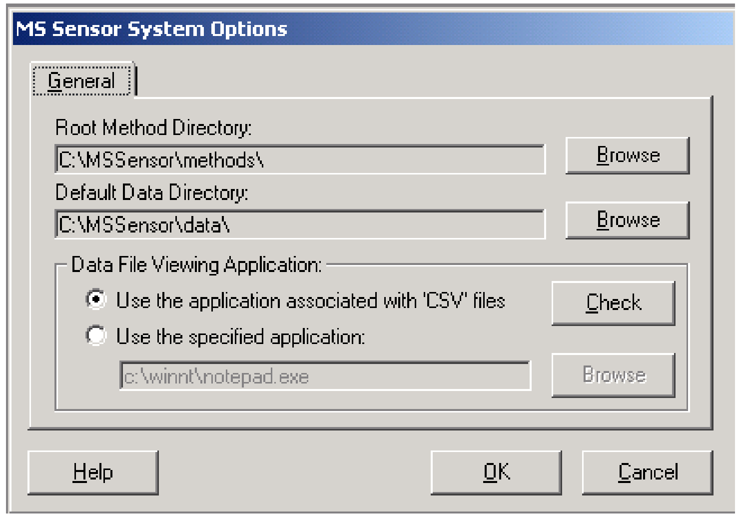


Figure 4 System options

3 **Root method directory.** Select **Browse** and choose a directory for storing methods. The default directory is **C:\MSSensor\methods**. The user can choose to put methods in a more convenient place if desired.

4 **Default data directory.** Select **Browse** and specify the path to the data directory for storing data folders. It is best to place the data directory on the same drive as the MSD ChemStation software that controls your Agilent 5973 MSD.

At the bottom of the window, the user can select a default program, such as Notepad or Excel, to open the data text file. If the user has specified that an application will use CSV files, it will launch that application when the file is accessed. In addition, the user can select the **Use the specified application** and browse to find the executable.

Creating a method

All data acquisition is controlled by a method. This section describes how to create a simple method that monitors the laboratory air.

Methods are not single files. Methods are directories named with a **.m** extension that contain sets of **.rcp** (recipe) files. When creating a new method, the directory is created first. The recipe files to fill that directory are created later as the user specifies method components in the Edit Method window.

1 Run **C:\MSSensor\MSSensor.exe** to start the software. For ease of use, we suggest creating a shortcut icon on the desktop to do this.

2 Select **[Method/New]** from the menu at the top of the screen. The Method Directory Specification screen appears (Figure 5).

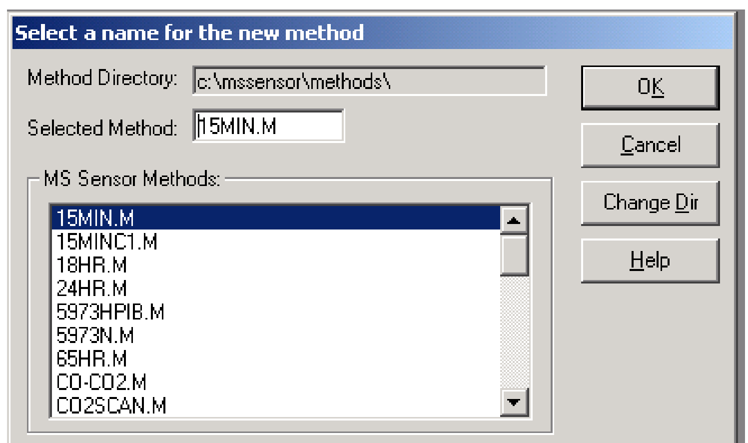


Figure 5 Specifying a method directory

3 Type a name in the **Selected Method** field. For this example, we suggest the name **Roomair**.

4 Select **OK** to create the new method directory and close the dialog box. The **Edit Method** window opens (Figure 6).

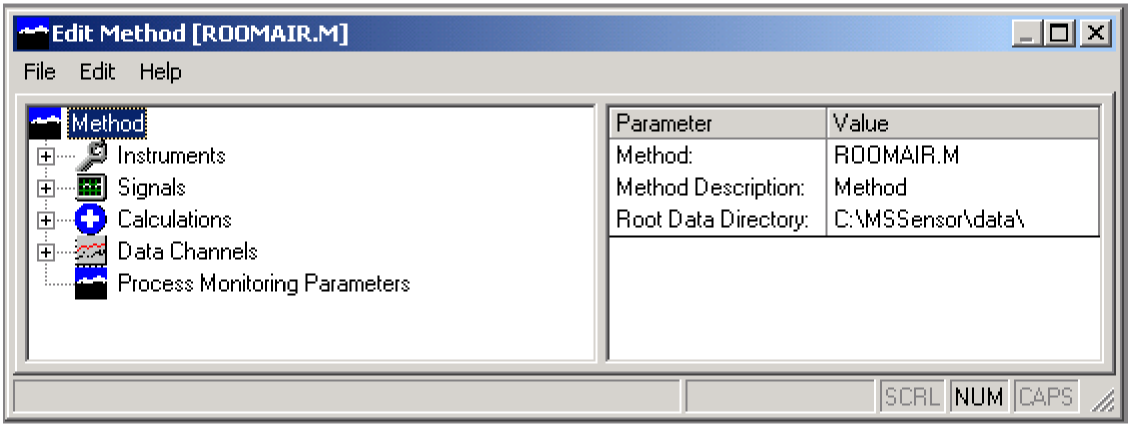


Figure 6 Editing a method

Method components

A method consists of five components, which are created in the order shown in Table 1.

Table 1 Method components

Instruments	Instruments are signal generating devices. Instruments can be added, deleted, or edited. The user must choose the instrument(s) to be used to acquire data and subsequently configure the selected instrument(s).
Signals	Signals are the numeric data values obtained from the various instruments. Some instruments only generate a single signal (e.g., pressure) whereas others can generate multiple signals (e.g., MSD). Define the specific signals wanted here. In addition, a simple linear calibration for raw signal response can be defined by the user and applied directly to the raw signal.

Table 1 Method components (continued)

Calculations	In the calculations section, one can define mathematical functions to apply to signal values. Calculations can contain one or more signal values as well as constants, mathematical operators, and mathematical functions. An example is to apply a non-linear calibration function to a signal that displays a non-linear response over the concentration range of interest.
Data channels	Data channels are the final calculations that create real-time trend plots and tables. This component applies a second user-defined equation, which can contain calculation results, signal values, constants, mathematical operators, and mathematical functions. While a calculation applies to a specific signal from a specific instrument, data channels can combine data from multiple signals and instruments.
Process monitoring parameters	This section allows the user to set the data acquisition rate, method run time and data signals collected, and to configure the display parameters for the data plots.

Instruments components

Instruments components are created first. They define the source (or sources) of the signals. A method can, and usually does, contain multiple instruments components.

1 If the Edit Method window is not open for **Roomair.m**, select **Method/Open/Roomair.m** from the top screen to build the method.

2 To create an instrument, right-click the **Instruments** icon and select **New Instrument** in the **Edit Method** window or select **Add Instrument** from the **Edit** pull-down menu. The **Add New Instrument** dialog box appears (Figure 7).

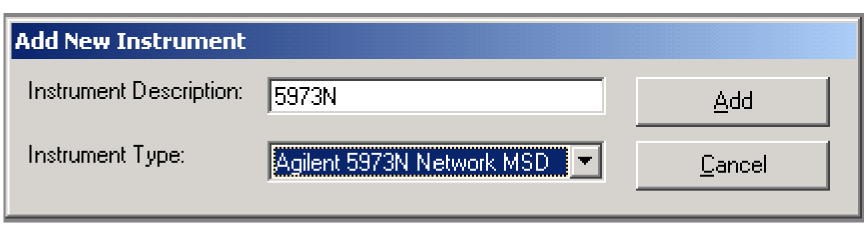


Figure 7 Add New Instrument dialog box

3 The **Instrument Description** is the name of the instrument. Type **5973N** in this field.

4 Select **Agilent 5973N Network MSD** from the **Instrument Type** drop-down window. Select **Add** and the **MSD Acquisition Parameters** window opens (Figure 8).

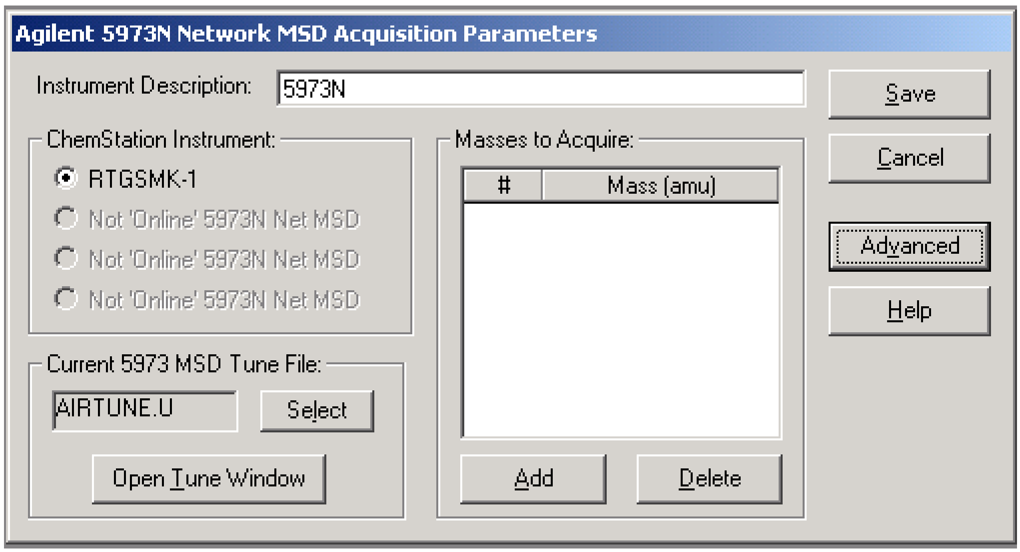


Figure 8 MSD Parameters

Add the masses desired for the method **Roomair**. In this case, masses 18 (water), 28 (nitrogen/carbon monoxide), 32 (oxygen), 40 (argon) and 44 (carbon dioxide) are appropriate. The system automatically determines the mass range to scan and puts these values in the signal selection window.

Click **Open Tune Window** to tune the RTGA.

Tuning the RTGA

Tuning the mass spectrometer standardizes its mass axis and relative response for a known calibration compound. For most applications on the RTGA, particularly fuel cell measurements, the mass spectrometer should be tuned for low molecular weight species. To optimize this performance, the mass spectrometer software has automated tuning algorithms for a wide range of molecular weights (Full Range Autotune), low molecular weights (Low Range Autotune), and a special tuning algorithm for hydrogen-containing samples such as fuel cell systems (Hydrogen Tune). The latter two are most useful with the RTGA.

To tune the RTGA:

1 Click the **Open Tune Window** button in the **5973N Instrument Acquisition Parameters** window. This launches the mass spectrometry tuning and control window.

   For additional information about the mass spectrometer and its operation, refer to chapter 2, “Operating the MSD” in the 5973N hardware manual. For mass spectrometer software help, click **Help** in the tune window.

2 Check the system status by clicking **Vacuum** and selecting **Vacuum/Temp** status. If the instrument is not already pumped down, click **Vacuum Status** and select **Pump Down**. Normally the mass spectrometer will begin a pump-down cycle automatically after initialization. The software will prompt what actions to take and will indicate how long to let the system pump down before operation.

3 **FOR NON-HYDROGEN APPLICATIONS**, make sure the sample isolation valve is in the closed position and that the mass spectrometer is pumped down and equilibrated for at least 1 hour. In the tuning and control window, click **Tune** and select **Low Range Autotune**. The system will then tune the mass spectrometer and produce a tune report at the printer.

   Archive this report as it will serve as a record of instrument performance and can be used to gauge maintenance intervals. The system is now ready to be calibrated for non-hydrogen applications.

4 **FOR HYDROGEN APPLICATIONS,** make sure the sample isolation valve is in the open position and the mass spectrometer is pumped down and equilibrated for at least 1 hour. In addition, make sure that the RV12 sampling pump is turned on.

Connect a sample line to the top of the sampling tee and an appropriately vented exit line to the bottom of the sample tee. To tune the mass spectrometer for hydrogen, the sample stream should be 50 to 100% hydrogen with nitrogen the preferred balance gas. Adjust the sample flow so that 30 to 50 mL/min is measured out the exit line.

In the tuning and control window, click **Tune** and select **Hydrogen Tune**. The system will then tune the mass spectrometer and produce both a low mass tune report and a hydrogen tune report at the printer.

Archive these reports as they will serve as a record of instrument performance and can be used to gauge maintenance intervals. The system is now ready to be calibrated for hydrogen applications.

Tuning should be performed when necessary and the final tune report should be kept in a log book. Use this information to detect the start of a tuning problem and to monitor the rise of the electron multiplier and ion focus voltages over time. These reports aid in planning ion source cleaning or multiplier replacement. More information on tuning can be located in the MSD ChemStation Help by typing **tuning**.

5 Save the 5973N instrument configuration.

Add the additional instruments (e.g., the pressure transducer)

Select the new instrument to be added from the pulldown menu (e.g., PDR-2000). Select **OK**. Configure the new instrument as appropriate (e.g., for the PDR2000, . . .).

If a pressure transducer is included in the interface, add another instrument. Name it (perhaps Pressure Transducer) and select the **MKS PDR 2000**. Select **Add** to open another window where the COMM port can be configured.

Make sure the cables connecting the pressure controller to the pressure sensor and the PC are correctly connected and the pressure controller has power. Once configured, select **Test** to verify the connection.

Click **Save** to exit.

Signals components

Now that instruments have been added to the method, signals must be defined and calibrated.

1 To create the first Signals component, right-click the **Signals** icon and select **New Signal** from the menu. The **Edit Signal** window opens (Figure 9).

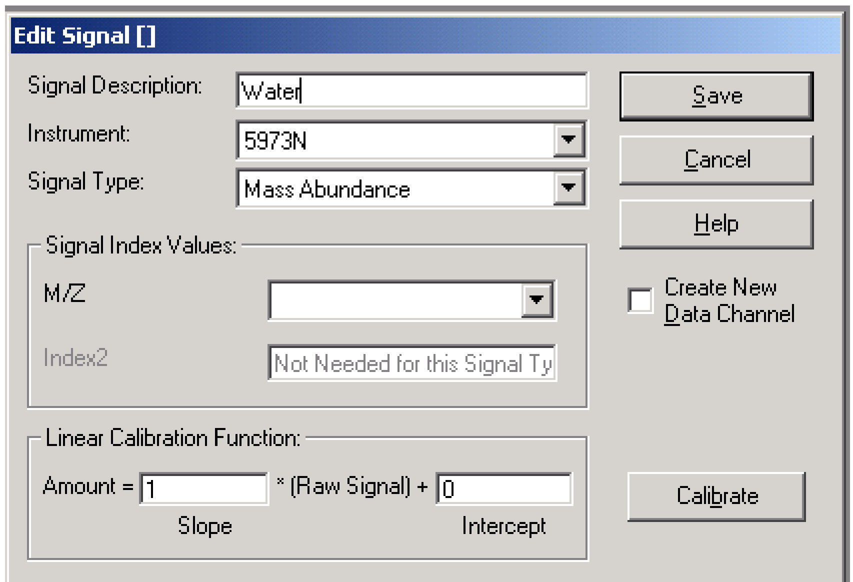


Figure 9 Editing Signals

2 **Signal Description** is the name of the signal. Enter **Water** in the field.

3 The **Instrument** field specifies the instrument that will supply the signal. Select **5973N** from the drop-down menu.

4 Select **Mass Abundance** in the **Signal Type** drop-down menu. In the **Signal Index Values**, select **18** for m/z from the list. Refer to the MS Sensor software manual for other signal types and usage.

5 Check the **Create New Data Channel** box. This will include the water signal as one of the values to be plotted.

6 The **Linear Calibration** function allows the user to enter a calibration equation for the analyte. Alternatively, the user can select the **Calibrate** button, enter the amount and signal data and the system will automatically calculate a linear calibration equation.

   The system will use a default equation with a slope of 1 and an intercept of 0 if the user enters no information. For this test, do not change the calibration entries.

   Select **Save** in the **Edit Signal Screen** to save the changes.

7 Create additional signals for each of the other masses. In addition, create a new signal for the total ion measurement. Name the signal **Total Ion** and set the signal type to **Total Ion Signal.** The Signal index values are grayed out with this choice since the system knows what signals to use as a source. Check the **Create a New Data Channel** box and click **Save**.

8 Finally, if you have another instrument (e.g., a pressure sensor) installed on the interface, create an additional signal for this named **Pressure**. Select **Pressure Transducer** as the instrument and **CH 1 Pressure** as the **Signal Type**. Check the **Create a New Data Channel** box and click **Save**.

The expanded trees in the method window should look like Figure 10.

Refer to NIST website for help in choosing m/z values.

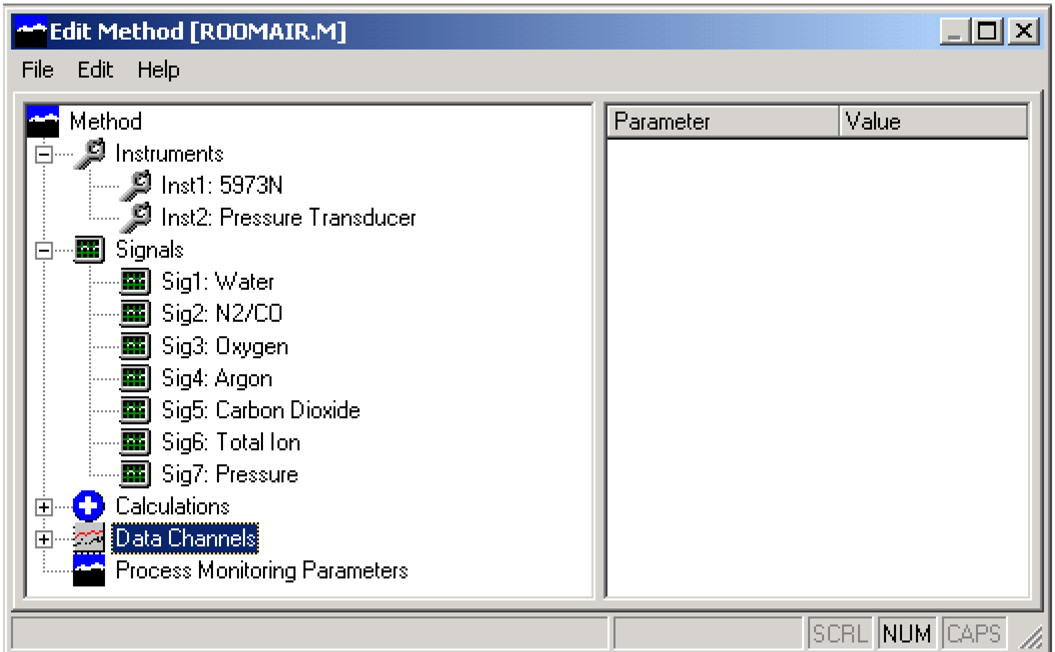


Figure 10 Method window

Calculations component (optional)

1 To create a new calculation, right-click the **Calculation** icon and select **New Calculation**. The **Edit Calculation** window opens (Figure 11).

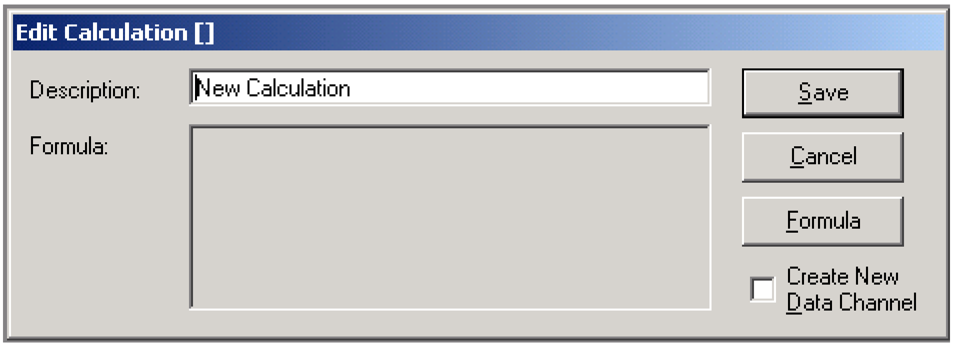


Figure 11 Editing a Calculation

2 Enter an appropriate label such as **Normalized Composition Total** into the **Description** field.

3 Click **Formula** and the **Edit Component Formula** window will appear. The window displays all available formula elements. To include a signal component in the formula, double-click the signal component in the list box. A small dialog appears which allows the user to choose from the raw signal, calibrated signal, calibration slope, or calibration intercept.

4 For this example, we will create a calculation to allow normalized percent compositions to be determined. For this calculation, we will need a sum of all the calibrated responses.

   Double-click the **Sig1: Water** signal in the **Components** window and select the calibrated signal response. Click **OK** and (Sig1.Cal) will appear in the Current Formula window.

   Click the **+** button in the **Operators** window and select the next calibrated signal. Repeat this procedure until all of the compound signals (signals 1 - 5) are added together (Figure 12).

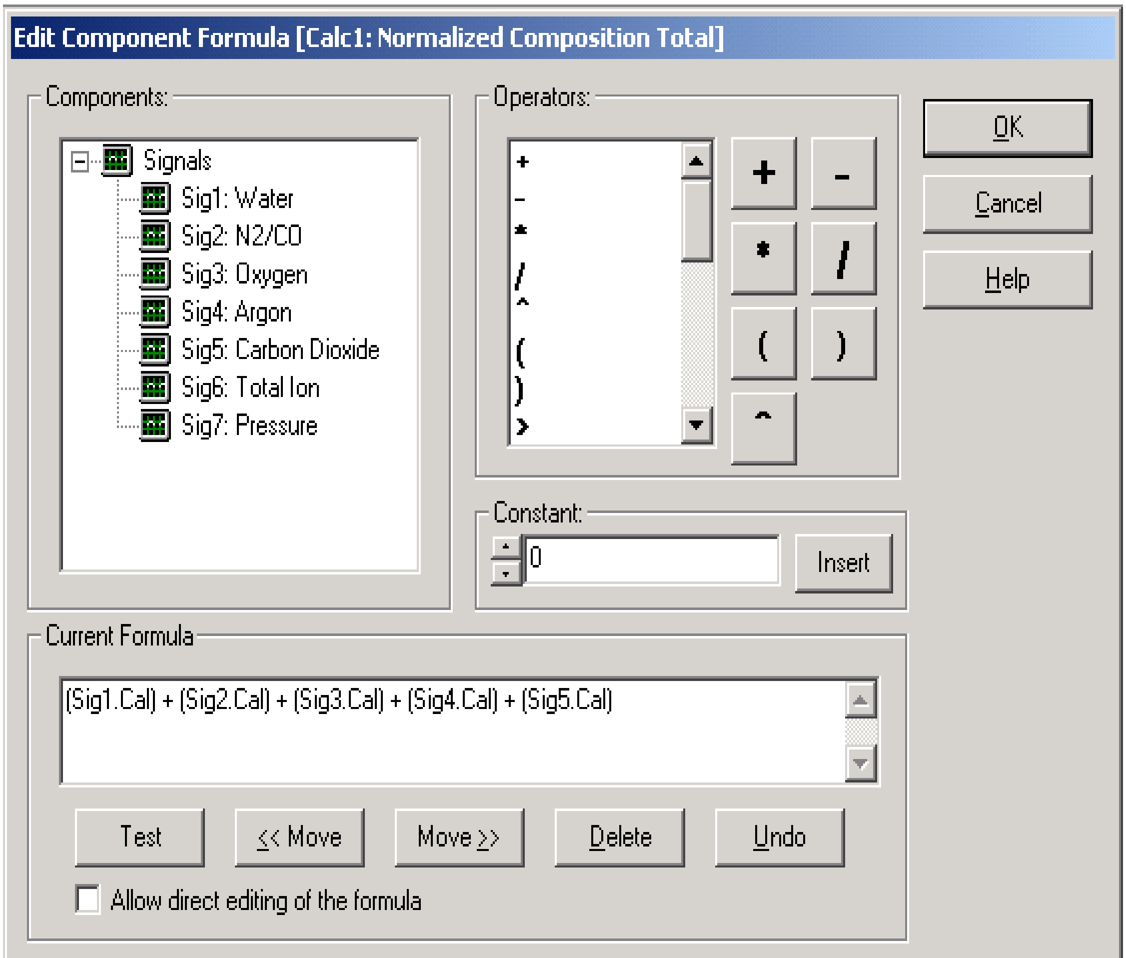


Figure 12 Editing a Formula

5 Confirm the function is valid by selecting the **Test** button. If the calculation is acceptable, a window will appear stating that the expression is valid.

6 Click **OK** on the **Edit Formula** screen.

7 If this signal is desired in the real time plotting, select **Create New Data Channel**.

8 Save your calculation.

Data channels component

The fourth area of the method is the data channels section. The data channels are the real-time, plotted data in the Real-Time window. A data channel can be as simple as an unaltered signals component or something much more complex involving multiple signals and functions

Two display options are listed at the bottom of the window (Figure 13). **Display Channel in Data Grid** allows the values to be placed in a tabular format in the real-time windows. **Display Channel in Trend Plot** allows multiple plot windows to be used and signals with very dissimilar magnitudes (i.e. sample pressure and total ion) to be placed in different plots.

In the current example, several data channels already exist. They were created when the signals components were made. To complete the normalized composition data for water, let's create a new data channel by right-clicking the **Data Channel** icon and selecting **New channel** or by clicking **Edit** and selecting **Add Data Channel**. Name the new data channel **Norm Water** and click **Formula**.

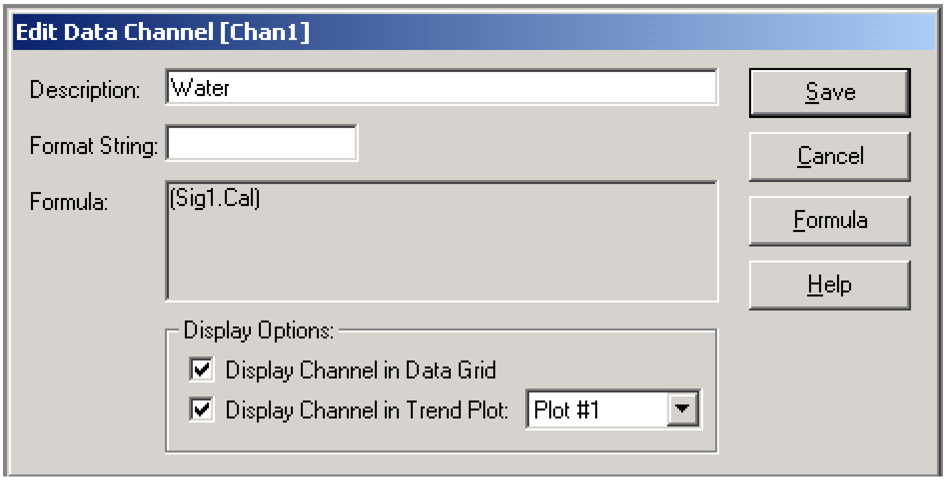


Figure 13 Editing a Data Channel

Formula allows the user to modify the existing formula for that data channel or create a new formula. In the Edit Channel Formula window, calculation components as well as signal components are selectable as signals. To finish the normalized composition signal for the water example, highlight the **0** in the constant box, enter **100**, and click **Insert**. This is how numerical values are entered into the formula.

Click the multiplication sign followed by double-clicking the water signal in the components window. Choose the signal type for water. In this case, both calibrated signal response and raw signal response will give the same value since there is no calibration defined for water. Next, click the divide operator and then double-click the **Normalized Components** calculation signal. This will perform the required calculation and output it to a new data channel (Figure 14). In this way, the user can automatically preprocess the data before it is plotted or recorded and simplify the data output for evaluation.

Click **OK** on the **Formula** screen and save the data channel.

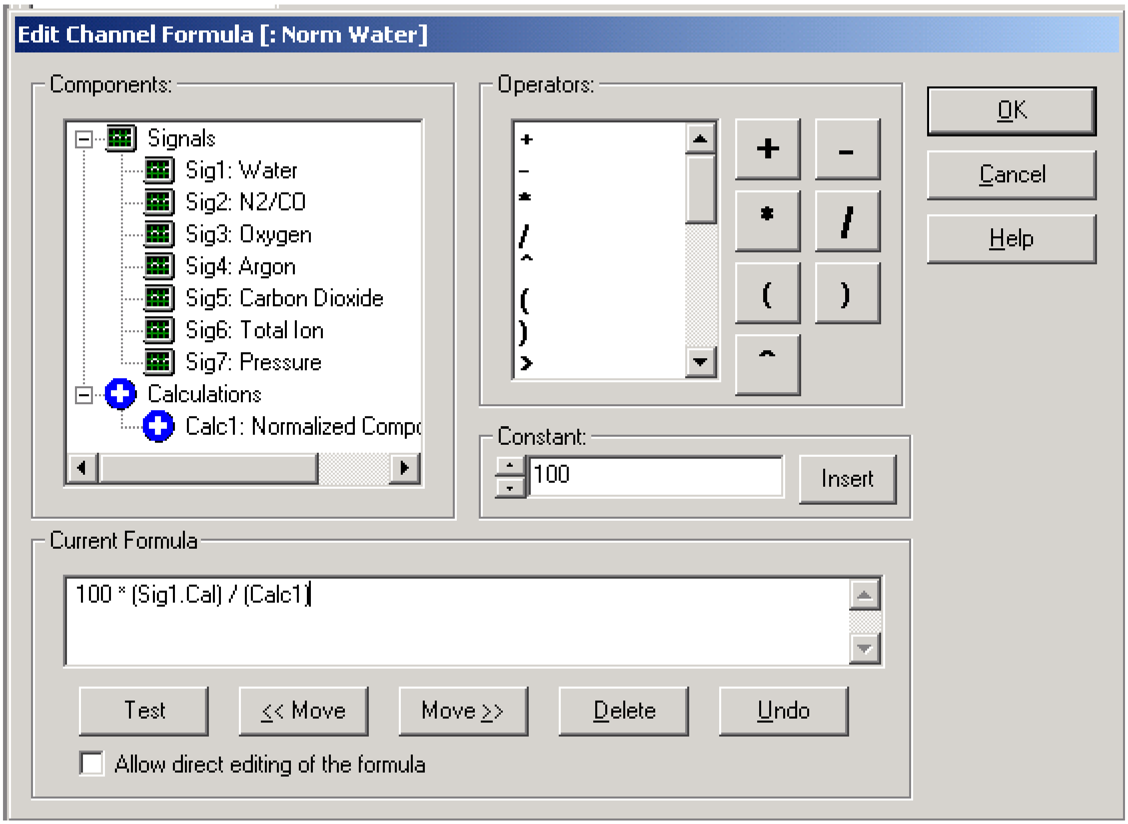


Figure 14 Normalized water channel

Process monitoring parameters

The final section of the method deals with the process monitoring parameters. To access these parameters, double-click the **Process Monitoring Parameters** tree or select **Edit Process Monitoring parameters** from the menu bar. A window with four tabs appears (Figure 15).

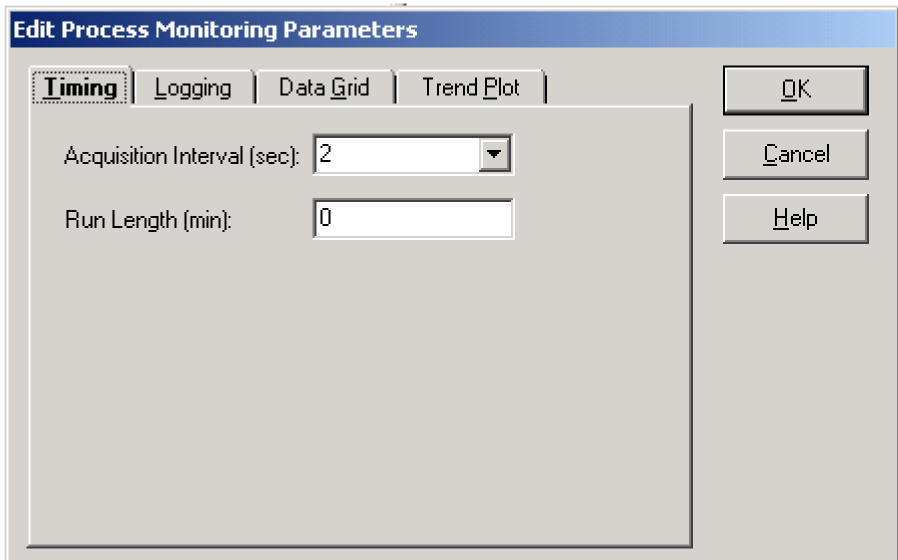


Figure 15 Process Monitoring dialog box

The **Timing** tab permits the user to set acquisition interval and run time. For this example, set **Acquisition Interval** to 2 seconds and **Run Length** to 10 minutes.

The **Logging** tab allows the user to select which components will be logged as data. Select Signal responses and Data Channel responses for this method.

Data Grid and **Trend Plot** allow the user to set the window size on the real-time logging and plotting displays. Set both at 10 minutes.

Click **OK** on the **Edit Process Monitoring Parameters** screen.

Completing the method

The new method will look like Figure 16 when finished. Select **File/Save** to save the new method and then **File/Exit** to close the window. The method is now ready to run.

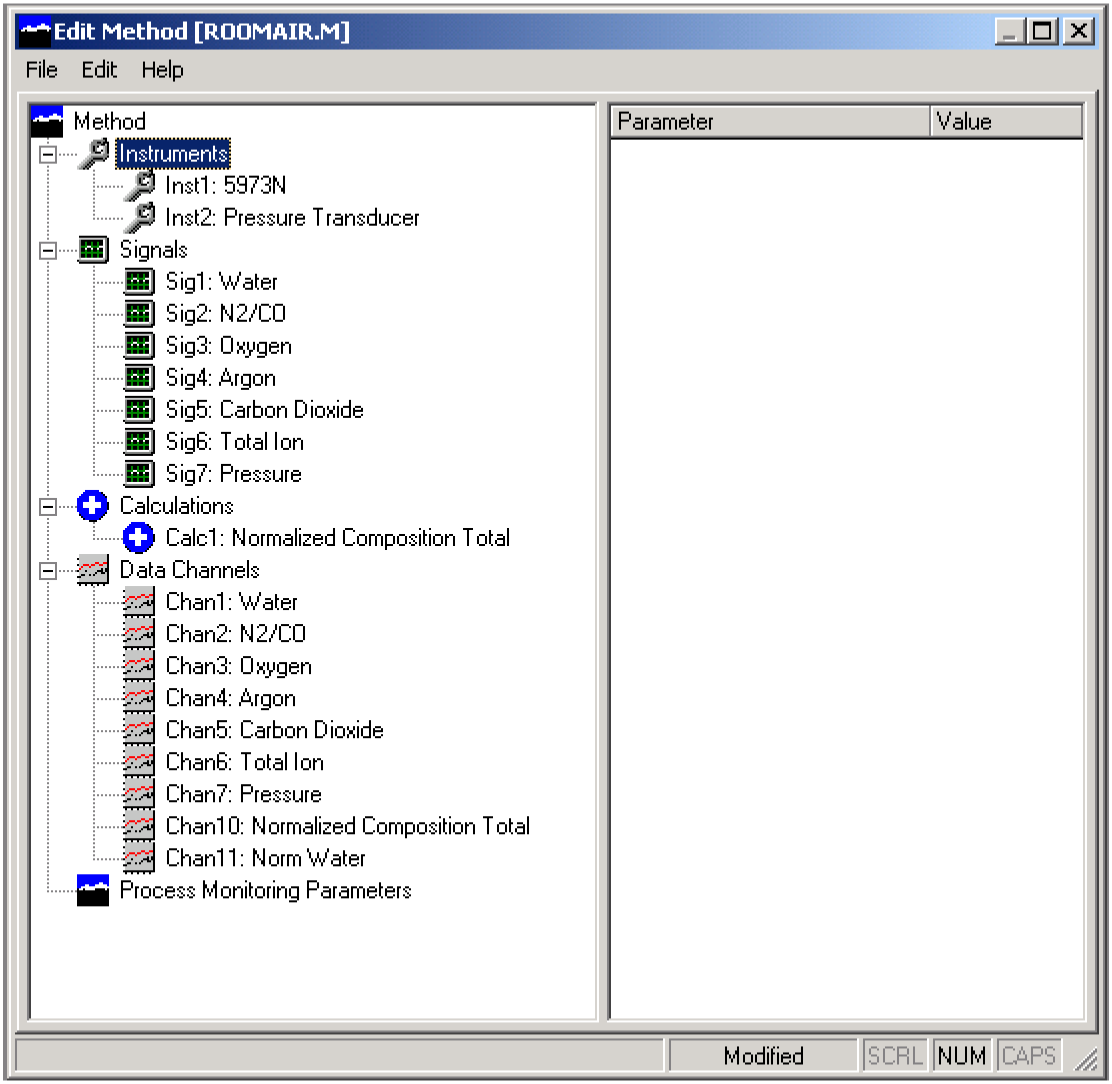


Figure 16 Completed method

Acquiring data

Preparation

Select **Acquisition/Manual** from the menu on the top screen to open the Real Time Gas Analyzer Manual Acquisition window (Figure 17).

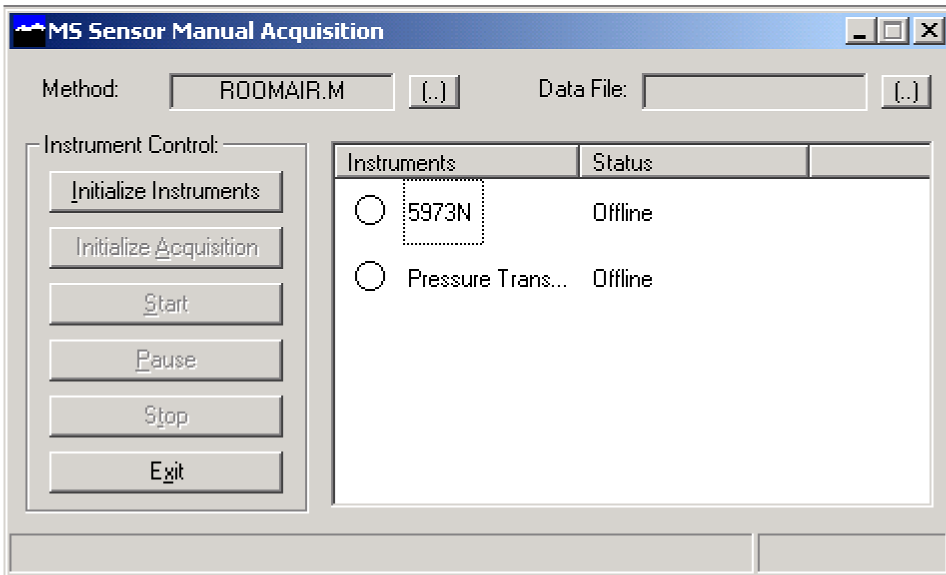


Figure 17 Manual data acquisition

This example will use the method just created to acquire data from the ambient air. The Acquisition screen will open with the currently loaded method already listed.

1 Select the button next to the **Method** field to choose a method to run. When the **Select Method** window opens, choose the **ROOMAIR.M** directory and select **OK**. **ROOMAIR.M** will now appear in the **Method** field.

2 A folder is needed to store the acquired data. Select the button next to the **Data File** field. The Select Data file window opens. Like methods, data files are composed of several

individual files in one folder. Data File folders are named with up to eight characters ending with a **.d** extension.

3 To create a new data file, select the **Data File** field at the top of the window, type **airtest** into the field and select **OK**.

4 Notice that the two instruments used in the method are listed in the window on the right. **5973N** and **Pressure transducer** are both offline. Click **Initialize Instruments** to bring the instruments online (Figure 18).

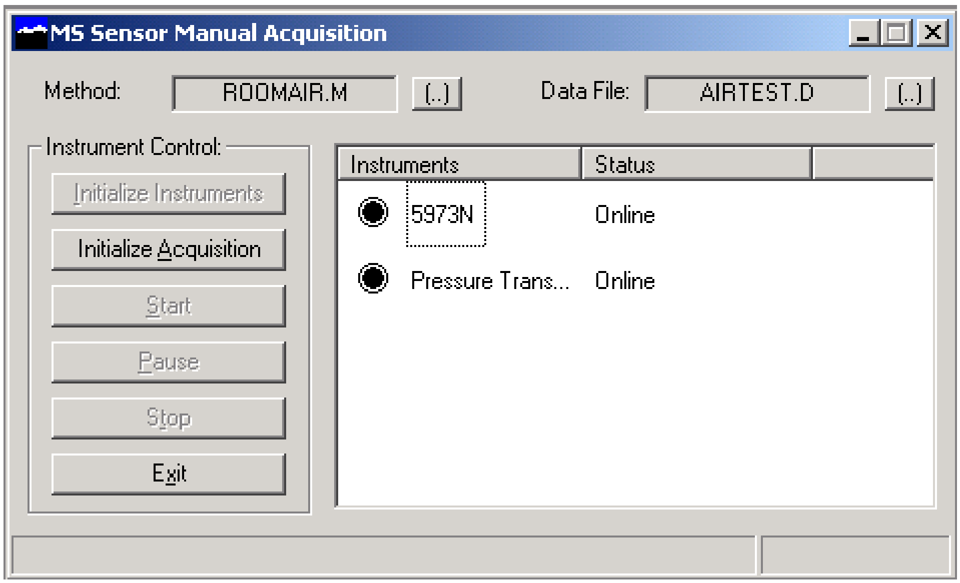


Figure 18 Initializing the instruments

Online status means that communication has been established with the instrument and it is ready to receive commands.

5 Select the **Initialize Acquisition** button to continue. Use the **Sample Information** window (Figure 19) to describe the sample and enter related information. Fill out the information fields as shown, then select **OK**.

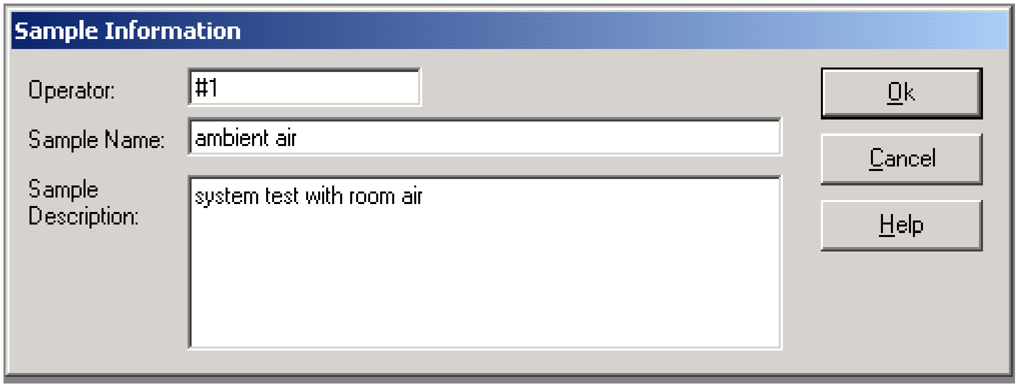


Figure 19 Sample information

One window opens for each trend plot and the data grid used by the method. Since no information is acquired yet, the trend plots and data grid are empty. Note that the status indicators for the instruments have both changed to Ready. The user can now size the windows according to their preference.

Start the run

Start the run by pressing **Start**. Data will begin appearing in the grid and trend plot windows and the instrument status will change to **Acquiring**.

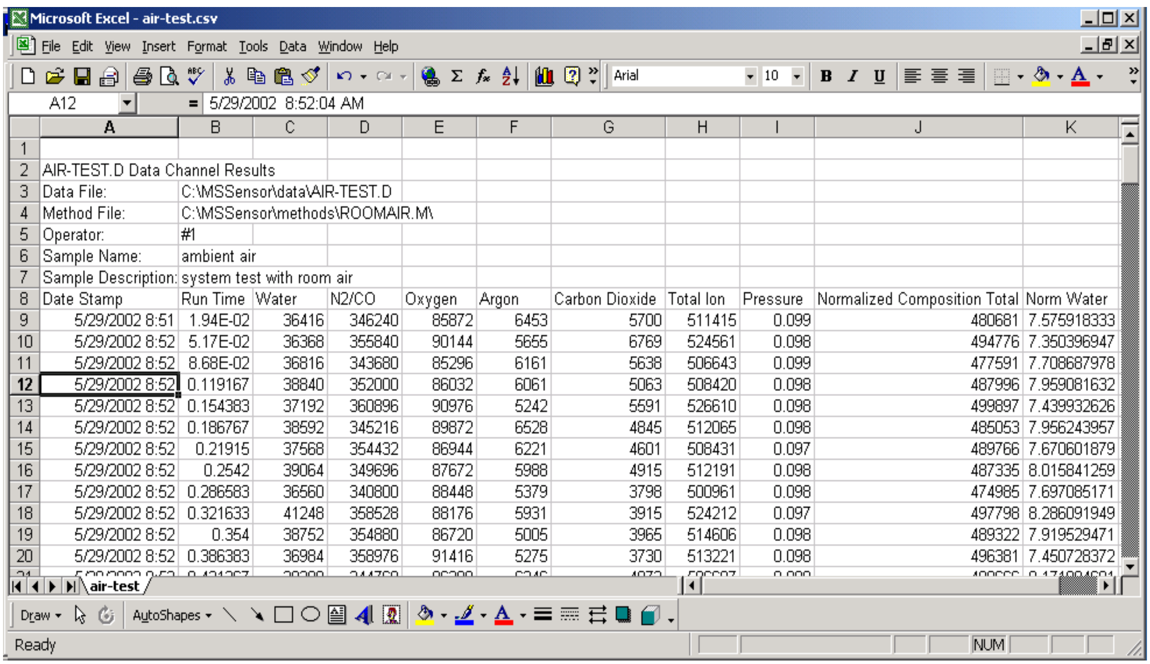
Stop the run

A running method collects data until **Stop** is pressed or the run time has elapsed. Once the method is stopped, the data can be reviewed in Excel or any other package capable of reading a .CSV file.

The data generated in the air sample run is illustrated in Figure 20. This is the data channel response data that was logged.

The signal channel response data is in a separate .CSV file named **signals**.

The data file can be directly accessed by selecting **Tools/View Data File**. A selection box will be presented that allows the user to select which of the saved data (signal results, calculation results, data channel results, or run log) to open. The data will be displayed by the application selected in the **Tools/Options** menu. Alternatively, you can open the data directory and then open the data files into a program such as Notepad or Excel.



	A	B	C	D	E	F	G	H	I	J	K
1											
2	AIR-TEST.D Data Channel Results										
3	Data File:	C:\MSSensor\data\AIR-TEST.D									
4	Method File:	C:\MSSensor\methods\ROOMAIR.M\									
5	Operator:	#1									
6	Sample Name:	ambient air									
7	Sample Description:	system test with room air									
8	Date Stamp	Run Time	Water	N2/CO	Oxygen	Argon	Carbon Dioxide	Total Ion	Pressure	Normalized Composition Total	Norm Water
9	5/29/2002 8:51	1.94E-02	36416	346240	85872	6453	5700	511415	0.099	480681	7.575918333
10	5/29/2002 8:52	5.17E-02	36368	355840	90144	5655	6769	524561	0.098	494776	7.350396947
11	5/29/2002 8:52	8.68E-02	36816	343680	85296	6161	5638	506643	0.099	477591	7.708687978
12	5/29/2002 8:52	0.119167	38840	352000	86032	6061	5063	508420	0.098	487996	7.959081632
13	5/29/2002 8:52	0.154383	37192	360896	90976	5242	5591	526610	0.098	499897	7.439932626
14	5/29/2002 8:52	0.186767	38592	345216	89872	6528	4845	512065	0.098	485053	7.956243957
15	5/29/2002 8:52	0.21915	37568	354432	86944	6221	4601	508431	0.097	489766	7.670601879
16	5/29/2002 8:52	0.2542	39064	349696	87672	5988	4915	512191	0.098	487335	8.015841259
17	5/29/2002 8:52	0.286583	36560	340800	88448	5379	3798	500961	0.098	474985	7.697085171
18	5/29/2002 8:52	0.321633	41248	358528	88176	5931	3915	524212	0.097	497798	8.286091949
19	5/29/2002 8:52	0.354	38752	354880	86720	5005	3965	514606	0.098	489322	7.919529471
20	5/29/2002 8:52	0.386383	36984	358976	91416	5275	3730	513221	0.098	496381	7.450728372

Figure 20 Data from RTGA

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