

Description of Device Parameters

FS 5.16 Firmware



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1 - INTRODUCTION

This Endress+Hauser analyzer was shipped with Endress+Hauser's FS 5.16 Firmware. This firmware version provides users with the features and functions to operate the tunable diode laser (TDL) analyzer.

This manual was designed to provide the user with an overview of the FS 5.16 firmware functionality. The information contained in this manual is divided into the following sections:

- Operations
- Serial Communication
- Firmware Troubleshooting

Who Should Read This Manual

This manual should be read and referenced by anyone operating or having direct contact with the analyzer.

General note icons

Instructional icons are provided in this manual to alert the user of important information and valuable tips. The following symbols and associated information can be found throughout the manual.



General notes and important information concerning the installation and operation of the analyzer.




Failure to follow all directions may result in malfunction of the analyzer.



INVISIBLE LASER RADIATION - Avoid exposure to beam.
Class 3b Radiation Product. Refer servicing to the manufacturer-qualified personnel.

Conventions used in this manual

In addition to the symbols and instructional information, this manual is created with "hot links" to enable the user to quickly navigate between different sections within the manual, and to other manuals. These links are identified by a pointing finger cursor  when rolling over the text. Simply click on the link to navigate to the associated reference.

Manufacturer Address

Endress+Hauser
11027 Arrow Route
Rancho Cucamonga, CA 91730
United States
www.endress.com

2 - OPERATING THE ANALYZER



The analyzer is designed to be a stationary measuring device. It should be securely mounted during normal operation.



The laser housing labels on the flanges of the sample cell warn about exposure to laser radiation inside. Never open the sample cell unless directed to do so by a service representative and the analyzer power is turned off.



*The optical head has a seal and "**WARNING**" sticker to prevent inadvertent tampering with the device. Do not attempt to compromise the seal of the optical head assembly. Doing so will result in loss of device sensitivity and inaccurate measurement data. Repairs can then only be performed by the factory and are not covered under warranty.*

Firmware Version

Each Endress+Hauser analyzer operates based on its own version of firmware. The firmware version for each analyzer is listed in the system calibration report, and displays upon start-up of the analyzer. The operation instructions provided in this chapter are intended for the FS 5.16 firmware version.

Powering Up the Analyzer

After mounting the analyzer, connecting the power wires, connecting the gas lines, connecting the (optional) output signal wires and checking for leaks, you are ready to power up the analyzer.



Refer to the figures for the analyzer electronic control boards in the Operating Instruction for locating fuses. If you need to replace a fuse, use only the same type and rating of fuse as the original as listed in the analyzer fuse specifications table in the Operating Instruction.

To power up the analyzer:

1. Power up the analyzer by energizing the circuit to the analyzer.
2. For systems with a heated enclosure, confirm that the sample system enclosure is heated to approximately the specified temperature by observing the temperature reading on the door mounted thermometer.



For systems with heated enclosures, a **Temperature too Low** or **Temperature too High** fault will activate the **General Fault Alarm** when the enclosure temperature is more than 5 °C above or below the specified temperature. Once the enclosure has reached the specified temperature, reset the **General Fault Alarm** (see "**To change parameters in Mode 2**" on page 2-16).

3. The system goes through an initialization period while showing the firmware version on the bottom line until the LCD displays the **Normal Mode** screen.
4. Enable **Peak Tracking** following the procedure outlined in "**Changing Measurement and Control Parameters**" on page 2-12.
5. Three to four minutes are required for the analyzer to establish reference spectra before displaying a reading.
6. After initialization and establishment of reference spectra, the LCD displays four lines, the third of which is blank.

```
<NORMAL MODE>
H2S: 5.036 ppmv
P: 954.4mb T: 76.1F
```

The measurements displayed are:

- **ANA**: Refers to the concentration in the sample cell (in units) of the analyte/component selected in **Mode 2**.
 - **P**: Pressure in the sample cell (in units) selected in **Mode 2**.
 - **T**: Temperature in the sample cell (in units) selected in **Mode 2**.
7. Continuous updates of the measurement parameters displaying on the LCD indicates that the analyzer is operating normally.



Definitions for the acronyms displayed on the LCD are given in the section "**Modes Defined**" on page 2-5.

Powering Down the Analyzer

It may be necessary to power down the analyzer for problem solving or maintenance reasons. An approved switch or circuit breaker rated for 15 amps should have been installed and clearly marked as the disconnecting device for the analyzer.

To power down the analyzer:

1. Switch off the power to the analyzer using the switch or circuit breaker designated as the disconnection device for the equipment.
2. If the analyzer is going to be shut down for a short period of time for routine maintenance, isolate the analyzer from the sample conditioning system (SCS). Refer to the appropriate Analyzer or SCS Operating Instruction.
3. If the analyzer is going to be shut down for a long period of time, follow the procedure for isolating the process sample tap for long-term shutdown (in the Analyzer or SCS Operating Instruction) or contact Endress+Hauser's Service. It is recommended to also disconnect the power completely from the analyzer to prevent potential damage from lightning strikes.

Operating the Analyzer from the Keypad

The keypad enables the operator to modify measurement units, adjust operational parameters, and perform diagnostics. During normal operation, the LCD continuously displays the measured component's concentration, sample cell temperature, and sample cell pressure.

The Endress+Hauser keypad is shown in Figure 2-1. To activate any functions on the keypad, press the mode key **#** followed by a number on the keypad to specify a mode.



*You must press the **#** key before pressing a number or function key to trigger a response from the keypad.*

When you press the **#** key, the words <MODE MENU> display on the LCD. If the keypad watchdog is enabled, a countdown timer will begin when <MODE MENU> displays. If the countdown expires and no buttons have been pressed, the analyzer will automatically revert to **Mode 1**.

The ***** key functions as the "Enter" key. When in **Mode 2**, always press ***** after entering a value using the keypad (unless the entry was made in error). Pressing the ***** key stores the displayed parameter value and cycles the LCD to the next parameter.

If you do make an error, press the ***** key followed by the TEST key, and then the ***** key to return to the parameter and enter the correct value.

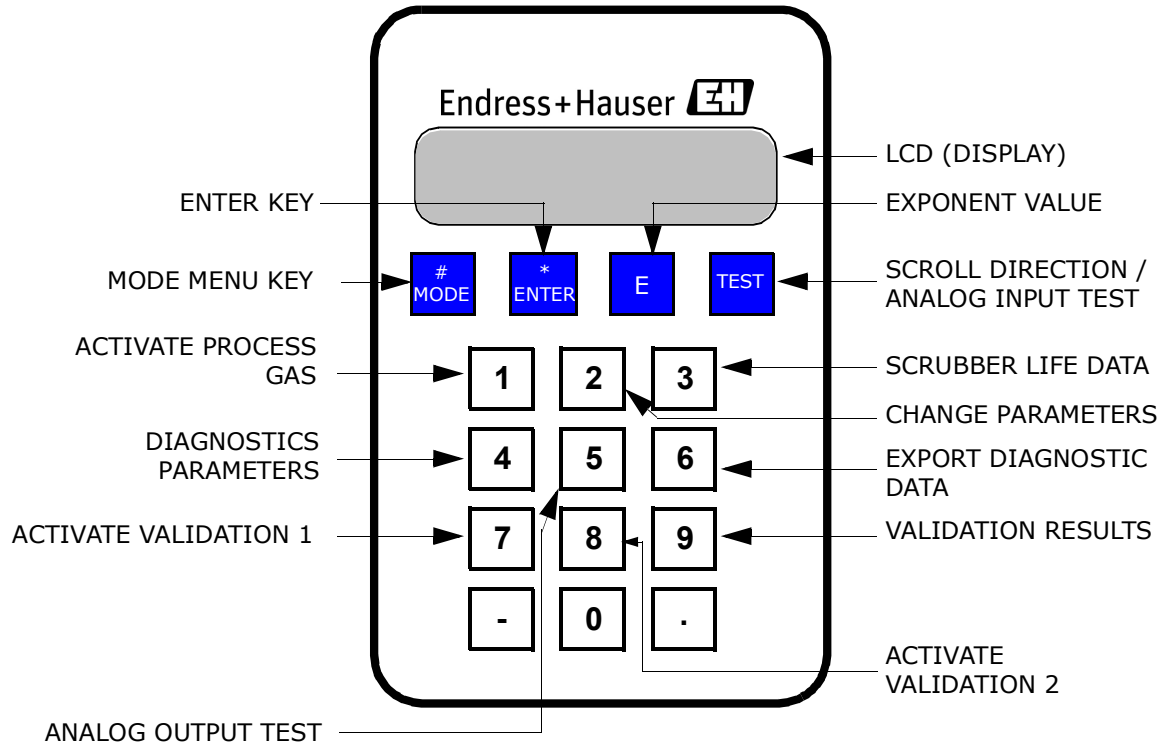


Figure 2-1 SS2100 Analyzer keypad

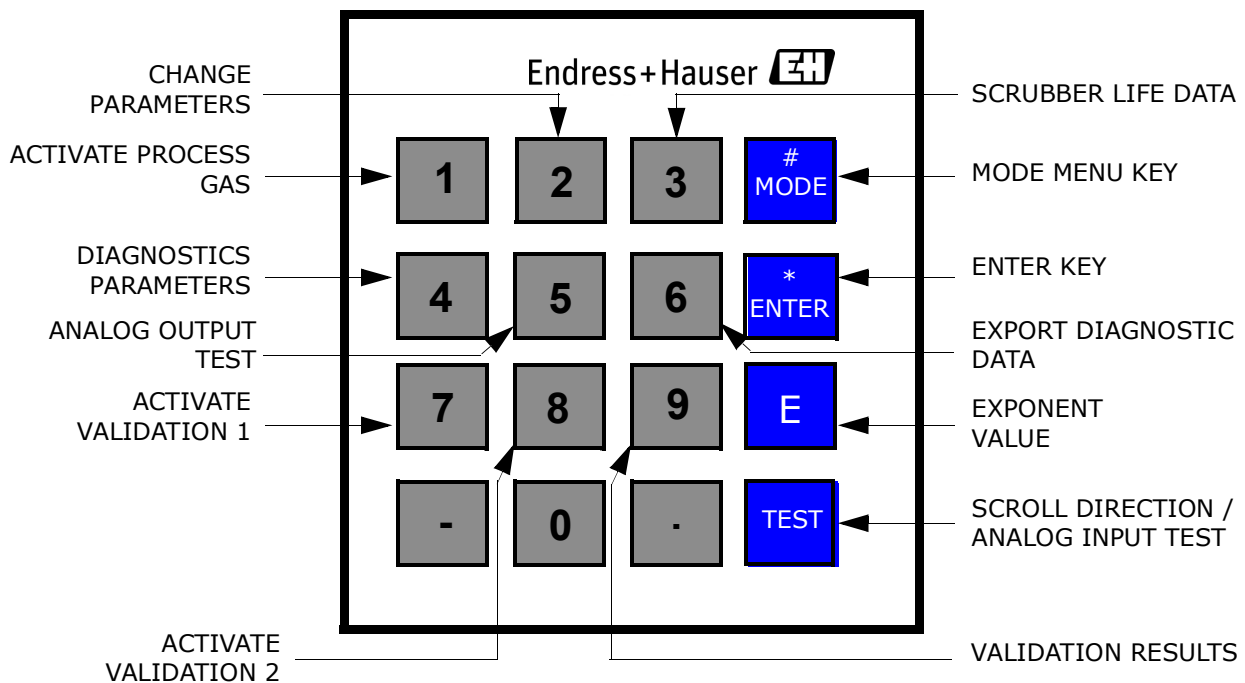


Figure 2-2 SS2100i Analyzer keypad

Modes Defined

Use the keypad to access the following modes by pressing the **#** key first followed by a number (**1, 2, 3, 4, 5, 6, 7, 8** or **9**) to activate a mode. The following section explains each mode and the corresponding information that displays on the LCD.



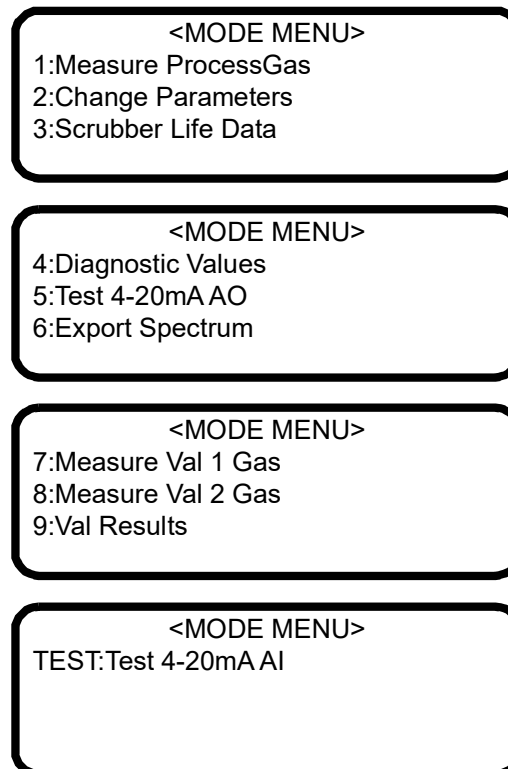
*When the **#** key is pressed, measurement will be suspended until the new mode is established, The only modes that produce measurements are **Mode 1, Mode 6, Mode 7** or **Mode 8**.*



*Every time the **#** key is pressed, the analyzer requires three to four minutes time upon returning to **Mode 1, Mode 6, Mode 7** or **Mode 8** to re-establish reference spectra before displaying a reading.*

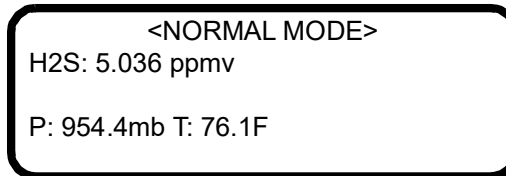
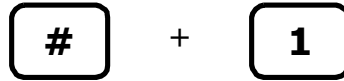
Mode MENU:

When the **#** key is pressed, <MODE MENU> displays on the LCD along with the options each key represents. The ***** key provides the ability to scroll through the <MODE MENU> selections. The following shows the choices available under <MODE MENU>:



Mode 1: (Normal Mode)

Mode 1 continuously displays updated measurements. Press the **#** key followed by the **1** key.



The measurements displayed are:

- **ANA**: Refers to the concentration in the sample cell (in units) of the analyte/component selected in **Mode 2**.
- **P**: Pressure in the sample cell in units selected in **Mode 2**.
- **T**: Temperature in the sample cell in units selected in **Mode 2**.



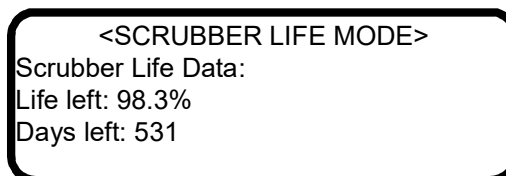
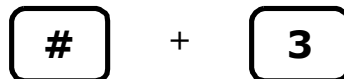
*If the analyzer supports multi-calibration, this display will also include an 'A' or 'B' at the end of the second line to designate the current calibration used. Refer to "**R1 Stream Option**" on page 2-33 for more information on multi-calibration.*

Mode 2: (Set Parameter Mode)

Mode 2 enables user to view and change measurement parameters. Follow the procedure under "**Changing Measurement and Control Parameters**" on page 2-12 for viewing and changing any of the parameters.

Mode 3: (Scrubber Life Data)

Displays the predicted remaining scrubber/dryer percent capacity and number of days remaining of service. Press the **#** key followed by the **3** key.

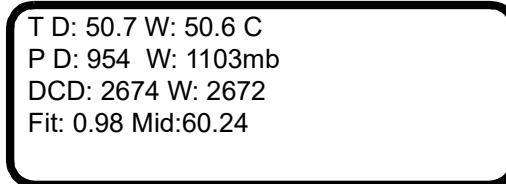
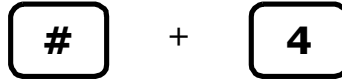


The **New Scrubber Alarm** fault will activate the **General Alarm Fault** when the scrubber/dryer capacity is predicted to be 5% or less, or when the value

for days left reaches 0. Refer to the Operating Instruction for information on servicing the scrubber.

Mode 4: (System Diagnostic Parameters)

Mode 4 displays system diagnostic data. These values may be useful when troubleshooting the system. Press the **#** key followed by the **4** key.



*While in this mode the analyzer suspends measurement until you return to **Mode 1**, **Mode 6**, **Mode 7** or **Mode 8**.*

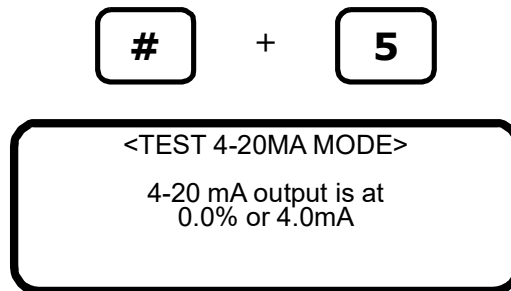
The diagnostic parameters displayed are:

- **DryTemp (T D)**: Shows the temperature in the measurement cell when scrubbed sample gas is flowing through it.
- **WetTemp (W)**: Shows the temperature in the measurement cell when normal sample gas is flowing through it.
- **DryPressure (P D)**: Shows the pressure in the measurement cell when scrubbed sample gas is flowing through it.
- **WetPressure (W)**: Shows the pressure in the measurement cell when normal sample gas is flowing through it.
- **DryDC (DC D)**: Shows the magnitude of the DC laser power in the measurement cell when scrubbed sample gas is flowing through it. Acceptable values are between 800 and 3300. A number below or above this range will trigger a **Laser Power too Low** or **Laser Power too High**, respectively (see "**Alarms**" on page 2-48) indicating that either the optics need to be cleaned or there is an alignment problem.
- **WetDC (W)**: Shows the magnitude of the DC laser power in the measurement cell when normal sample gas is flowing through it. Acceptable values are between 800 and 3300. A number below or above this range will trigger a **Laser Power too Low** or **Laser Power too High**, respectively (see "**Alarms**" on page 2-48) indicating that either the optics need to be cleaned or there is an alignment problem.
- **Fit**: The measure of "goodness of fit" for the last measurement point.

- **Mid:** The laser current set point after adjustment by the peak-tracking software.

Mode 5: (Analog Output Test Mode)

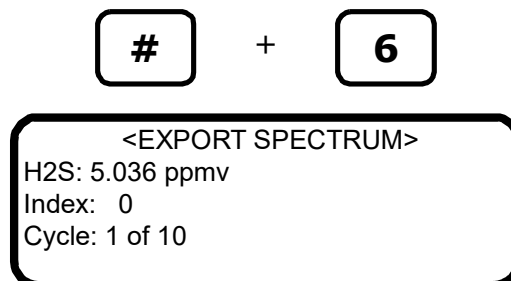
Mode 5 is used to turn on the 4-20 mA current loop output (at the current set with the **4-20 mA Test** parameter) for test and calibration purposes. Press the **#** key followed by the **5** key.



Returning to **Mode 1** re-establishes normal 4-20 mA current loop operation.

Mode 6: (Diagnostic Data Download)

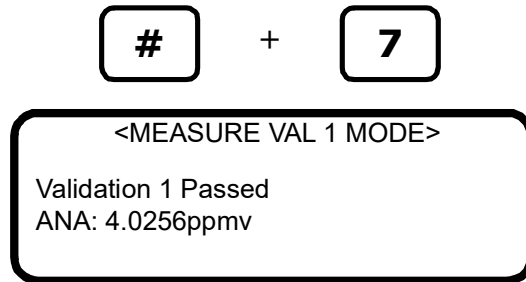
Mode 6 is used to transfer diagnostic data to the serial port and read the individual data points of both the **DC** and **2f** spectra that the instrument analyzes to calculate the gas concentration. Viewing these data can be helpful in diagnosing problems with the analyzer. Press the **#** key followed by the **6** key.



The data points, along with intermediate calculation results, are output to the serial port whenever **Mode 6** is selected.

Mode 7: (Measure Val 1 Mode)

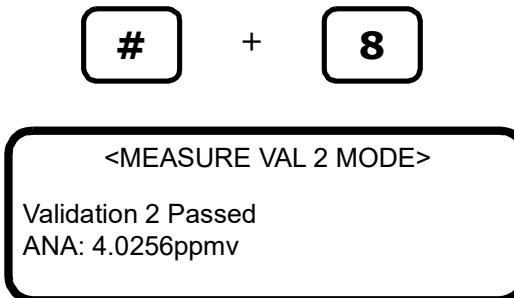
Mode 7 switches the analyzer to measure validation 1 gas supply. Press the **#** key followed by the **7** key.



Returning to **Mode 1** re-establishes normal operation measuring process gas.

Mode 8: (Measure Val 2 Mode)

Mode 8 switches the analyzer to measure validation 2 gas supply. Press the **#** key followed by the **8** key.



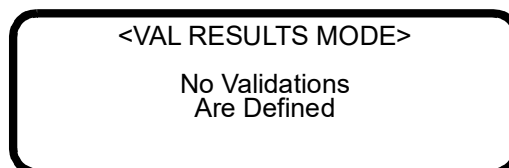
Returning to **Mode 1** re-establishes normal operation measuring process gas.

Mode 9: (Recall Validation Results)

Mode 9 recalls the measured value from the last autovalidation cycle on units with autovalidation capability. Press the **#** key followed by the **9** key.



For systems not set up for a validation, the following screen displays:



For systems set up for a single validation, the following screens may be displayed:

1. If an automatic validation or **Mode 7** has not yet been processed:

```
<VAL RESULTS MODE>
Date: 14-5-16 13:00
1:          NO DATA
```

2. If an automatic validation or **Mode 7** has been processed:

```
<VAL RESULTS MODE>
Date: 14-5-16 13:00
1:P 1000.00ppmv
Rng:1000.0 to 1000.0
```

Definitions for the displayed parameters are as follows:

- **Date:** Displays the time of the last validation.
- **1:** Represents validation, i.e., Validation 1.
- **P or F:** Indicates 'Pass' or 'Fail' for the validation result.
- **1000.00ppmv:** The concentration of the last validation result in the user's selected engineering units. If the value is from a **Mode 7** validation, then it is the average validation value for the time period during which the **Mode 7** was run.
- **Rng:1000.0 to 1000.0:** The minimum and maximum concentration value, in the user's selected engineering units, during the last validation time period.

For systems set up for dual validation, the following screens may be displayed:

1. If an automatic validation or **Mode 7** or **Mode 8** has not yet been processed:

```
<VAL RESULTS MODE>
Date: 14-5-16 13:00
1:          NO DATA
2:          NO DATA
```

2. If an automatic validation, **Mode 7** or **Mode 8** has been processed:

```

<VAL RESULTS MODE>
Date: 14-5-16 13:00
1:P 1000.00ppmv
2:P 1000.00ppmv

```

Definitions for the displayed parameters are as follows:

- **Date:** Displays the time of the last validation.
- **1** or **2:** Represents validation, i.e., Validation 1 or Validation 2.
- **P** or **F:** Indicates 'Pass' or 'Fail' for the validation result.
- **1000.00ppmv:** The concentration of the last validation result in the user's selected engineering units. If the value is from a **Mode 7** or **Mode 8** validation, then it is the average validation value for the time period during which the **Mode 7** or **Mode 8** was run.

Mode TEST: (Analog Input Test Mode)

Mode Test is used to view a real-time reading of the 4-20 mA analog input state, as well as its current raw and scaled values for test and calibration purposes. In this mode, the analyzer functions normally, as in **Mode 1**, except that the LCD (display) shows the 4-20 mA analog input signal instead of the current concentration, temperature and pressure. Press the **#** key followed by the **TEST** key.

+ TEST

```

<NORMAL MODE>

4-20mA input is ON
4095 or 68948 mb

```

Configuring the Analyzer at Start-Up

Endress+Hauser analyzers are pre-programmed at the factory with most parameters set to default values, which are suitable for most applications.

There are a few parameters that should be set by the end user. Endress+Hauser recommends checking all the parameters at start-up.

Parameter Setting/Checking Procedure:

1. After the analyzer has been installed and start up has been completed, press **Mode 2 (#2)** from the analyzer keypad and enter password **3142**.
2. Press the * key repeatedly to scroll through the parameters and verify the settings.



The firmware default parameter settings are reflected in Table 2-1.

1. **Peak Tracking** set = 1 (On).



Peak Tracking may be turned off at the factory prior to shipment to prevent the peak tracking algorithm from shifting the spectrum during initial warm-up of the unit. Once the unit is installed in the field and the cell temperature has stabilized (typically after 5 hours minimum), the Peak Tracking should be turned on and left on at all times.

2. Set remaining parameters as desired for the specific analyzer application. Refer to Table 2-1.
3. After the analyzer is configured, allow the system to run for 24 hours and then clear all alarms.
 - a. Press **Mode 2 (#2)** from the analyzer keypad and enter password **3142**.
 - b. Set the **General Alarm DO** parameter to **2**.
 - c. Set the **Cancel Val Alarms** parameter to **1**.

Changing Measurement and Control Parameters

In **Mode 2**, all of the pertinent measurement and control parameters can be viewed and changed. Refer to Table 2-1 for a list of parameters and value range. The parameters are listed in the order viewed during **Mode 2** operation.

Table 2-1 Typical values for parameter setpoints

Parameter	Setting	Function	Notes
R1 Stream Option	0, 1 Default = 0	When multi-calibration is enabled, this sets the calibration for the stream.	This parameter will be hidden if the analyzer does not support multi-calibration.

Table 2-1 Typical values for parameter setpoints (Continued)

Parameter	Setting	Function	Notes
Process Purge Time	1 - 10000 Default = 60	Sets the purge time before process measurements and after a validation.	Contact Endress+Hauser before resetting this parameter. Refer to "Service" on page C-4.
Logger Rate	1-1000 readings Default = 16	Sets the number of measurements included in the running average.	
Rapid Change Monitor	0, 1 Default = 0	Sets the dynamic logger rate based on the concentration of rate change.	
Temperature Unit	0 or 1 Default = 0	Sets the display unit for temperature.	Check for all analyzers. Set per customer preference.
Pressure Unit	0, 1, 2, or 3 Default = 0	Sets the display unit for pressure.	
Concentration Unit	0-9 Default = 0	Sets the display unit for concentration.	
Custom Precision	0-5 Default = 2	Sets the number of viewable digits to the right of the decimal point.	
RATA (Relative Accuracy Test Audit)	0 or 1 Default = 0	Enables or disables adjustment factors.	Refer to "Adjusting Analyzer Reading to Match Specific Standard(s)" on page 2-41.
RATA Multiplier	-1.E+06 to 1.E+06 Default = 1	Slope adjustment factor.	
RATA Offset	-1.E+06 to 1.E+06 Default = 0	Offset adjustment factor.	
Update RATA	0 or 1 Default = 0	Updates RATA Multiplier and RATA Offset to automatically calculated values.	
Peak Tracking	0, 1 or 2 Default = 0	Sets peak tracking capability to off, on or reset for the system.	Set to '1' <u>after</u> process flow is established and analyzer is warm.
New Scrub Installed	0 or 1 Default = 0	Resets scrubber/dryer lifetime monitor.	Contact Endress+Hauser before resetting this parameter. Refer to "Service" on page C-4.
Keypad Watchdog	0 - 10000 Default = 10	Sets the time in seconds before the <MODE MENU> screen automatically reverts to Normal Mode.	
Set Time - Hour	0 - 23 Default = 0	Sets the current hour.	Check for all analyzers. Set per customer preference.
Set Time - Minute	0 - 59 Default = 0	Sets the current minute.	
Set Time - Day	1 - 31 Default = 0	Sets the present day.	

Table 2-1 Typical values for parameter setpoints (Continued)

Parameter	Setting	Function	Notes
Set Time - Month	1 - 12 Default = 1	Sets the present month.	Check for all analyzers. Set per customer preference.
Set Time - Year	2006-2144 Default = 2012	Sets the present year.	
General Alarm DO	0, 1, 2 Default = 0	Sets the general fault alarm to be latching, non-latching or reset.	After analyzer is configured press '2' to reset. Parameter will return to previous setting.
DO Alarm Setup	0 - 4.3E+09 Default = 8192	Sets the functionality of the Assignable Alarm digital output.	Check for all analyzers. Set per customer preference.
Low Alarm Setpoint	-1.0E-06 to 1.0E+06 Default = -10000	Sets the concentration low alarm threshold in ppmv or moisture dew point.	
High Alarm Setpoint	-1.0E-06 to 1.0E+06 Default = 10000	Sets the concentration high alarm threshold in ppmv or moisture dew point.	
AO 4-20 mA Test	0 - 100.0 Default = 0	Sets the 4-20 mA output to a percentage of full scale.	
4-20 mA Alarm Action	0, 1, 2 or 3 Default = 0	Sets the current loop state upon alarm condition.	Check for all analyzers. Set per customer preference.
AO 4 mA Value	-1.0E-06 to 1.0E+06 Default = 0	Sets ppmv or moisture dew point value corresponding to 4 mA current loop z output.	
AO 20 mA Value	-1.0E-06 to 1.0E+06 Default = Full scale	Sets ppmv or moisture dew point value corresponding to 20 mA current loop output.	
Calculate Dew Point	0, 1 or 2 Default = 0	Enables the dew point calculation and controls its output.	Check for all analyzers. Set per customer preference.
Dew Point Method	0, 1, 2 or 3 Default = 0	Type of dew point calculation.	
Pipeline Pressure	0-500000 Default = 1000	Pressure used for dew point calculation.	
AI Pressure Input	0 or 1 Default = 0	Controls analog input of pipeline pressure.	
AI 4 mA Value	0-500000 Default = 0	Analog input 4 mA value.	
AI 20 mA Value	0-500000 Default = 100000	Analog input 20 mA value.	

Table 2-1 Typical values for parameter setpoints (Continued)

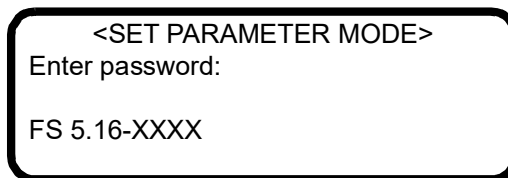
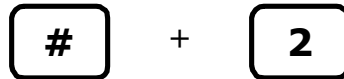
Parameter	Setting	Function	Notes
Modbus Address	User Set, 0-250 Default = 1	Sets the address for the analyzer.	Check for all analyzers. Set per customer preference.
Modbus Mode	0, 1, or 2 Default = 0	Sets type of Modbus protocol.	
2 Way Com Port	0, 1, 2, 3 Default = 1	Sets the port that allows two-way communications.	
Baud Rate	0, 1, 2, 3 or 4 Default = 3	Sets the baud rate for the customer port.	
Val Purge Period	1 - 4000 Default = 60	Sets the amount of time (in seconds) for validation gas to purge the system.	Set for standard validation only, not permeation validation.
Val Duration	0 - 8000 Default = 240	Sets the duration (in seconds) of the validation routine.	These parameters apply to permeation validation only. Refer to "Service" on page C-4.
Val Attempts	1 - 8000 Default = 2	Sets the number of validations to be attempted before signaling failure.	
Val 1 Concentration	0-Full Scale Default = 4	Sets concentration of validation gas supply #1.	Check for all analyzers. Set per customer preference.
Val 2 Concentration	0-Full Scale Default = 4	Sets concentration of validation gas supply #2.	Set for standard validation only, not permeation validation.
Validation Allowance	1-100 Default = 100	Sets acceptable deviation (in%) for validation.	Check for all analyzers. Set for customer preference.
Zero Val Tolerance	0 - 2000 Default = 1	Sets maximum acceptable zero measurement reading during validation routine.	Set for standard validation only, not permeation validation.
Daily Validation	0 or 1 Default = 0	Turns daily autovalidation on or off.	Check for all analyzers. Set for customer preference.
Val Interval	1 - 400 Default = 1	Interval (in days) between validation cycles.	
Val Start Time	0 - 23 Default = 8	Sets the hour of the day for validation.	
Start Validation	0 or 1 Default = 0	Initiates validation cycle.	
4-20 mA Val Action	0 or 1 Default = 0	Sets the current loop mode during validation.	

Table 2-1 Typical values for parameter setpoints (Continued)

Parameter	Setting	Function	Notes
Val Perm Const Kp(A)	0-1000000 Default = 0	Sets the system constant for permeation tube devices on single stream analyzers and Stream A permeation tube devices on multi-calibration analyzers.	Contact Endress+Hauser before resetting this parameter. Refer to "Service" on page C-4.
Val Perm Const Kp(B)	0-1000000 Default = 0	Sets the system constant for Stream B permeation tube devices on multi-calibration analyzers.	
Val Perm Rate Rp	0-1000000 Default = 0	Sets the calibrated permeation rate for the permeation tube.	
Cancel Val Alarms	0 or 1 Default = 0	Resets the validation alarms and relays.	After analyzer is configured press '1' to reset. Parameter will return to default setting.
Val Auto DumpSpectrm	0 or 1 Default = 0	Sets the analyzer to dump spectrum information during a validation measurement.	Contact Endress+Hauser before resetting this parameter. Refer to "Service" on page C-4.
Operator Password	0-9999 Default = 0	Sets the password required to view the Operator Parameters.	
Operator Parameter01 to Operator Parameter20	Parameter Index Default: 0	Parameter setup for Operator Parameter section. Refer to Table 2-4.	Check for all analyzers. Set for customer preference.

To change parameters in Mode 2

1. Press the # key followed by the 2 key.



The LCD prompts for a numeric password.

2. To enter the Customer Parameter section where complete access is provided to all customer parameters, enter the user password (**3142**) on the keypad. To enter the Operator Parameter section where a user definable set of customer parameters resides, enter the operator password as defined in the Operator Password parameter. Then press the * key to enter the number.

```

<SET PARAMETER MODE>
Process Purge Time
60
Enter a value (secs)
```

3. Starting with the first parameter that displays, enter a new value and/or press the * key to store the value and cycle to the next parameter.
4. When finished changing or viewing the measurement and control parameters, press the # key followed by the **1** key to return to **Mode 1** and normal operation.



*The scroll direction can be reversed by pressing the **TEST** key followed by the * key.*

Measurement and Control Parameters Defined

The definitions for the measurement and control parameters are shown below in alphabetical order for easy reference. Refer to Table 2-1 to review order listed during **Mode 2** configuration.

2 Way Com Port

The **2 Way Com Port** parameter sets the port that allows two-way communications, including Modbus and the diagnostic protocol. Enter **0** to turn off two-way communications, **1** for the customer port, **2** for the service port, or **3** for the Ethernet port (if applicable).

```

<SET PARAMETER MODE>
2 Way Com Port
1
0:Off1:Cus2:Ser3:Eth
```

The customer port baud rate is set from the **Baud Rate** parameter with 8 data bits, 1 stop bit, and no parity. The service port baud rate is 115200 with 8 data bits, 1 stop bit, and no parity. If the Ethernet port is available, refer to **“Configuring the Built-in Ethernet Port”** on page 4-1 for setup information.

4-20 mA Alarm Action

The **4-20 mA Alarm Option** determines the current loop state upon an alarm condition. Enter **0** for no action, **1** for the current loop to assume a low state upon an alarm condition, **2** for the current loop to assume a high state upon an alarm condition, or **3** for the current loop to track and hold the current state upon an alarm condition.

```
<SET PARAMETER MODE>
4-20mA Alarm Action
0
0:None 1:L 2:H 3:T&H
```

4-20 mA Val Action

The **4-20 mA Val Action** parameter sets the operation mode of the 4-20 mA current loop during validation cycles. Enter **0** for the current loop to track and hold the last process measurement or **1** for the current loop to continue to output the analyzer measurements during the validation cycle.

```
<SET PARAMETER MODE>
4-20 mA Val Action
0
0:Hold 1:Measure
```

AI 4 mA Value

The **AI 4 mA Value** parameter sets the pipeline pressure (in mbar) corresponding to a 4 mA current loop input.

```
<SET PARAMETER MODE>
AI 4 mA Value
0.00000
Enter a value (mb)
```

AI 20 mA Value

The **AI 20 mA Value** parameter sets the pipeline pressure (in mbar) corresponding to a 20 mA current loop input.

```
<SET PARAMETER MODE>
AI 20 mA Value
100000.00000
Enter a value (mb)
```

AI Pressure Input

The **AI Pressure Input** parameter enables or disables usage of a live pipeline pressure via the analog input for the calculation and display of dew point temperature. There are two choices: **0** to turn the analog pressure input off, and **1** to turn it on. If this parameter is disabled, then a fixed pipeline pressure must be entered through the **Pipeline Pressure** parameter.

```
<SET PARAMETER MODE>
AI Pressure Input
0
0:Disable 1:Enable
```

AO 4 mA Value

The **AO 4 mA Value** parameter sets the concentration (in ppmv) or dew point temperature (in degrees Celsius or Fahrenheit), depending on whether dew point temperature calculation and display are enabled (i.e., the **Calculate Dew Point** parameter set equal to **1**), corresponding to a 4 mA current loop output.

```
<SET PARAMETER MODE>
AO 4 mA Value
0.00000
ppmv or DewPoint F/C
```

AO 20 mA Value

The **AO 20 mA Value** parameter sets the concentration (in ppmv) or dew point temperature (in degrees Celsius or Fahrenheit), depending on whether dew point temperature calculation and display are enabled (i.e., the **Calculate Dew Point** parameter set equal to **1**), corresponding to a 20 mA current loop output.

```
<SET PARAMETER MODE>
AO 20 mA Value
20.00000
ppmv or DewPoint F/C
```

AO 4-20 mA Test

The **AO 20 mA Test** parameter sets the output of the current loop when in Mode 5 for testing and calibration purposes. The value entered represents a percent of scale value where zero equals 4 mA and full scale equals 20 mA. Thus, the current loop output, I , is given by

$$I = R(20mA - 4mA) + 4mA,$$

where R is the **AO 4-20 mA Test** parameter value.

```
<SET PARAMETER MODE>
AO 4-20 mA Test
0.00000
Enter a value (%)
```

Baud Rate

The **Baud Rate** parameter sets the baud rate for the customer RS-232 port. Enter **0** for 19200, **1** for 38400, **2** for 57600, or **3** for 115200, or **4** for 9600 baud rate. The other settings for this port are 8 data bits, 1 stop bit, no parity and no hardware flow control.

```
<SET PARAMETER MODE>
Baud Rate
3
0:19 1:38 2:57 3:115
```



Make sure that the COM port used is set for the same baud rate as the analyzer.

Calculate Dew Point

The **Calculate Dew Point** parameter enables or disables the calculation and display of dew point temperature. There are three choices: **0** to turn the calculation and display of dew point temperature off, **1** to allow the dew point to be output on the LCD and on the analog output (setup of the AO 4 mA and 20 mA values is required), and **2** to allow the dew point to be output on the LCD only.

```
<SET PARAMETER MODE>
Calculate Dew Point
0
0:Off 1:lcd&AO 2:lcd
```

Cancel Val Alarms

The **Cancel Val Alarms** parameter cancels the validation alarm and resets all validation flags once activated. Entering **1** cancels the alarm. Once the action is complete the parameter automatically reverts to **0**.

```
<SET PARAMETER MODE>
Cancel Val Alarms
0
1:Cancel
```

Concentration Unit

The **Concentration Unit** parameter designates the options for measured concentration, which include:

- **0** for ppmv
- **1** for lb/MMscf [displays as lb/MM; MMscf = million standard cubic feet]
- **2** for %
- **3** for mg/sm³ [sm³ = standard cubic meters]
- **4** for ppmw
- **5** for ppbv
- **6** for ppbw
- **7** for grains/100scf [displays as grns; 100scf = 100 standard cubic feet]
- **8** for custom display units and conversion factor (user EU Tag Part 1 and 2 as defined by Modbus registers 45203 and 45205)
- **9** for mg/Nm³ [Nm³ = normal cubic meters]



Based on ISO 13443:1996 Natural Gas, ISO, 5024, ASTM D1071- Standard reference conditions are 15° C, 101.325 kPa and Normal reference conditions are 0° C, 101.325 kPa. Furthermore, default conversion factors are based on pipeline quality natural gas.

```
<SET PARAMETER MODE>
Concentration Unit
0
0:ppm 1:lbs 2:% 3:mg
```

After making a **Concentration Unit** selection and pressing *, a sub-screen will display that shows the current conversion factor and allows a custom conversion factor to be entered. For this screen to display, a selection must be made, even if it represents the same selection, or the sub-screen will be skipped. Two potential sub-screens can display depending on whether or not the **Concentration Unit** selection has a default conversion. If a default conversion factor exists, then the screen will display as:

```

<SET xxxxxxxx CONVE>
Default: 1.00000000
ConvFac: 0.00000000
0:Default >0:ConvFac

```

where "xxxxxxx" = the **Concentration Unit** setting.

In this case, if the default conversion factor is correct, press * to move to the next parameter. If the conversion factor needs to be updated, enter the value and press * to accept it.

If a default conversion factor does not exist, the screen will display as:

```

<SET xxxxxxxx CONVE>
Default: Undefined
ConvFac: 0.00000000
0:ppmv >0:ConvFac

```

where "xxxxxxx" = the **Concentration Unit** setting.

In this case, the conversion factor must be entered, otherwise the analyzer will not be able to perform the concentration unit conversion. If a new conversion factor is not entered and the value "ConvFac" is zero, the **Concentration Unit** setting will revert to ppmv when * is pressed.

The default conversion factors per analyte are defined in Table 2–2. Concentration units measured in ppmw and ppbw are defaulted to NULL because weight-based units are dependent on the molecular weight of the background stream, and therefore the conversion factor has to be determined on a case-by-case basis. For lb/mmscf, mg/sm³, mg/NM³ and grn/ccf, default conversions are only provided for applicable or uncommon analytes.

The custom conversion factors can also be directly updated using Modbus. Refer to the following Modbus parameters for more information:

- ppmv ConvFactor 00
- lb ConvFactor 01
- % ConvFactor 02
- mg/s ConvFactor 03
- ppmw ConvFactor 04
- ppbv ConvFactor 05
- ppbw ConvFactor 06
- grn ConvFactor 07
- user ConvFactor 08
- mg/N ConvFactor 09

Table 2-2 Default conversion factors per analyte

Analyte	ppmv 0	lb/MMcf 1	% 2	mg/sm3 3	ppmw 4	ppbv 5	ppbw 6	grn/ccf 7	user define 8	mg/Nm3 9
H ₂ O	1.00	0.04758	0.0001	0.7619	NULL	1000.00	NULL	NULL	NULL	0.8038
CO ₂	1.00	NULL	0.0001	NULL	NULL	1000.00	NULL	NULL	NULL	NULL
H ₂ S	1.00	NULL	0.0001	1.4414	NULL	1000.00	NULL	0.0630115	NULL	1.5205
NH ₃	1.00	NULL	0.0001	NULL	NULL	1000.00	NULL	NULL	NULL	NULL
HCL	1.00	NULL	0.0001	NULL	NULL	1000.00	NULL	NULL	NULL	NULL
C ₂ H ₂	1.00	NULL	0.0001	NULL	NULL	1000.00	NULL	NULL	NULL	NULL

If a correct concentration unit option for the display units does not exist, then a custom display unit and conversion can be created using Modbus. To set a custom display unit, select option 8 for the **Concentration Unit** parameter. Next define the ASCII display text and associated conversion factor using Modbus. Refer to the Modbus Parameters user **EU Tag Part 1** and **user EU Tag Part 2** to set this ASCII display text. AMS100 software can also be used.

Custom Precision

The **Custom Precision** parameter sets the number of viewable digits to the right of the decimal point. The total number of digits the analyzer can display at any one time is 6. Therefore, when the size of the value plus the Custom

Precision exceeds 6 the number of digits to the right of the decimal point will be reduced accordingly.

```
<SET PARAMETER MODE>
Custom Precision
2
Enter a value
```

Daily Validation

The **Daily Validation** parameter enables or disables the time of day autovalidation feature. When enabled, an autovalidation cycle is initiated every 'X' day (where 'X' is defined by **Val Interval**) at the time of day established by **Val Start Time**. Enter **0** to turn the feature off or **1** to turn the feature on.

```
<SET PARAMETER MODE>
Daily Validation
0
0:Disable 1:Enable
```

Dew Point Method

The **Dew Point Method** parameter sets the type of industry standard dew point calculation to be performed when **Calculate Dew Point** is enabled. Enter **0** for ISO 18453:2006, **1** for the ASTM 1142-95 Eq. (1), **2** for the ASTM 1142-95 Eq. (2), or **3** for the Arden Buck method. Refer to Appendix A for further information on the dew point calculation methods.

```
<SET PARAMETER MODE>
Dew Point Method
0
0:ISO1:AS12:AS23:AB
```



The ISO method is valid only for sample pressures greater than 10000 mBar (10 Bar), and therefore should not be used for samples with pipeline pressures less than 10000 mBar. The analyzer software assumes that any pipeline pressure less than 10 Bar is the same as 10 Bar, so the measured Dew Point value will not change for sample pressures from 0-10 Bar. For Natural Gas sample pressures in the 0 – 10000 mBar range, Endress+Hauser recommends users select ASTM1 or ASTM2 methods. For air or nitrogen samples, we recommend the Arden Buck method (Dew Point Method = 3).

DO Alarm Setup

The **DO Alarm Setup** parameter sets the functionality of the **Assignable Alarm**. Add together the hexadecimal values according to Table 2-3 for each fault chosen to trigger the **Assignable Alarm**. Convert the resulting hexadecimal value to a decimal value and enter the number for normally deactivated relay functionality. Add '1' to the resulting decimal value to switch to normally activated functionality.

```
<SET PARAMETER MODE>
DO Alarm Setup
8192
Enter decimal value
```

For example, the hexadecimal value of 0002000 converts to decimal value of 8192, which when entered results in a normally deactivated relay triggered by the **Concentra High Alarm**. Entering a value of 8193 would result in a normally activated relay (fail safe) triggered by the **Concentra High Alarm**. To enable the relay to be triggered by the **New Scrubber Alarm** as well, the two hexadecimal values 0002000 and 8000000 are added to give 8002000, which converts to a decimal value of 134225920.

Table 2–3 Assignable Alarm functionality

Bit	Decimal	Hex Value	Alarm Functionality
0	1	00000001	Power Fail (Always activated)
1	2	00000002	Any alarm active
2	4	00000004	Laser Power Low Alrm
3	8	00000008	Laser Powr High Alrm
4	16	00000010	Laser Zero Low Alarm
5	32	00000020	Laser Zero High Alrm
6	64	00000040	Laser Curnt Low Alrm
7	128	00000080	Laser Curnt High Alrm
8	256	00000100	Pressure Low Alarm
9	512	00000200	Pressure High Alarm
10	1024	00000400	Temp Low Alarm
11	2048	00000800	Temp High Alarm
12	4096	00001000	Concentra Low Alarm
13	8192	00002000	Concentra High Alarm
14	16384	00004000	PeakTk Restart Alarm
15	32768	00008000	Fitting Restart Alrm
16	65536	00010000	RampAdj Restart Alarm
17	131072	00020000	Not Used
18	262144	00040000	Not Used
19	524288	00080000	Flow Switch Alarm
20	1048576	00100000	Val 1 Fail Alarm
21	2097152	00200000	Val 2 Fail Alarm
22	4194304	00400000	Not Used
23	8388608	00800000	Neg Conc 2f Restart Alarm
24	16777216	01000000	DeltaDC Restart Alrm
25	33554432	02000000	DeltaT Restart Alarm

Table 2-3 Assignable Alarm functionality (Continued)

Bit	Decimal	Hex Value	Alarm Functionality
26	67108864	04000000	Dry Pressure Alarm
27	134217728	08000000	New Scrubber Alarm
28	268435456	10000000	R2 Restart Alarm
29	536870912	20000000	R3 Restart Alarm
30	1073741824	40000000	Pressure Restart Alarm
31	2147483648	80000000	Low Purge Rate Alarm

General Alarm DO

The **General Alarm DO** sets the operation of the general alarm relay digital output when a **General Fault Alarm** occurs. The relay is normally energized making it fail-safe for detection of not only alarms, but also power failures. Enter **0** to make the relay latching, which means any **General Fault Alarm** will de-energize the relay and keep it de-energized even if the alarm condition clears. It takes a reset of the relay using this parameter to return the relay to 'normal' state. Enter a **1** to make the relay non-latching, which means any general fault alarm will de-energize the relay; however, when the alarm condition clears, the relay will automatically reset to its normal state. Enter a **2** to reset the relay and any active alarms to the 'normal' state. After the relay resets, this parameter will automatically revert to the setting from before the reset was initiated.

```
<SET PARAMETER MODE>
General Alarm DO
0
0:L 1:NonL 2:Reset
```

High Alarm Setpoint

The **High Alarm Setpoint** parameter determines the concentration threshold above which the **Concentra High Alarm** fault will be triggered (see "**Alarms**" on page 2-48). The value entered is compared to the moving average over the number of measurement points set by the **Logger Rate**. To be turned off, the setpoint must have a value greater than the maximum range of the analyzer or maximum dew point.

```
<SET PARAMETER MODE>
High Alarm Setpoint
0.00000
ppmv or DewPoint F/C
```

Keypad Watchdog

The **Keypad Watchdog** parameter sets the allowable time (in seconds) that the analyzer can be on the <MODE MENU> screen or the **Mode 2** (Set Parameter Mode) password screen before automatically reverting to **Mode 1** (Normal Mode). Setting this parameter to a value less than five (5) will disable this feature. If it is set for greater than or equal to five (5), then the value represents the number of seconds before the analyzer reverts to Normal Mode.

```
<SET PARAMETER MODE>
Keypad Watchdog
60
<5:Off >=5:Secs
```

Logger Rate

The **Logger Rate** parameter sets the number of measurements included in the running average. The display and the current loop output will each have a value representing the running average of the concentration over a number of measurements equal to **Logger Rate**.

```
<SET PARAMETER MODE>
Logger Rate
16
Enter a value
```

Low Alarm Setpoint

The **Low Alarm Setpoint** parameter determines the concentration threshold below which the **Concentra Low Alarm** fault will be triggered (see "**Alarms**" on page 2-48). The value entered is compared to the moving average over the number of measurement points set by the **Logger Rate**. To be turned off, the setpoint must have a value less than the minimum range of the analyzer or minimum dew point.

```
<SET PARAMETER MODE>
Low Alarm Setpoint
0.00000
ppmv or DewPoint F/C
```

Modbus Address

The **Modbus Address** parameter sets the analyzer address when the analyzer is used as a Modbus slave device. Addresses from 1 to 250 can be used.

```
<SET PARAMETER MODE>
Modbus Address
1
Enter node (1-250)
```

Modbus Mode

The **Modbus Mode** parameter sets the communications protocol for the port selected by the **2 Way Com Port** parameter. There are three choices: **0** for turning the Modbus capabilities off and defaulting to generic serial output as described in "**Receiving Serial Data (Customer Port Output)**" on page 3-1 (the ports not designated for two-way communications will also output the generic serial output); **1** for enabling the analyzer to respond to Gould Modbus RTU function codes 3, 6 and 16; and **2** for enabling the analyzer to respond to Daniel Modbus RTU function codes 3, 6 and 16.

```
<SET PARAMETER MODE>
Modbus Mode
0
0:Off 1:GMR 2:DMR
```

New Scrub Installed

The **New Scrub Installed** parameter resets the scrubber/dryer alarm once activated, and the scrubber/dryer lifetime monitor. The **New Scrubber Alarm** fault will activate the **General Fault Alarm** when the scrubber/dryer capacity is predicted to be 5% or less, or when the scrubber days of service remaining reaches 0 days (refer to the Operating Instruction for information on servicing the scrubber). Once the scrubber/dryer is replaced, enter **1** to reset the scrubber/dryer alarm and lifetime monitor.

```
<SET PARAMETER MODE>
New Scrub Installed
0
1:Yes
```

Operator Parameter01 to Operator Parameter20

These parameters enable the setup of the Operator Parameter section. A parameter index may be entered for each parameter to be displayed when the analyzer is in the Operator Parameter section. Refer to Table 2-4. Entering **0** (zero) will prevent a parameter from being displayed.

To access the Operator Parameter section:

1. From the analyzer keypad, press the **#** key followed by the **2** key to enter **Mode 2**.
2. Enter the Operator Password as defined in the Operator Password parameter and press the ***** key.



Refer to the section called "**Operator Password**" on page 2-32 for more information.

Only those parameters with a parameter index indicated will be displayed. If none of the 20 parameters have an index defined, the following screen will display while in Operator Parameter section.

<SET PARAMETER MODE>
No Operator
parameters defined.
Press MODE to exit.

<SET PARAMETER MODE>
Operator Parameter01
0
Enter a parameter #

Table 2-4 Operator Parameters

Parameter	Index	Parameter	Index
R1 Stream Option	288	Calculate Dew Point	215
Process Purge Time	190	Dew Point Method	217
Logger Rate	34	Pipeline Pressure	216
Rapid Change Monitor	183	AI Pressure Input	230
Temperature Unit	35	AI 4 mA Value	231
Pressure Unit	36	AI 20 mA Value	232
Concentration Unit	37	Modbus Address	125
Custom Precision	200	Modbus Mode	126
RATA	87	2 Way Com Port	202
RATA Multiplier	88	Baud Rate	73
RATA Offset	89	Val Purge Period	98
Update RATA	250	Val Duration	99
Peak Tracking	248	Val Attempts	100
New Scrub Installed	42	Val 1 Concentration	39
Keypad Watchdog	201	Val 2 Concentration	83
Set Time - Hour	46	Validation Allowance	40
Set Time - Minute	47	Zero Val Tolerance	104
Set Time - Day	45	Daily Validation	84
Set Time - Month	44	Val Interval	101
Set Time - Year	43	Val Start Time	48
General Alarm DO	41	Start Validation	97
DO Alarm Setup	102	4-20 mA Val Action	103
Low Alarm Setpoint	132	Val Perm Const Kp(A)	198
High Alarm Setpoint	33	Val Perm Const Kp(B)	298
AO 4-20 mA Test	105	ValPerm Rate Rp	199
4-20 mA Alarm Action	71	Cancel Val Alarms	155
AO 4 mA Value	153	Val Auto DumpSpectrm	156
AO 20 mA Value	154	Operator Password	251

Operator Password

The **Operator Password** parameter enables or disables a password requirement for entering the Operator Parameter section. Enter **0** for a password to disable a password requirement, or a positive value (up to four digits) to require a password. If **0** is used, accessing the Operator Parameter section requires only pressing the **#** key followed by the **2** key (to enter **Mode 2**), and then pressing the ***** key (without entering a password) to display the first parameter.

```
<SET PARAMETER MODE>
Operator Password
0
0:No p/w >0:p/w
```

Peak Tracking

The **Peak Tracking** parameter enables a software utility that periodically adjusts the laser current to keep the absorption peak of the measured component at a known location. There are three choices: **0** for no peak tracking, **1** for peak tracking (default) and **2** for resetting the peak to its factory default setting. Selecting **2** will return the current analyzer midpoint to the factory default midpoint, and then automatically revert the parameter value to its setting before the reset was initiated. In most cases, the peak tracking should be set to **1** for on.

```
<SET PARAMETER MODE>
Peak Tracking
1
0:Off 1:On 2:Rst
```

Pipeline Pressure

The **Pipeline Pressure** parameter sets the pipeline pressure (in mbar) in the current dew point calculation or, if enabled, displays the current pipeline pressure input through the AI Pressure Input.

```
<SET PARAMETER MODE>
Pipeline Pressure
10000.00000
Enter a value (mb)
```


Pressure Unit

The **Pressure Unit** parameter designates the display units for the measured absolute pressure in the cell. There are four choices: **0** for millibar, **1** for Torr, **2** for kPa, and **3** for PSIA.

```
<SET PARAMETER MODE>
Pressure Unit
0
0:mb1:Torr2:kPa3:psi
```

Process Purge Time

The **Process Purge Time** sets the time in seconds that the analyzer will purge the system with process gas before starting a dry cycle when switching to the process stream after a validation.

```
<SET PARAMETER MODE>
Process Purge Time
60
Enter a value (secs)
```

R1 Stream Option

The **R1 Stream Option** parameter sets the calibration used for the concentration calculations and should be based on the stream entering the analyzer. This parameter is only visible when the analyzer is configured to support the multi-calibration feature. The other parameter that is affected by this setting is the **Val Perm Const Kp(B)**. There are two choices for this parameter setting: **0** for Stream A, **1** for Stream B.

```
<SET PARAMETER MODE>
R1 Stream Option
0
0:A 1:B
```

Rapid Change Monitor

The **Rapid Change Monitor** parameter enables or disables the dynamic logger rate based on the concentration rate of change. Enter **0** to turn the feature off or **1** to turn the feature on.

```
<SET PARAMETER MODE>
Rapid Change Monitor
0
0:Disable 1:Enable
```

RATA (Relative Accuracy Test Audit)

The **RATA** parameter enables or disables user definable values that allow adjustment (without affecting the factory calibration) of the analyzer reading in the field [see "**Adjusting Analyzer Reading to Match Specific Standard(s)**" on page 2-41].

```
<SET PARAMETER MODE>
RATA
0
0:Disable 1:Enable
```

RATA Multiplier

The **RATA Multiplier** parameter is a user definable value that enables adjustment (without affecting the factory calibration) of the analyzer response (or slope) in the field [see "**Adjusting Analyzer Reading to Match Specific Standard(s)**" on page 2-41].

```
<SET PARAMETER MODE>
RATA Multiplier
1.00000
Enter a value
```

RATA Offset

The **RATA Offset** parameter is a user definable value that enables adjustment (without affecting the factory calibration) of the analyzer offset in the field [see "**Adjusting Analyzer Reading to Match Specific Standard(s)**" on page 2-41].

```
<SET PARAMETER MODE>
RATA Offset
0.00000
Enter a value
```

Set Time - Day

The **Set Time - Day** parameter sets the current day for the clock driving daily validations.

```
<SET PARAMETER MODE>
Set Time - Day
17
Enter a value (DD)
```

Set Time - Hour

The **Set Time - Hour** parameter sets the current hour for the clock driving daily validations.

```
<SET PARAMETER MODE>
Set Time - Hour
7
Enter a value (0-23)
```

Set Time - Minute

The **Set Time - Minute** parameter sets the current minute for the clock driving daily validations.

```
<SET PARAMETER MODE>
Set Time - Minute
5
Enter a value (0-59)
```

Set Time - Month

The **Set Time - Month** parameter sets the current month for the clock driving daily validations.

```
<SET PARAMETER MODE>
Set Time - Month
10
Enter a value (MM)
```

Set Time - Year

The **Set Time - Year** parameter sets the current year for the clock driving daily validations.

```
<SET PARAMETER MODE>
Set Time - Year
2014
Enter a value (YYYY)
```

Start Validation

The **Start Validation** parameter initiates the validation cycle. After the cycle begins, this parameter automatically reverts to 0.

```
<SET PARAMETER MODE>
Start Validation
0
1:Start
```

Temperature Unit

The **Temperature Unit** parameter designates the display units for the measured cell temperature. There are two choices: **0** for degrees Celsius and **1** for Fahrenheit. The default value is the standard unit of measurement in the region the analyzer is being used.

```
<SET PARAMETER MODE>
Temperature Unit
0
0:C 1:F
```

Update RATA

The **Update RATA** parameter is used to update the **RATA Multiplier** and **RATA Offset** parameters with the latest automatically calculated values. Each time an automatic, semi-automatic, manual **Mode 7** or manual **Mode 8** validation is completed, a new **RATA Multiplier** and **RATA Offset** will be calculated. This parameter displays the current **RATA Multiplier** and **RATA Offset** in the left column of the display as defined in their respective parameter descriptions. In the right column, the newly calculated values are displayed. To accept and use the newly calculated values, enter **1**. These values will be invoked when pressing the MODE button while exiting **Mode 2**.

```
<SET PARAMETER MODE>
Mult: 1.00 New: 1.00
Ofst: 0.00 New: 0.00
0          1: Update RATA
```



Refer to the section called "**Adjusting Analyzer Reading to Match Specific Standard(s)**" on page 2-41 for more information.

Val 1 Concentration

The **Val 1 Concentration** parameter sets the concentration value of validation gas supply #1. The analyzer can be configured for a zero gas by setting this parameter to 0.0 and then setting the **Zero Val Tolerance** to the maximum acceptable reading. Otherwise, set this parameter to the concentration value of the validation gas supply and set **Validation Allowance** to the allowable variation range ($\pm\%$).

```
<SET PARAMETER MODE>
Val 1 Concentration
4.00000
0:ZeroGas >0:ppmvVal
```



When procuring a gas standard, make sure the background gas is that specified or a mix that closely resembles the contents of the process stream and have the gas standard certified to better than the specified precision of the analyzer, if possible.

Val 2 Concentration

The **Val 2 Concentration** parameter sets the concentration value of validation gas supply #2. The analyzer can be configured for a zero gas by setting this

parameter to 0.0 and then setting the **Zero Val Tolerance** to the maximum acceptable reading. Otherwise, set this parameter to the concentration value of the validation gas supply and set **Validation Allowance** to the allowable variation range ($\pm\%$).

```
<SET PARAMETER MODE>
Val 2 Concentration
16.0000
0:ZeroGas >0:ppmvVal
```



When procuring a gas standard, make sure the background gas is that specified or a mix that closely resembles the contents of the process stream and have the gas standard certified to better than the specified precision of the analyzer, if possible.

Val Attempts

The **Val Attempts** parameter sets the maximum number of failures of the analyzer to measure the validation gas within the set tolerances (see **Zero Val Tolerance** and **Validation Allowance**) before stopping the autovalidation sequence and triggering a **Validation Fail Alarm**.

```
<SET PARAMETER MODE>
Val Attempts
2
Enter a value
```

Val Auto DumpSpectrm

The **Val Auto DumpSpectrm** parameter determines whether a **Mode 6** dump automatically occurs after each validation measurement. There are two choices: **0** to turn the automatic data dump during validation off, and **1** to turn it on.

```
<SET PARAMETER MODE>
Val Auto DumpSpectrm
0
0:Disable 1:Enable
```

Val Duration

The **Val Duration** parameter sets the total number of seconds a validation cycle will run. Actual validation measurement time is equal to **Val Duration** minus **Val Purge Period** minus the time required to get the first measurement

value. Thus, **Val Duration** must be set to a value greater than the sum of these components.

```

<SET PARAMETER MODE>
Val Duration
240
Enter a value (secs)

```

Validation Allowance

The **Validation Allowance** parameter sets the tolerance ($\pm\%$) for validation measurements when **Val 1 Concentration** or **Val 2 Concentration** is set to a value greater than 0.

```

<SET PARAMETER MODE>
Validation Allowance
100.00000
% of Val Concentratn

```

Val Interval

The **Val Interval** parameter sets the number of days between autovalidation cycles. The next scheduled validation cycle would occur in **Val Interval** days at the **Val Start Time**.

```

<SET PARAMETER MODE>
Val Interval
1
Enter a value (days)

```

Val Perm Const Kp(A)

The **Val Perm Const Kp(A)** parameter is used for permeation validation devices and defines the system constant (K_p), which is determined at the factory at the time of calibration. The permeation device can be replaced with another permeation device with a different permeation rate, and the correct new permeation concentration will be calculated by the analyzer software using the system constant. The K_p will be constant over the life of the analyzer provided the temperature, sample flow rate and pressure of the system are not changed from the factory settings. If the system constant needs to be reset,

refer to "**Recalculating the System Constant Kp**" on page B-3 for details on recalculating the system constant.

```
<SET PARAMETER MODE>
Val Perm Const Kp(A)
0.24
0:Off >0:System Cons
```

Val Perm Const Kp(B)

The **Val Perm Const Kp(A)** parameter is used for permeation validation devices and defines the system constant (Kp) for stream B on multi-calibration analyzers. Refer to "**Val Perm Const Kp(A)**" for more information. The analyzer will use either **Val Perm Const Kp(A)** or **Val Perm Const Kp(B)** based on the setting of the parameter "**R1 Stream Option**".

```
<SET PARAMETER MODE>
Val Perm Const Kp(B)
0.24
0:Off >0:System Cons
```

Val Perm Rate Rp

The **Val Perm Rate Rp** parameter is used for permeation validation devices and defines the permeation rate in ng/min, referenced on the permeation device certification. This certification is valid for a period of one year; however, the permeation device may be used longer than this period if a factory certified validation concentration is not required. When the validation concentration begins to drop steadily, the permeation device must be replaced. When replacing the device, the Val Perm Rate Rp must also be updated. For instruction on replacing the permeation device, refer to the section called "**Validation of Trace Moisture Measurements**" in the sample conditioning system (SCS) chapter or manual.

```
<SET PARAMETER MODE>
Val Perm Rate Rp
0.33
0:Off >0:ng/min
```

Val Purge Period

The **Val Purge Period** parameter sets the number of seconds the analyzer will purge the system with validation gas before starting a dry cycle upon validation initiation. Because validation gas may be introduced into the system at various

distances from the analyzer, adjustment of the **Val Purge Period** parameter is necessary to optimize the time the validation gas is allowed to purge through the transport tubing before the analyzer makes a validation measurement. Optimization of the **Val Purge Period** parameter ensures an accurate measurement of the validation gas while minimizing gas consumption.

```
<SET PARAMETER MODE>
Val Purge Period
60
Enter a value (secs)
```

Val Start Time

The **Val Start Time** parameter sets the hour of the day for the daily autovalidation to begin.

```
<SET PARAMETER MODE>
Val Start Time
8
Hour of day (0-23)
```

Zero Val Tolerance

The **Zero Val Tolerance** parameter is used to set the maximum acceptable reading when validating with zero gas. To configure the analyzer for zero gas set the parameter **Val 1 Concentration** or **Val 2 Concentration** to 0.0.

```
<SET PARAMETER MODE>
Zero Val Tolerance
1.00000
Enter a value (ppmv)
```

Adjusting Analyzer Reading to Match Specific Standard(s)

In some instances, the user may wish to adjust the analyzer reading to match the concentration (or concentrations) of a specific standard (or standards). The **RATA Multiplier** and **RATA Offset** parameters are used to adjust the analyzer output in the field without affecting the factory calibration. Both parameters are used when samples from two different concentration standards are available, whereas only the **RATA Multiplier** parameter is used when a non-zero gas sample from only one concentration standard is available. If using a zero gas sample from only one concentration standard, then only the **RATA Offset** parameter should be calculated.

The value of the **RATA Multiplier** parameter, S , is determined by

$$S = \frac{C_2 - C_1}{A_2 - A_1} ,$$

where C_1 is the certified concentration of standard No. 1, C_2 is the certified concentration of standard No. 2, A_1 is the measured concentration (analyzer reading) of standard No. 1 without any RATA adjustment, and A_2 is the measured concentration (analyzer reading) of standard No. 2 without any RATA adjustment.

The **RATA Offset** parameter, O , is determined by

$$O = C_1 - (S \cdot A_1) ,$$

where S can be 1 when a sample from only one concentration standard is available.

For a non-zero single concentration standard **RATA Multiplier** parameter, S is determined by

$$S = (C_1 - O) /$$

where O can be zero, if desired.

After an automatic, semi-automatic, manual **Mode 7** or manual **Mode 8** validation completes, the analyzer automatically calculates new **RATA Multiplier** and **RATA Offset** values. These values are based on the number of validations that the analyzer is configured to accept and the type of validation used.

To perform this calculation, the most recent validation result(s) will be used. These calculations are based on the average measurement values during the validation, which can be viewed from the **Mode 9** display. These values are not constrained by the measurement range of the analyzer, which will ensure accurate **RATA Multiplier** and **RATA Offset** values are calculated.

To perform the calculation:

If RATA is enabled, the current **RATA Multiplier** and **RATA Offset** values must be removed from the measured Validation 1 and/or Validation 2 concentration values. Depending on the number of validations, or the validation type, one of the following scenarios occur:

- If using a non-permeation single validation system with a zero gas as the standard, then a new **RATA Offset** is calculated leaving the **RATA Multiplier** at its previous value.
- If using a non-permeation single validation system with a non-zero gas as the standard, then a new **RATA Multiplier** is calculated leaving the **RATA Offset** at its previous value.

- If using a permeation-based single validation system, then a new **RATA Multiplier** is calculated and the **RATA Offset** is left at its previous value.
- If using a dual validation system, then both a new **RATA Multiplier** and **RATA Offset** are calculated.

To adjust the analyzer reading:

1. Validate the analyzer using one or two concentration standards (refer to **“Validating the Analyzer”** on page 2-52).



Endress+Hauser recommends validating the analyzer using only the analyte mixed in the validation gas specified on the analyzer calibration certificate. A bottle of test gas with certified concentrations of approximately 20% and 80% of full scale are recommended for a two point validation. For a single point validation, a bottle with a certified concentration of approximately 50% of full scale should be used.



When procuring a gas standard, make sure the background gas is that specified or a mix that closely resembles the contents of the process stream and have the gas standard certified to better than the specified precision of the analyzer, if possible.

2. Enter **Mode 2** by pressing the **#** key followed by the **2** key. The LCD prompts for a numeric password.
3. Enter the user password (**3142**) on the keypad, then press the ***** key.
4. View the newly calculated **RATA Multiplier** and **RATA Offset** parameters from the **Update RATA** parameter or calculate the **RATA Multiplier** and/or **RATA Offset** parameter(s) manually using the equations above.
5. Follow the procedure under **“To change parameters in Mode 2”** on page 2-16 to enter the new values.

Confirm the new values by re-measuring the bottle(s) of test gas.



RATA values are also applied to the validation measurements. If RATA free validation values are required, the RATA parameter must be disabled before running the validation.

Application Examples

Manual Dual Validation

Two standards are used in this example, Validation 1 and Validation 2, which are manually introduced into the analyzer. **Mode 7** and **Mode 8** are used to run these standards.

1. Configure the **Operator Parameter01** to **Operator Parameter20** with the **Operator Password** set to **0** and one parameter.
 - Configure **Update RATA** by setting **Operator Parameter01** to **250**. Other parameters can be added, if desired.
2. Introduce Validation 1 and press **#** followed by the **7** key (to enter **Mode 7**) to allow Validation 1 to run for the desired amount of time.
3. Introduce Validation 2 and press **#** followed by the **8** key (to enter **Mode 8**) to allow validation to run for the desired amount of time.
4. Press the **#** key followed by the **2** key (to enter **Mode 2**) and then the ***** key.
5. View the newly calculated RATA values, and if desired, set **Update RATA** to **1** accept the changes. Leave the setting at **0** to reject the changes and start over.
6. Re-run steps 2 and 3.
7. Press the **#** key followed by the **9** key (to enter **Mode 9**) to verify the validation results and confirm that new RATA values are operating correctly.
8. Press the **#** key followed by the **1** key (to enter **Mode 1**) to return to Normal Mode.

Semi-Automatic Single or Dual Validation

In this scenario, either one or two standards (Validation 1 and/or Validation 2) are used, which are automatically introduced and controlled by the analyzer. Typically, the validation is initiated locally by the user or while the user is present by initiating the **Start Validation** parameter or the Start Validation digital input.

1. Configure the **Operator Parameter01** to **Operator Parameter20** with the **Operator Password** set to **0** and two parameters.
 - Configure **Start Validation** by setting **Operator Parameter01** to **97**.
 - Configure **Update RATA** by setting **Operator Parameter02** to **250**. Other parameters can be added, if desired.

2. Press the **#** key followed by the **2** key (to enter **Mode 2**) and then press the ***** key.
3. Set the **Start Validation** parameter to **1**, then press the ***** key followed by the **#** and the **1** key to allow the validation to start. Allow the validation sequence to complete.
4. Press the **#** key followed by the **2** key (to enter **Mode 2**) and then press the ***** key twice.
5. View the newly calculated RATA values, and if desired, set **Update RATA** to **1** to accept the changes. Leave the setting at **0** to reject the changes and start over.
6. Re-run steps 2 through 4.
7. Press the **#** key followed by the **9** key (to enter **Mode 9**) to verify the validation results and confirm that new RATA values are operating correctly
8. Press the **#** key followed by the **1** key (to enter **Mode 1**) to return to Normal Mode.

Automatic Single or Dual Validation

Either one or two standards can be used for automatic single or dual validation; Validation 1 and/or Validation 2, which are automatically introduced and controlled by the analyzer. The validation is automatically initiated based on the hour of the day and is controlled by the **Val Start Time**, **Daily Validation** and **Val Interval** parameters. Validation can also be initiated remotely using the **Start Validation** parameter or the **Start Validation** digital input.

1. Configure the **Operator Parameter01** to **Operator Parameter20** with the **Operator Password** set to **0** and one parameter.
 - Configure **Update RATA** by setting **Operator Parameter01** to **250**. Other parameters can be added, if desired.
2. Press the **#** key followed by the **9** key (to enter **Mode 9**) to verify the validation results.
3. Press the **#** key followed by the **2** key (to enter **Mode 2**) and then press the ***** key.
4. View the newly calculated RATA values, and if desired, set **Update RATA** to **1** to accept the changes. Leave the setting at **0** to reject the changes and start over.
5. Press the **#** key followed by the **1** key (to enter **Mode 1**) to return to Normal Mode.

Scaling and Calibrating the Current Loop Signal

The 4-20 mA current loop signals are most conveniently scaled and calibrated at the receiving end (RTU, flow computer, etc.).



The 4-20 mA current loop is factory set as the source unless otherwise specified. Contact your sales representative if a change is required.

To scale the receiver's output, the analyzer's current loop output is forced to 4 mA (0%) and 20 mA (100%) using the **4-20 mA Test** parameter. The receiver is adjusted to read "0" and "Full Scale," respectively.



Be sure to work in a non-hazardous area while handling any electrical connector.

To scale the current loop signal:

1. Make sure the current loop is connected and the receiver is set for the analyzer to source the current.
2. Set the **AO 4-20 mA Test** parameter to 0% (see Table 2-1).
3. Enter **Mode 5** by pressing the **#** key followed by the **5** key to force the loop current to 4 mA.
4. Adjust the receiver calibration control to read the appropriate value. A current loop output of 4 mA represents the value set in **AO 4 mA Value**.
5. Set the **4-20 mA Test** parameter to 100%.
6. Enter **Mode 5** by pressing the **#** key followed by the **5** key to force the loop current to 20 mA.
7. Adjust the receiver calibration controls for the appropriate value. A current loop output of 20 mA represents the value set in **AO 20 mA Value**.
8. If needed, repeat steps 2-7 to obtain an accurate calibration over the range.
9. After obtaining an accurate calibration of the current loop receiver, press the **#** key followed by the **1** key to return to **Normal Mode**.



*Every time the **#** key is pressed, the analyzer requires three to four minutes time upon returning to **Mode 1**, **Mode 6**, **Mode 7** or **Mode 8** to re-establish reference spectra before displaying a reading.*

Warnings

Warning messages appear on the front panel LCD and are transmitted via RS-232. Changes in flow conditions such as composition, temperature or pressure since the last scrubber/dryer cycle may produce a warning. Warnings may trigger a system re-start beginning with a fresh scrubber/dryer cycle. It typically takes three consecutive instances of the warning condition before triggering a system re-start. Furthermore, too many consecutive system restarts, normally five, based on the same warning condition, will elevate the warning to an alarm as described in the next section. Warnings may include one or more of the following:

- **DCdelta out of range:** This warning occurs when the difference between the measured cell DC power during a wet cycle and previous dry cycle is out of range.
- **Delta P out of range:** This warning occurs when the difference between the measured cell pressure during a wet cycle and previous dry cycle is out of range.
- **Delta T out of range:** This warning occurs when the difference between the measured cell temperature during a wet cycle and the previous dry cycle is out of range.
- **Diff 2f CC/Wet/Dry Peak Tracking:** This warning indicates when a peak tracking correction has occurred.
- **Diff 2f/Dry 2f Ramp Adjust:** This warning indicates when a ramp adjustment correction has occurred.
- **Dry P out of range:** This warning occurs when the pressure in the sample cell during a dry cycle is out of range indicating that the scrubber/dryer may be clogged.
- **Fitting out of range:** This warning occurs when the system is unable to adequately fit a curve to the measured signal typically as a result of too much noise in the signal or an unexpected gas mixture in the measurement cell.
- **Neg 2f out of range:** This warning occurs when the concentration is below the allowable range, typically as the result of too much noise in the signal, an unexpected gas mixture in the measurement cell, a sample leak or an exhausted scrubber/dryer.
- **R2 out of range:** This warning occurs when reference 2 is out of range, typically as a result of too much of the gas component found in the measurement cell.
- **R3 out of range:** This warning occurs when reference 3 is out of range, typically as a result of too much of the gas component found in the measurement cell.
- **Unable to do validation:** This warning occurs if using a permeation validation system with the Daily Validation feature and the current analyzer concentration is beyond an allowable threshold. It is

designed to protect the dryer from high concentrations, which can shorten its life cycle. This does not apply to validations that are initiated by the digital input, **Mode 7**, **Mode 8** or **Mode 2 Start Validation** parameter.

Alarms

The analyzer is equipped with three dry contact relays that indicate a system fault or alarm state, the **General Fault Alarm** relay, the user **Assignable Alarm** relay and the **Validation Fail Alarm** relay. Refer to the system drawings for this analyzer for relay assignments.

In addition, alarm and fault messages appear on the front panel LCD and are transmitted via RS-232.

System Faults

The **General Fault Alarm** is triggered by system faults that cause the **General Fault Alarm** relay to be activated and the current loop to respond according to the **4-20mA Alarm Option** setting. Once activated, the **General Fault Alarm** can be reset via the **General Alarm DO** parameter (see “**Changing Measurement and Control Parameters**” on page 2-12).

System faults include one or more of the following:

- **DeltaDC Restart Alarm:** This fault occurs when the number of consecutive system restarts caused by the **DC delta out of range** warning, a difference between the measured DC signal during a wet cycle and the previous dry cycle, exceeds a pre-set limit.
- **DeltaT Restart Alarm:** This fault occurs when the number of consecutive system restarts caused by the **Delta T out of range** warning, a difference between the measured cell temperature during a wet cycle and the previous dry cycle, exceeds a pre-set limit.
- **Dry Pressure Restart Alarm:** This fault occurs when the number of consecutive system restarts caused by the **Dry P out of range** warning, an out of range dry pressure value, exceeds a pre-set limit.
- **Fitting Restart Alarm:** This fault occurs when the number of consecutive system restarts caused by the **Fitting out of range** warning, the systems' inability to adequately fit a curve to the measured signal, exceeds a pre-set limit.
- **Flow Switch Alarm:** This fault occurs on systems with a digital input flow switch enabled and the digital input triggers the alarm state.
- **Laser Current Low Alarm:** This fault occurs when the laser current goes below the minimum allowable indicating a potential problem with the laser.
- **Laser Power High Alarm:** This fault occurs when the DC signal is saturated typically as a result of the absence of absorbing gas in the sample cell.

- **Laser Power Low Alarm:** This fault occurs when the DC signal becomes too weak for a reliable measurement typically as a result of mirror contamination.
- **Laser Zero High Alarm:** This fault occurs if the detector signal value is above the set normal range when the laser is turned off.
- **Laser Zero Low Alarm:** This fault occurs if the detector signal value is below the set normal range when the laser is turned off.
- **Lasr Curnt High Alarm:** This fault occurs when the laser current goes above the maximum allowable indicating a potential problem with the laser.
- **Low Purge Rate Alarm:** This fault occurs when the scrubber/dryer is unable to remove the analyte being measured at a quick enough rate typically due to scrubber/dryer saturation.
- **Neg 2f Restart Alarm:** This fault occurs when the number of consecutive system restarts caused by the **Neg 2f out of range** warning, which occurs when the concentration is below the allowable range, exceeds a pre-set limit. Once this alarm occurs, no additional system restarts will be generated from the **Neg 2f out of range** warning. Furthermore, the alarm is latching and can only be cleared through the "**General Alarm DO**" parameter reset procedure.
- **New Scrubber Alarm:** This fault occurs when the internal scrubber/dryer monitor signals that a new scrubber/dryer is necessary.
- **PeakTk Restart Alarm:** This fault occurs when the number of consecutive system restarts caused by the **Diff 2f CC/Wet/Dry Peak Tracking** warning, a peak tracking correction, exceeds a pre-set limit.
- **Pressure High Alarm:** This fault occurs when the pressure in the sample cell exceeds the specified maximum operating pressure.
- **Pressure Low Alarm:** This fault occurs when the pressure in the sample cell is below the specified minimum operating pressure.
- **Pressure Restart Alarm:** This fault occurs when the number of consecutive system restarts caused by the **Delta P out of range** warning, a difference between the measured cell pressure during a wet cycle and the previous dry cycle, exceeds a pre-set limit.
- **R2 Restart Alarm:** This fault occurs when the number of consecutive system restarts caused by the **R2 out of range** warning, due to reference 2 being out of range, exceeds the pre-set limit. This is typically the result of too much of the gas component found in the measurement cell.
- **R3 Restart Alarm:** This fault occurs when the number of consecutive system restarts caused by the **R3 out of range** warning, due to reference 3 being out of range, exceeds the pre-set limit. This

is typically the result of too much of the gas component found in the measurement cell.

- **Ramp Adjust Restart Alarm:** This fault occurs when the number of consecutive system restarts caused by the **Diff 2f/Dry 2f Ramp Adjust** warning, a ramp adjustment, exceeds a pre-set limit.
- **Temp High Alarm:** This fault occurs when the temperature in the measurement cell exceeds the specified maximum operating temperature.
- **Temp Low Alarm:** This fault occurs when the temperature in the measurement cell is below the specified minimum operating temperature.



*For systems with heated enclosures, a **Temperature too Low** or **Temperature too High** fault will activate the **General Fault Alarm** when the enclosure temperature is more than 5 °C above or below the specified temperature (refer to the system specifications for this analyzer located in the Operating Instruction). Once the enclosure has reached the specified temperature, reset the **General Fault Alarm** (see "**Changing Measurement and Control Parameters**" on page 2-12).*

- **Validation 1 Failed/Validation 2 Failed Alarm:** An additional alarm for systems equipped with autovalidation that is triggered when the measured concentration of the validation 1 or 2 gas does not agree with the user defined allowable limits. These alarms also trigger the Validation Fail dry contact relay. Refer to "**Validation Allowance**" on page 2-39. Once activated, the **Validation Fail Alarm** must be manually reset via the **Cancel Val Alarms** parameter (see "**Cancel Val Alarms**" on page 2-21).

See Appendix C for recommendations and solutions to common firmware problems resulting in a system fault.

User Alarms

User alarms are generated based on measurement readings and their relation to **Mode 2** parameter settings. They include the following:

- **Concentra High Alarm:** This fault occurs when the measured concentration is above the limit set with the **High Alarm Setpoint** parameter (see "**High Alarm Setpoint**" on page 2-27).
- **Concentra Low Alarm:** This fault occurs when the measured concentration is below the set limit with the **Low Alarm Setpoint** (see "**Low Alarm Setpoint**" on page 2-28).

Historical Alarm Flag

A **Historical Alarm Flag** code will also display on the LCD, as shown in Figure 2-3, and remain until the alarm is reset.

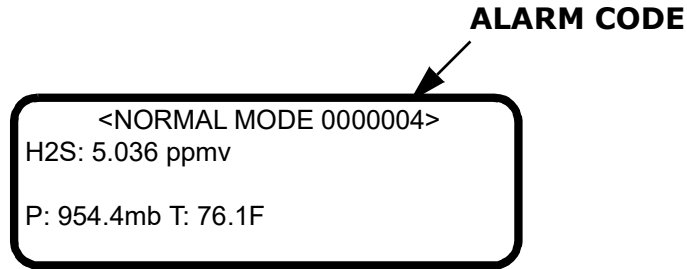


Figure 2-3 LCD display with alarm code visible indicating **Pressure Low Alarm** fault

Table 2-5 lists the potential alarm codes and corresponding fault conditions. In the event of multiple alarms, the hexadecimal code from each alarm is added together to yield the **Historical Alarm Flag** code. For example, a **Historical Alarm Flag** code of 00C04 indicates that three alarms have occurred: 00004 **Laser Power Low Alarm**, 00400 **Temp Low Alarm**, and 00800 **Temp High Alarm**, where 'C' represents '12' in hexadecimal notation.

Table 2-5 LCD display alarm codes

Hex Value	Fault Condition
00000001	General fault condition exists or happened in the past
00000002	General fault condition exists (any alarm is active)
00000004	Laser Power Low Alrm
00000008	Laser Powr High Alrm
00000010	Laser Zero Low Alarm
00000020	Laser Zero High Alrm
00000040	Laser Curnt Low Alrm
00000080	Lasr Curnt High Alrm
00000100	Pressure Low Alarm
00000200	Pressure High Alarm
00000400	Temp Low Alarm
00000800	Temp High Alarm
00001000	Concentra Low Alarm
00002000	Concentra High Alarm
00004000	PeakTk Restart Alarm
00008000	Fitting Restart Alrm

Table 2-5 LCD display alarm codes (Continued)

Hex Value	Fault Condition
00010000	RampAdj Restart Alarm
00020000	Not Used
00040000	Not Used
00080000	Flow Switch Alarm
00100000	Validation Fail Alarm 1
00200000	Validation Fail Alarm 2
00400000	Not Used
00800000	Neg 2f Restart Alarm
01000000	DeltaDC Restart Alarm
02000000	DeltaT Restart Alarm
04000000	Dry Pressure Alarm
08000000	New Scrubber Alarm
10000000	R2 Restart Alarm
20000000	R3 Restart Alarm
40000000	Pressure Restart Alarm
80000000	Low Purge Rate Alarm

Assignable Alarm

The functionality of the **Assignable Alarm** is determined by the **DO Alarm Setup** parameter set in **Mode 2** according to Table 2-3. For example, the **Assignable Alarm** can be configured as a **Concentra High Alarm** or **Concentra Low Alarm** that is triggered when the measured concentration is above or below, respectively, the level set in **Mode 2**. A high concentration causes the **Assignable Alarm** relays to be activated and the message "Concentration High" to appear on the LCD.

Validating the Analyzer

Validation of the analyzer using an appropriate gas standard is automatically conducted at each **Val Interval** period at the **Val Start Time**, semi-

automatically when initiated via the Validation DI or the **Start Validation** parameter, or manually by accessing **Mode 7** or **Mode 8**.



*If using a permeation validation system with the **Daily Validation** feature, and the current analyzer concentration is beyond an allowable threshold, the analyzer will output a warning message of "Unable to do validation," activate the **Validation Fail** alarm and not conduct the validation. The system is designed to protect the dryer from high concentrations, which can shorten its life cycle. This does not apply to validations that are initiated by the digital input **Mode 7**, **Mode 8** or **Mode 2 - Start Validation** parameter.*

To validate automatically:

1. Verify that the validation gas source(s) has been properly installed and/or connected.
2. If necessary, set the current time, date, desired validation hour and validation interval (see Table 2–1 for parameter default values).
3. Set the **Daily Validation** parameter to **1**. The analyzer should run a validation cycle at the number of days and hour set by **Val Interval** and the **Val Start Time** parameter.

To validate semi-automatically:

1. Verify that the validation gas source(s) has been properly installed and/or connected.
2. Initiate a validation cycle by closing the contacts connected to the Validation DI input or by setting the **Start Validation** parameter to **1**.



The keypad is disabled when Validation DI is active.

To validate manually:

1. Verify that the validation gas source(s) has been properly installed and/or connected.
2. Initiate validation measurements by pressing the **#** key followed by the **7** key (**Mode 7**) or the **#** key followed by the **8** key (**Mode 8**) for a dual validation system.
3. Once validation measurements are complete, press the **#** key followed by the **1** key (**Mode 1**) to return to Normal Mode and stop the validation.

If the **4-20 mA Val Action** parameter is set to **1**, the 4-20 mA signal will output validation measurements and the appropriate relay (Val #1 Active or Val #2 Active) will be activated. During the automatic or semi-automatic validation, if the concentration measured does not fall within the allowable limits for the number of times defined by the **Val Attempts** parameter (see "**Validation Allowance**" on page 2-39), the **Validation Fail Alarm** relay will activate. Once activated, the **Validation Fail Alarm** must be manually canceled (see "**Cancel Val Alarms**" on page 2-21). Initiating a new automatic, semi-automatic or manual validation will clear the Validation Fail Alarm so that the new validation can determine its state.



Once the validation completes, the analyzer requires three to four minutes upon returning to Mode 1 to re-establish reference spectra before displaying a reading.



Endress+Hauser recommends validating the analyzer using only the analyte mixed in the validation gas specified on the analyzer calibration report. A bottle of test gas with a certified concentration representing 50% of full scale) for single validation systems), or bottles representing 20% and 80% of full scale (for dual validation systems) are recommended.



When procuring a gas standard, make sure the background gas is that specified or a mix that closely resembles the contents of the process stream and have the gas standard certified to better than the specified precision of the analyzer, if possible.

Calibrating the Analyzer

Calibrating the analyzer is typically not required under normal circumstances. Endress+Hauser calibrates each analyzer to a National Institute of Standards and Technology (NIST) traceable standard before shipping the unit to the end user. Because Endress+Hauser analyzers use a non-contact form of measurement, they are relatively insensitive to contamination, quite rugged and virtually maintenance free ensuring years of reliable service.

3 - SERIAL PORT COMMUNICATIONS

Receiving Serial Data (Customer Port Output)

When the **Modbus Mode** parameter is set to **0**, the analyzer is configured to transfer a string of data from the analyzer to a serial device via the customer port output. The receiving device is typically a computer terminal running HyperTerminal, which is a program included with Microsoft® Windows® 95, 98, and XP that enables serial communication and the viewing, capturing and storage of serial port data and messages.

To launch HyperTerminal:

1. On your Windows desktop, click **Start** followed by **Run** (usually located in the lower right side of the **Start Menu**).
2. Type **Hypertrm.exe** and hit **Return** to launch HyperTerminal.



For faster access to HyperTerminal, save a HyperTerminal shortcut to the desktop.

3. Once HyperTerminal is activated, the **Connection Description** window appears, as shown in Figure 3-1. Type in a **Filename** (where the terminal session settings will be stored for future recall) and click on any icon. Click **OK**.
4. The **Connect To** window appears prompting for a connection, as shown in Figure 3-2. Click the **Menu Arrow** under **Connect Using** to view the choices.
5. Click on the appropriate port to which your analyzer is connected (COM1, COM2, COM3, etc.) as established under "**To connect the signal and alarm cables**" in the Operating Instruction. Click **OK**.
6. Once the port is chosen, the **COM Properties** window appears. Make sure the COM properties for the port selected reflect those shown in Figure 3-3 (19200 baud or as set in **Mode 2**, 8 data bits, 1 stop bit, no parity, and no flow control).
7. Click **OK** to establish the connection.

Mode 1 Data String

Once connected, the data will start streaming through the Hyperterminal Window as shown in Figure 3-4.

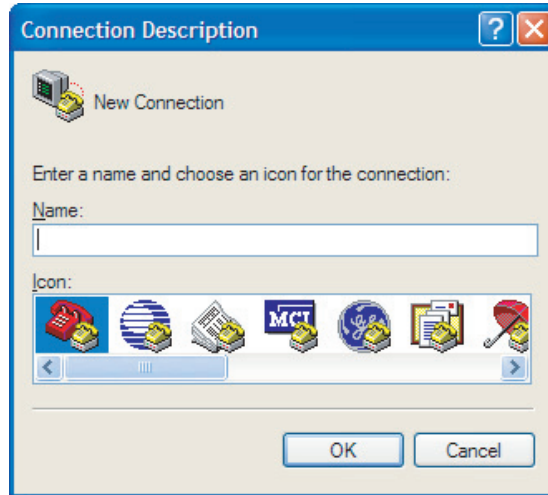


Figure 3-1 Connection Description window



Figure 3-2 Connect To window

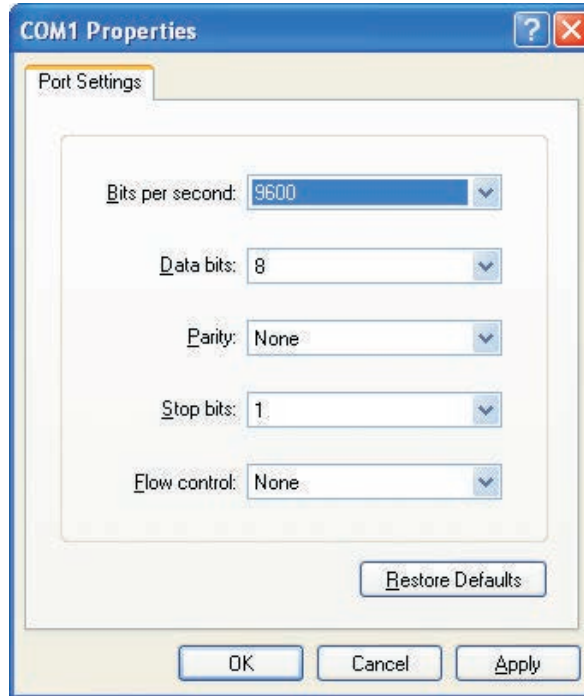
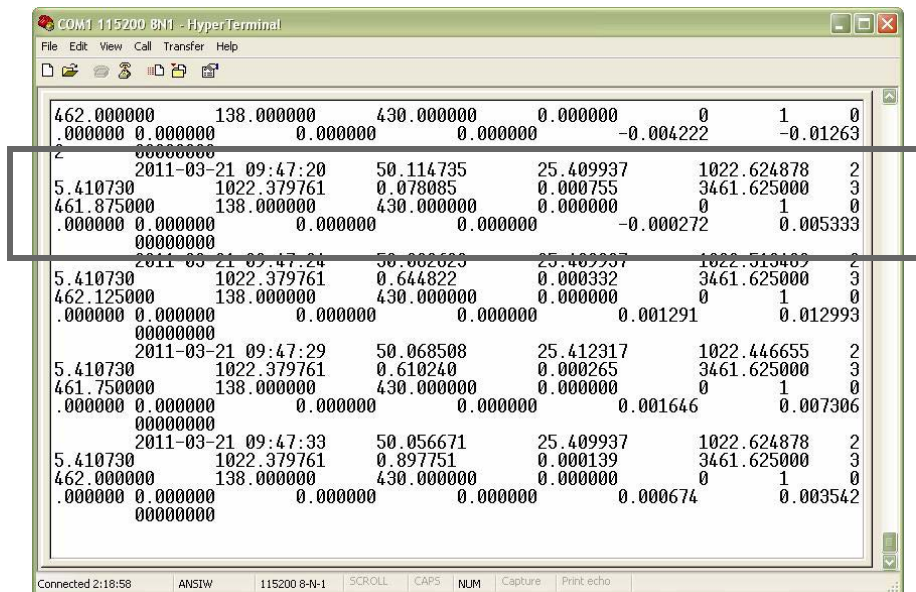


Figure 3-3 COM Properties window



Refer to data output headings in Figure 3-5; reading left to right

Figure 3-4 Hyperterminal window with streaming data

The data string is tab delimited (each row starting with a tab) forming 23 columns in the following order:

- **Date:** Current date (in MM:DD:YY).
- **Time:** Current time (in HH:MM:SS).
- **Concentration (ppmv):** Current measured analyte/component concentration (ppmv).
- **Wet Temp (C):** Current temperature (C) of the gas sample when normal sample gas is flowing.
- **Wet Pressure (mb):** Current pressure (mb) of the gas sample when normal sample gas is flowing.
- **Dry Temp:** Current temperature (0.0 for non-differential units) of the gas sample (in selected engineering units) when scrubbed sample gas is flowing.
- **Dry Pressure:** Current pressure (0.0 for non-differential units) of the gas sample (in selected engineering units) when scrubbed sample is flowing.
- **Fit Residue:** Value ranging from 0 to 1 indicating how well the measured spectrum fits the referenced spectrum, where 1 represents a perfect match.
- **Fit Ratio:** Ratio of the measured spectrum versus the Reference 1 spectrum.
- **Dry DC:** Signal level (laser intensity in counts, 0.0 for non-differential units) at the high end of the current ramp during the dry cycle.
- **Wet DC:** Signal level at the high end of the current ramp during the wet cycle.
- **Peak Index:** Peak index of the measured spectrum.
- **Ref Index:** Peak index used for reference.
- **Index Difference:** Difference between measured and reference peak indices, where a value other than 0 indicates peak tracking is functioning.
- **Val Flg:** Indicates current stream being measured (0 = Process, 1 = Val 1, 2 = Val 2).
- **Process Path Flg:** Calculation path (reference spectra) used for the concentration calculation (0 = Process Reference Spectra, 1 = Validation Reference Spectra).
- **Current Midpoint:** Current midpoint that the analyzer is using, including any peak tracking adjustments.
- **Fit Ratio 2:** Ratio of the measured spectrum versus the Reference 2 spectrum, where a value of 0 indicates that the Reference 2 spectrum was not used in the calculation of concentration.

- **Fit Ratio 3:** Ratio of the measured spectrum versus the Reference 3 spectrum, where a value of 0 indicates that the Reference 3 spectrum was not used in the calculation of concentration.
- **Fit Ratio 4:** Ratio of the measured spectrum versus the Reference 4 spectrum, where a value of 0 indicates that the Reference 4 spectrum was not used in the calculation of concentration.
- **Fit Ratio 5:** Ratio of the measured spectrum versus the Reference 5 spectrum, where a value of 0 indicates that the Reference 5 spectrum was not used in the calculation of concentration.
- **Fit Ratio Dry:** Ratio of the measured spectrum versus the Reference Dry spectrum, where a value of 0 indicates that the Reference Dry spectrum was not used in the calculation of concentration.
- **Fit Ratio Dry-1:** Ratio of the measured spectrum versus the Reference Dry spectrum shifted by 1 index value, where a value of 0 indicates that the Reference Dry spectrum shifted by 1 index value was not used in the calculation of concentration.
- **Alarm Flags:** Value representing the status of each individual alarm in the analyzer, as listed in Table 2–2.

Any alarm messages will be transmitted along with the data string and will appear in a separate row.



*The number of seconds between each line of data output should be the # **Spectrum Average** number set in **Mode 2** divided by 4. The factory default setting of 16 for # **Spectrum Average** results in a line of output each 4 seconds.*

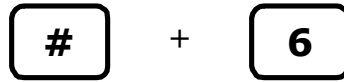
To capture and save data from the serial port:

1. To save the data from the serial port, use the **Transfer/Capture Text** function and enter the **Filename** to where you would like to store the captured data.
2. To stop the capture of the serial data, click on **Transfer/Capture Text/Stop**.

To read diagnostic data with HyperTerminal:

1. Before entering **Mode 6**, make sure the serial port on the computer used for serial communication is connected to the analyzer and the output stream is showing on the screen as described under "**To launch HyperTerminal**" on page 3-1.
2. To save the data from the serial port, use the **Transfer/Capture Text** function and enter the **Filename** to where you would like to store the captured data.

3. Once capturing is in place, enter **Mode 6** by pressing **#** key followed by the **6** key.



```

<EXPORT SPECTRUM>
H2S: 5.036 ppmv
Index: 0
Cycle: 1 of 10

```

The index shown on the LCD display counts by 50's from 0 to 511. The analyzer will repetitively output this information until the **#** button is pressed or the number of cycles completes. At the end of the data dump, the screen will display:

```

<MODE MENU>
1:Measure ProcessGas
2:Change Parameters
3:Scrubber Life Data

```

4. Press the **#** key followed by the **1** key to return to **Mode 1**.
5. Once normal operation resumes, stop the capture of the serial data. To stop the capture of the serial data, click on **Transfer/Capture Text/Stop**. The resulting data file contains the downloaded data as shown in Figure 3-5.

Mode 6 Data

The 20 columns of tab delimited data in the file resulting from a **Mode 6** data dump are labeled as follows:

- **Index:** Index value of points on spectrum scan curve.
- **DC Dry:** Dry DC spectrum of sample gas.
- **DC Dry Ref 1:** Reference 1 dry DC spectrum.
- **DC Wet:** Wet DC spectrum of sample gas.
- **DC Wet Ref 1:** Reference 1 wet DC spectrum.
- **2f Dry:** Dry AC spectrum of sample gas.
- **2f Dry Ref 1 Pdry/Pwet:** Reference 1 dry AC spectrum based on dry pressure.
- **2f Wet:** Wet AC spectrum of sample gas.

```

<DUMP SPECTRUM MODE>
Date:2016-5-14 Time:14:55:54
SpectraSensors Inc
TDL Analyzer
1100002175.D
FS 5.16-G205

```

Cycle: 1 of 10

Dry DC Fit Ratio	DC Wet DC Fit Ratio 3	Date & Time	DC Dry Ref 4	DC Dry Ref 1	DC Wet Ref 0	DC Wet Ref 1	Wet Temp Index Difference	Wet Pressure Val Flg	Dry Temp Process Path Flg	Dry Pressure Current	Fit Residue Midpoint	Fit Ratio Fit Ratio 2		
0.312500	0.000000	2014-10-17 14:56:15	0.000000	0.000000	0.000000	0.500000	20.630304	1011.550171	20.625299	1011.862122	0.758966	0.066575		
0.000000	0.000000		0.000000	0.000000	0.000000	0.000000	409.000000	0.000000	0	70.000000	0.000000	0.000000		
			0.000000	0.000000	0.000000	0.000000	-0.973848	0.000000	00000000					
Index Ref 2	DC Dry Ref 3	DC Dry Ref 4	DC Dry Ref 1	DC Wet Ref 0	DC Wet Ref 1	DC Wet Ref 1	2f Dry Ref Val	2f Dry Ref Val	Ref 1 Pdry/Pwet	2f wet Ref Val	2f wet Ref Val	Ref 1 Pwet	2f Composite	Ref 1
0	0.375000	0.000000	0.000000	0.000000	0.500000	0.000000	0.000000	0.000000	-42909.093750	0.000000	0.000000	-23555.556641	0.000000	0.000000
0	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1	0.250000	0.000000	0.000000	0.000000	0.250000	0.000000	0.000000	0.000000	-37818.183594	0.000000	0.000000	-20888.888672	0.000000	0.000000
0	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.187500	0.000000	0.000000	0.000000	0.250000	0.000000	0.000000	0.000000	-32000.000000	0.000000	0.000000	-19555.556641	0.000000	0.000000
0	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3	0.125000	0.000000	0.000000	0.000000	0.312500	0.000000	0.000000	0.000000	-28363.636719	0.000000	0.000000	-16888.888672	0.000000	0.000000
0	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
4	0.250000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	-24727.273438	0.000000	0.000000	-14666.666992	0.000000	0.000000
0	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
5	0.250000	0.000000	0.000000	0.000000	0.062500	0.000000	0.000000	0.000000	-21818.181641	0.000000	0.000000	-12000.000000	0.000000	0.000000
0	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
6	0.125000	0.000000	0.000000	0.000000	-0.062500	0.000000	0.000000	0.000000	-18181.818359	0.000000	0.000000	-11111.111328	0.000000	0.000000
0	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
7	0.000000	0.000000	0.000000	0.000000	0.187500	0.000000	0.000000	0.000000	-16727.273438	0.000000	0.000000	-8888.888672	0.000000	0.000000
0	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
8	0.062500	0.000000	0.000000	0.000000	0.062500	0.000000	0.000000	0.000000	-14545.455078	0.000000	0.000000	-8000.000000	0.000000	0.000000
0	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
9	0.125000	0.000000	0.000000	0.000000	0.187500	0.000000	0.000000	0.000000	-11636.364258	-461.782318	-8000.000000	-10181.587891	0.000000	0.000000
4348	125000	-9719.805664	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
10	0.062500	0.000000	0.000000	0.000000	0.125000	0.000000	0.000000	0.000000	-11636.364258	-651.170105	-7111.111328	-9274.558594	0.000000	0.000000
3607	163818	-8623.388672	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
11	0.062500	0.000000	0.000000	0.000000	-0.062500	0.000000	0.000000	0.000000	-12363.636719	-857.883789	-5777.777832	-8534.494141	0.000000	0.000000
3079	392578	-7676.610352	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Figure 3-5 Sample diagnostic data output

- **2f Wet Ref 1 Pwet:** Reference 1 wet AC spectrum based on wet pressure.
- **2f:** AC spectrum of sample gas.
- **Ref 1:** Reference 1 AC spectrum.
- **Ref 2:** Reference 2 AC spectrum.
- **Ref 3:** Reference 3 AC spectrum.
- **Ref 4:** Reference 4 AC spectrum.
- **Ref 0:** Reference 0 AC spectrum.
- **Ref 0 RT:** Reference 0 real-time AC spectrum.
- **Ref Val:** Reference Validation AC spectrum.
- **2f Dry Ref Val Pdry/Pwet:** Reference Validation dry AC spectrum based on dry pressure.
- **2f Wet Ref Val Pwet:** Reference Validation wet AC spectrum based on wet pressure.
- **2f Composite:** Recreated AC spectrum based on the reference curve fitting ratios.

Viewing Diagnostic Data with Microsoft Excel

A spreadsheet program such as Microsoft Excel can import the data collected in the **Mode 6** data dump for viewing and plotting.

To import the data file into Excel:

1. In Excel, click **Open** and choose the name of the spectrum file saved while in **Mode 6**. Be sure to select **All Files (*.*)** under **Files of type:** while searching, as shown in Figure 3-6.
2. The **Text Import Wizard** should open. Choose the **Delimited** option and click **Next**, as shown in Figure 3-7.
3. Under **Delimiters**, choose the **Tab** and **Space** options, check the **Treat Consecutive Delimiters as One** box, as shown in Figure 3-8, and then click **Finish** to display the spreadsheet. The first few lines look like the normal serial output data received before the **Mode 6** command was entered. Look for the three columns of numbers at the bottom of the file.
4. Click on the upper right cell of the three columns, as shown in Figure 3-9. Hold the **Shift** key down while pressing the **End** key followed by the **Down Arrow** key to highlight the third column. Keep holding down the **Shift** key and press the **End** key followed by the **Left Arrow** key to select the three columns by 512 rows.

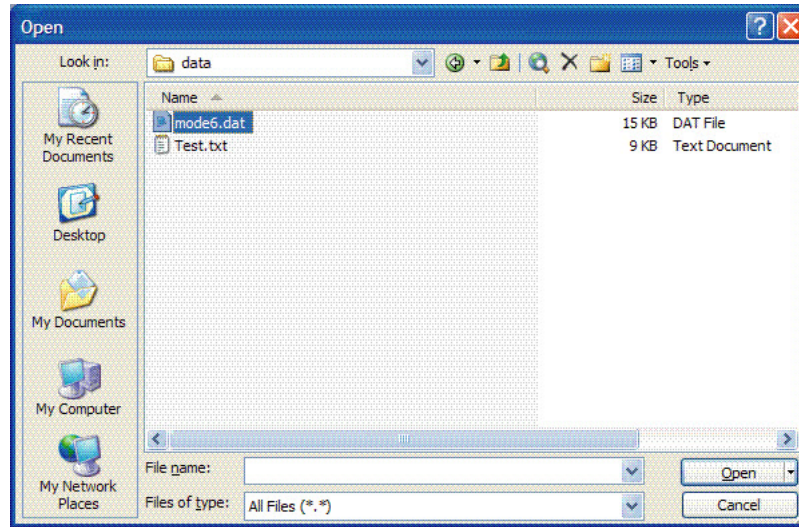


Figure 3–6 Opening a data file in Excel

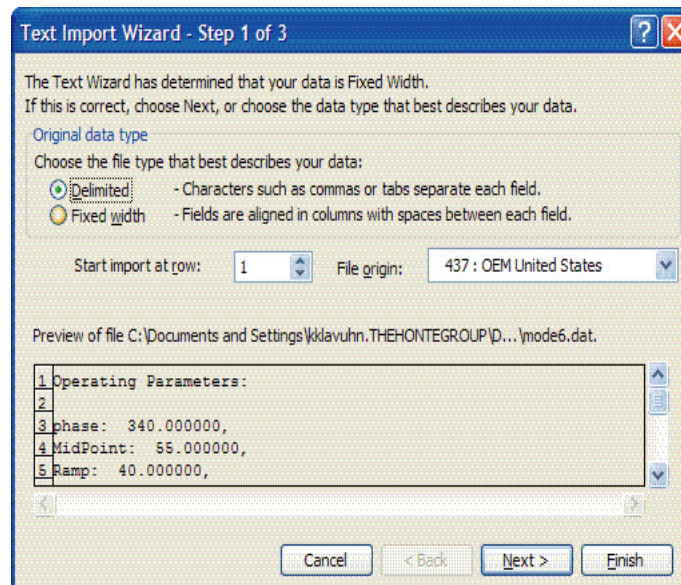


Figure 3–7 Setting data type in Text Import Wizard

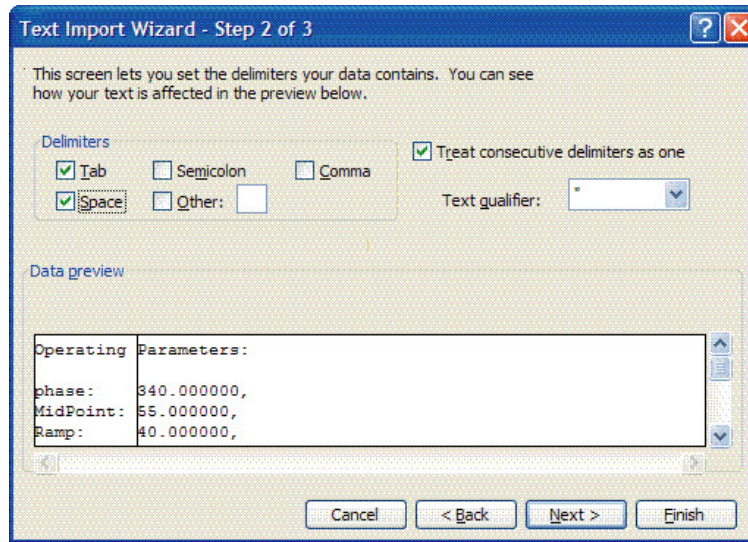


Figure 3-8 Setting Tab and Space as delimiters

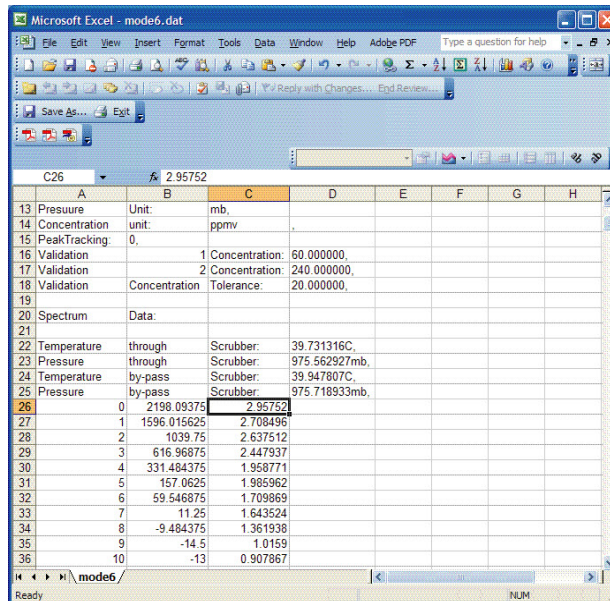



Figure 3-9 Highlighting imported data for plotting in Excel

5. Click the **Chart Wizard** button  on the **Task Bar**. The **Chart Wizard** should open, as shown in Figure 3-10.

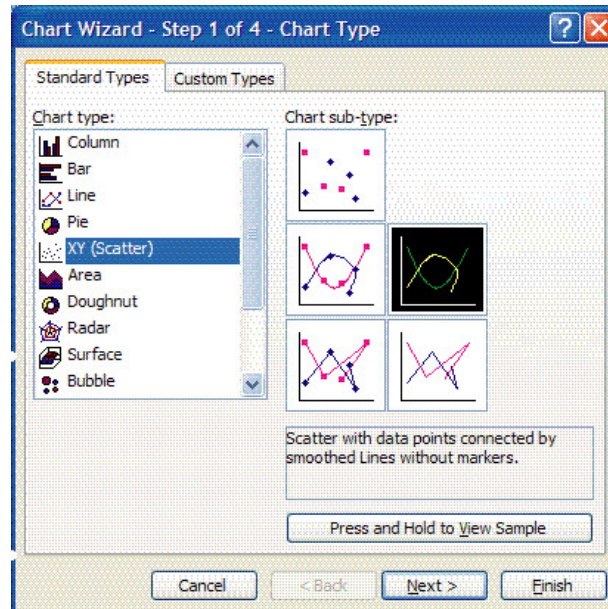


Figure 3–10 Chart Wizard - Step 1 window

6. Choose the **X-Y (Scatter)** chart type and the **Smoothed Lines Without Markers** sub-type. Click **Finish** to display a graph of the spectrum, as shown in Figure 3–11.

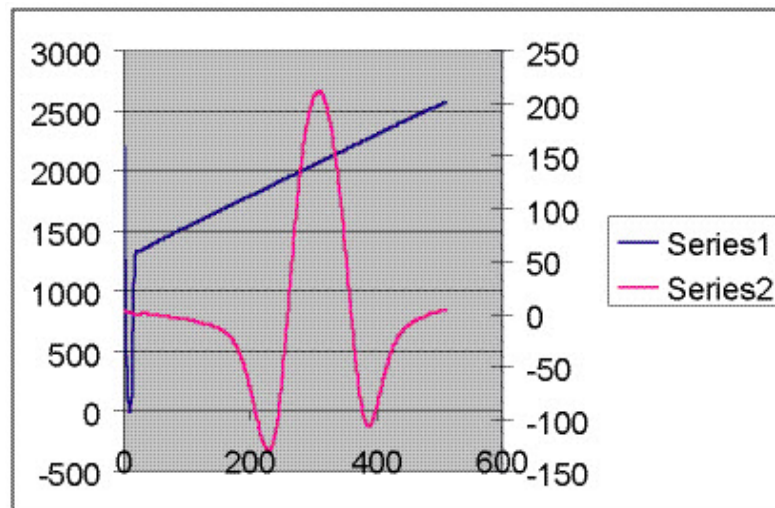


Figure 3–11 Data file plot in Excel

7. If the $2f$ curve appears flat, double click on it to get to the **Format Data Series Window**, as shown in Figure 3–12. Select the **Axis** tab, and select **Plot Series on Secondary Axis**. Click **OK** to rescale the plot.

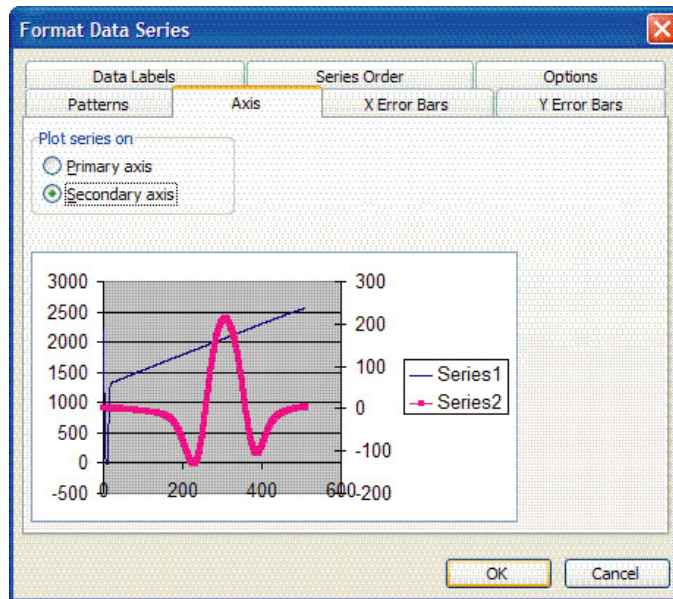


Figure 3–12 *Format Data Series window*

Modbus Communications Protocol

Modbus is a serial communications protocol published by Modicon in 1979 for use with its programmable logic controllers (PLCs). It has become a *de facto* standard communications protocol in industry, and is now the most commonly available means of connecting industrial electronic devices. Modbus is used extensively in lieu of other communications protocols because it is openly published and royalty-free, relatively easy to deploy, and capable of moving raw bits or words without placing many restrictions on vendors.

Modbus enables communication between many devices connected to the same network, for example, a supervisory computer with a remote terminal unit (RTU) in supervisory control and data acquisition (SCADA) systems.

The Endress+Hauser analyzer acts as a client in a client/server network of devices. It can receive queries from a master and send responses back using either Gould Modbus RTU protocol or Daniel Extended Modbus RTU protocol.

Framing/Protocol

The transmission mode used to communicate is either Gould Modbus RTU or Daniel Modbus RTU with port parameters 9600 to 115200 (baud rate), 8 (data bits), 1 (stop bit), no (parity), and none (flow control/handshake).

The transmission mode is set by the user via the **Modbus Mode** parameter (see **"To change parameters in Mode 2"** on page 2-16). Note that the

generic serial output (HyperTerminal) is disabled if either Gould or Daniel Modbus is selected.

Functions

Available functions are 0x03 (read holding registers), 0x06 (write to a single register), 0x10 (write to multiple registers), and 0x2B (read device identification).

Addressing

The analyzer's Modbus slave node address can be in the range of 0-250 with the default being 1. All analyzers will respond to an address of 0, so this address can be used to interrogate a single unit when its address is unknown or to determine its address.

See Table 3-1 on page 3-15 for register definitions for both Gould and Daniel Modbus modes. Be aware that for Gould Modbus the table follows the convention of identifying the register with an offset of 40001. Therefore, the actual value transmitted in the starting register field of the command is the listed register value minus 40001 (e.g., register 47001 is addressed as 7000).

Reading/Writing in Daniel Modbus Mode

Daniel Modbus supports three types of registers: short integer, long integer and floating point. Each "short integer" register is two bytes in length and will contain an integer value. Each "long integer" register is four bytes in length and will contain an integer value and each "floating point" register is four bytes in length and will contain a floating point value.

Reading/Writing in Gould Modbus Mode

Gould Modbus supports three types of variable data, short integer, long integer and floating point, but all registers are addressed as word (two byte) registers. A "short integer" value is contained in one register whereas a "long integer" or "floating point" value requires two contiguous registers. The registers are defined as Read or Read/Write.



Use caution when writing to registers as changing the value of a writable register may affect the calibration of the analyzer.

An appropriate password must be downloaded to the password register prior to writing to most registers. The User Level 1 (L1) user password **3142** will allow access to those registers which have been pre-defined as user configurable. Other writable registers can only be downloaded or changed by Endress+Hauser support personnel using a User Level 2 (L2) password.

Endianness

Endianness, often referred to as *byte order*, is the ordering of individually addressable sub-units (words, bytes, or even bits) within a longer data word. Byte orders with the *most* versus *least* significant byte first are called big-endian and little-endian, respectively. In Endress+Hauser analyzers, all bytes are stored big-endian. Thus, for floating point and long-integer data types, the byte order will look like:

HighWord-HighByte	HighWord-LowByte	LowWord-HighByte	LowWord-LowByte
-------------------	------------------	------------------	-----------------

Note that floating point values follow the IEEE Standard for Floating-Point Arithmetic (IEEE 754-2008).

To enable Modbus communications:

1. Confirm that the serial cable has been properly connected (see **"Connecting the Signals and Alarms"** in the Operating Instruction).
2. Power up the analyzer (see **"Powering Up the Analyzer"** on page 2-1).
3. Enter **Mode 2** by pressing the **#** key followed by the **2** key.

```
<SET PARAMETER MODE>
Enter password:
FS 5.16-XXXX
```

The LCD prompts for a numeric password. Enter the user password (**3142**) on the keypad, then press the ***** key to enter the number to enter **Mode 2** (Set Parameter Mode).

```
<SET PARAMETER MODE>
Process Purge Time
60
Enter a value(secs)
```

4. Press the ***** key repeatedly until the **Modbus Address** parameter is displayed.

```
<SET PARAMETER MODE>
Modbus Address
1
Enter node (1-250)
```

5. Enter the desired **Modbus Address** and press the * key to store the value and cycle to the **Modbus Mode** parameter.

```
<SET PARAMETER MODE>
Modbus Mode
0
0:Off 1:GMR 2:DMR
```

6. Enter the desired **Modbus Mode** and press the * key to store the value (see **"To change parameters in Mode 2"** on page 2-16).
7. Enter the **2 Way Com Port** assignment and press the * key to store the value.

```
<SET PARAMETER MODE>
2 Way Com Port
1
0:Off1:Cus2:Ser3:Eth
```

8. Press the # key followed by the 1 key to return to **Mode 1**. The analyzer is now ready to receive Modbus queries.

Table 3-1 Modbus register map

Parameter	Daniel Reg.	Gould Reg.	Data Type	Action	Min.	Max.
Concentration Process	7001	47001	Float	Read	-	-
Temperature	7002	47003	Float	Read	-	-
Pressure	7003	47005	Float	Read	-	-
Concentration ppmv	7004	47007	Float	Read	-	-
Wet Temp C	7005	47009	Float	Read	-	-
Wet Pressure mb	7006	47011	Float	Read	-	-
Fit Residue	7007	47013	Float	Read	-	-
Current Midpoint	7008	47015	Float	Read	-	-
Dew Point	7009	47017	Float	Read	-	-
DC Level	7010	47019	Float	Read	-	-
Zero Level	7011	47021	Float	Read	-	-
4-20 mA Output Value	7012	47023	Float	Read	-	-
4-20 mA Input Value	7013	47025	Float	Read	-	-
RATA Mult Proposed	7014	47027	Float	Read	-	-
RATA Offset Proposed	7015	47029	Float	Read	-	-

Table 3-1 Modbus register map (Continued)

Parameter	Daniel Reg.	Gould Reg.	Data Type	Action	Min.	Max.
Conc Process ppmv	7016	47031	Float	Read	-	-
Concentration	7017	47033	Float	Read	-	-
Val Date	7026	47051	Float	Read	-	-
Val Time	7027	47053	Float	Read	-	-
Val 1 Value	7028	47055	Float	Read	-	-
Val 2 Value	7029	47057	Float	Read	-	-
Val 1 Value ppmv	7030	47059	Float	Read	-	-
Val 2 Value ppmv	7031	47061	Float	Read	-	-
Val 1 Avg Value	7032	47063	Float	Read	-	-
Val 1 Avg Value ppmv	7033	47065	Float	Read	-	-
Val 1 Min Value ppmv	7034	47067	Float	Read	-	-
Val 1 Max Value ppmv	7035	47069	Float	Read	-	-
Val 2 Avg Value	7036	47071	Float	Read	-	-
Val 2 Avg Value ppmv	7037	47073	Float	Read	-	-
Val 2 Min Value ppmv	7038	47075	Float	Read	-	-
Val 2 Max Value ppmv	7039	47077	Float	Read	-	-
Dry Temp C	7041	47081	Float	Read	-	-
Dry Pressure mb	7042	47083	Float	Read	-	-
Dry DC Level	7043	47085	Float	Read	-	-
Scrubber Life Left	7044	47087	Float	Read	-	-
Common Weight	7051	47101	Float	Read	-	-
Fitting Ratio	7052	47103	Float	Read	-	-
Fitting Ratio 2	7053	47105	Float	Read	-	-
Fitting Ratio 3	7054	47107	Float	Read	-	-
Fitting Ratio 4	7055	47109	Float	Read	-	-
Fitting Ratio 5	7056	47111	Float	Read	-	-
Fitting Ratio Dry	7057	47113	Float	Read	-	-
Fitting Ratio Dry-1	7058	47115	Float	Read	-	-
Cross Shift	7060	47119	Float	Read	-	-
Peak Track Index	7061	47121	Float	Read	-	-
Peak Index Ref	7062	47123	Float	Read	-	-
Peak Track Index Dry	7091	47181	Float	Read	-	-

Table 3-1 Modbus register map (Continued)

Parameter	Daniel Reg.	Gould Reg.	Data Type	Action	Min.	Max.
Peak Index Ref Dry	7092	47183	Float	Read	-	-
RATA Multiplier	7101	47201	Float	R/W L1	-1.00E+06	1.00E+06
RATA Offset	7102	47203	Float	R/W L1	-1.00E+06	1.00E+06
Low Alarm Setpoint	7103	47205	Float	R/W L1	-1.00E+06	1.00E+06
High Alarm Setpoint	7104	47207	Float	R/W L1	-1.00E+06	1.00E+06
AO 4 mA Value	7105	47209	Float	R/W L1	0	1.00E+05
AO 20 mA Value	7106	47211	Float	R/W L1	0	1.00E+05
AO 4-20 mA Test	7107	47213	Float	R/W L1	0	100
AI 4 mA Value	7108	47215	Float	R/W L1	0	499999
AI 20 mA Value	7109	47217	Float	R/W L1	0	499999
Val 1 Concentration	7110	47219	Float	R/W L1	0	1.00E+06
Val 2 Concentration	7111	47221	Float	R/W L1	0	1.00E+06
Validation Allowance	7112	47223	Float	R/W L1	0	100
Zero Val Tolerance	7113	47225	Float	R/W L1	0	1.00E+06
Pipeline Pressure	7125	47249	Float	R/W L1	5000	499999
Methane	7126	47251	Float	R/W L1	0	1
Ethane	7127	47253	Float	R/W L1	0	1
Nitrogen	7128	47255	Float	R/W L1	0	1
Carbon Dioxide	7129	47257	Float	R/W L1	0	1
Propane	7130	47259	Float	R/W L1	0	1
I-Butane	7131	47261	Float	R/W L1	0	1
N-Butane	7132	47263	Float	R/W L1	0	1
Neo-Pentane	7133	47265	Float	R/W L1	0	1
I-Pentane	7134	47267	Float	R/W L1	0	1
N-Pentane	7135	47269	Float	R/W L1	0	1
Hexane	7136	47271	Float	R/W L1	0	1
ppmv ConvFactor 00	7139	47277	Float	R/W L1	0	1.00E+06
lb ConvFactor 01	7140	47279	Float	R/W L1	0	1.00E+06
% ConvFactor 02	7141	47281	Float	R/W L1	0	1.00E+06
mg/s ConvFactor 03	7142	47283	Float	R/W L1	0	1.00E+06
ppmw ConvFactor 04	7143	47285	Float	R/W L1	0	1.00E+06
ppbv ConvFactor 05	7144	47287	Float	R/W L1	0	1.00E+06

Table 3-1 Modbus register map (Continued)

Parameter	Daniel Reg.	Gould Reg.	Data Type	Action	Min.	Max.
ppbw ConvFactor 06	7145	47289	Float	R/W L1	0	1.00E+06
grn ConvFactor 07	7146	47291	Float	R/W L1	0	1.00E+06
user ConvFactor 08	7147	47293	Float	R/W L1	0	1.00E+06
mg/N ConvFactor 09	7148	47295	Float	R/W L1	0	1.00E+06
Val Perm Const Kp(A)	7212	47423	Float	R/W L1	0	1.00E+06
Val Perm Rate Rp	7213	47425	Float	R/W L1	0	1.00E+06
Val Perm Const Kp(B)	7280	47559	Float	R/W L1	0	1.00E+06
Alarm Flags	5001	45001	Long	Read	-	-
Status Flags	5002	45003	Long	Read	-	-
DO Alarm Setup	5101	45201	Long	R/W L1	0	4.29E+09
user EU Tag Part 1	5102	45203	Long	R/W L1	0	4.29E+09
user EU Tag Part 2	5103	45205	Long	R/W L1	0	4.29E+09
Serial Date	3001	43001	Integer	Read	-	-
Serial Number	3002	43002	Integer	Read	-	-
Scrubber Days Left	3081	43081	Integer	Read	-	-
Current 2F Flag	3103	43103	Integer	Read	-	-
Logger Rate	3202	43202	Integer	R/W L1	1	1000
4-20 mA Alarm Action	3204	43204	Integer	R/W L1	0	3
Temperature Unit	3205	43205	Integer	R/W L1	0	1
Pressure Unit	3206	43206	Integer	R/W L1	0	3
Concentration Unit	3207	43207	Integer	R/W L1	0	9
Modbus Address	3208	43208	Integer	R/W L1	0	250
Modbus Mode	3209	43209	Integer	R/W L1	0	2
AI Pressure Input	3210	43210	Integer	R/W L1	0	1
RATA	3211	43211	Integer	R/W L1	0	1
New Scrub Installed	3212	43212	Integer	R/W L1	0	1
General Alarm DO	3213	43213	Integer	R/W L1	0	2
Baud Rate	3214	43214	Integer	R/W L1	0	4
Set Time - Year	3215	43215	Integer	R/W L1	2007	2143
Set Time - Month	3216	43216	Integer	R/W L1	1	12
Set Time - Day	3217	43217	Integer	R/W L1	1	31
Set Time - Hour	3218	43218	Integer	R/W L1	0	23

Table 3-1 Modbus register map (Continued)

Parameter	Daniel Reg.	Gould Reg.	Data Type	Action	Min.	Max.
Set Time - Minute	3219	43219	Integer	R/W L1	0	59
Cancel Val Alarms	3220	43220	Integer	R/W L1	0	1
Daily Validation	3221	43221	Integer	R/W L1	0	1
Val Start Time	3222	43222	Integer	R/W L1	0	23
Val Interval	3223	43223	Integer	R/W L1	1	400
Start Validation	3224	43224	Integer	R/W L1	0	1
Val Purge Period	3225	43225	Integer	R/W L1	0	4000
Val Duration	3226	43226	Integer	R/W L1	0	8000
Val Attempts	3227	43227	Integer	R/W L1	1	8000
4-20 mA Val Action	3228	43228	Integer	R/W L1	0	1
Val Auto DumpSpectrm	3230	43230	Integer	R/W L1	0	1
Update RATA	3231	43231	Integer	R/W L1	0	1
Stream Switch ID	3232	43232	Integer	R/W L1	0	10
Stream Switch	3233	43233	Integer	R/W L1	0	1
Conversion Type	3251	43251	Integer	R/W L1	0	1
Calculate Dew Point	3252	43252	Integer	R/W L1	0	2
Dew Point Method	3253	43253	Integer	R/W L1	0	3
2 Way Com Port	3365	43365	Integer	R/W L1	0	3
Keypad Watchdog	3368	43368	Integer	R/W L1	0	9999
Rapid Change Monitor	3402	43402	Integer	R/W L1	0	1
Process Purge Time	3408	43408	Integer	R/W L1	60	9999
Custom Precision	3413	43413	Integer	R/W L1	0	5
Peak Tracking	3419	43419	Integer	R/W L1	0	2
R1 Stream Option	3424	43424	Integer	R/W L1	0	1
Operator Password	3501	43501	Integer	R/W L1	0	9999
Operator Parameter01	3502	43502	Integer	R/W L1	0	305
Operator Parameter02	3503	43503	Integer	R/W L1	0	305
Operator Parameter03	3504	43504	Integer	R/W L1	0	305
Operator Parameter04	3505	43505	Integer	R/W L1	0	305
Operator Parameter05	3506	43506	Integer	R/W L1	0	305
Operator Parameter06	3507	43507	Integer	R/W L1	0	305

Table 3-1 Modbus register map (Continued)

Parameter	Daniel Reg.	Gould Reg.	Data Type	Action	Min.	Max.
Operator Parameter07	3508	43508	Integer	R/W L1	0	305
Operator Parameter08	3509	43509	Integer	R/W L1	0	305
Operator Parameter09	3510	43510	Integer	R/W L1	0	305
Operator Parameter10	3511	43511	Integer	R/W L1	0	305
Operator Parameter11	3512	43512	Integer	R/W L1	0	305
Operator Parameter12	3513	43513	Integer	R/W L1	0	305
Operator Parameter13	3514	43514	Integer	R/W L1	0	305
Operator Parameter14	3515	43515	Integer	R/W L1	0	305
Operator Parameter15	3516	43516	Integer	R/W L1	0	305
Operator Parameter16	3517	43517	Integer	R/W L1	0	305
Operator Parameter17	3518	43518	Integer	R/W L1	0	305
Operator Parameter18	3519	43519	Integer	R/W L1	0	305
Operator Parameter19	3520	43520	Integer	R/W L1	0	305
Operator Parameter20	3521	43521	Integer	R/W L1	0	305
Password	4999	44999	Integer	R/W L0	0	9999

Modbus Accessible Parameter Definitions

For definitions of the Modbus accessible parameters shown in “Modbus register map” on page 3-15, see below. For more detailed information, refer to “**Measurement and Control Parameters Defined**” on page 2-17.

- **% ConvFactor 02:** Sets a custom conversion factor when the parameter Concentration Unit = 2 (%) and this value is greater than 0.0. When it is equal to 0.0, the default conversion factor is used.
- **2 Way Com Port:** Sets the port that allows two-way communications, including Modbus and the diagnostic protocol.
- **4-20 mA Alarm Action:** Determines the current loop state upon an alarm condition.
- **4-20 mA Input Value:** The current value of the 4-20 mA input for pipeline pressure in mA’s.
- **4-20 mA Output Value:** The current value of the 4-20 mA output for concentration in mA’s.
- **4-20 mA Val Action:** Sets the operation mode of the 4-20 mA current loop during validation cycles.
- **AI 4 mA Value:** Sets the pipeline pressure (in mbar) corresponding to a 4 mA current loop input.

- **AI 20 mA Value:** Sets the pipeline pressure (in mbar) corresponding to a 20 mA current loop input.
- **AI Pressure Input:** Enables or disables the analog input pipeline pressure capability.
- **AO 4mA Value:** Sets the concentration (in ppmv) or dew point temperature (in degrees Celsius or Fahrenheit) corresponding to a 4 mA current loop output.
- **AO 20mA Value:** Sets the concentration (in ppmv) or dew point temperature (in degrees Celsius or Fahrenheit) corresponding to a 20 mA current loop output.
- **AO 4-20 mA Test:** Sets the 4-20 mA output to a percentage of full scale when in **Mode 5**.
- **Alarm Flags:** Long integer register identifying the current status of each individual alarm in the analyzer, as shown in Table 2–2.
- **Baud Rate:** Sets the baud rate for the customer port.
- **Calculate Dew Point:** Enables the calculation of the dew point value and controls where the value will be output.
- **Cancel Val Alarms:** Cancels all validation alarms once activated.
- **Carbon Dioxide:** Sets the mole fraction of carbon dioxide in the dry gas mixture that is used when calculating the dew point temperature per ISO 18453:2006. The default value corresponds to natural gas mixture NG3 of Table A–5 on page A–12.
- **Common Weight:** Ratio of the measured spectrum that did not match a reference spectrum.
- **Concentration:** Current measured (live) analyte concentration (process or validation) in selected engineering units.
- **Concentration ppmv:** Current measured (live) analyte concentration (process or validation) in parts per million by volume (ppmv).
- **Concentration Process:** Measured analyte concentration (process or validation) of last process reading in selected engineering units.
- **Conc Process ppmv:** Measured analyte concentration of last process reading in parts per million by volume (ppmv).
- **Concentration Unit:** Sets the display units for the measured concentration.
- **Conversion Type:** Sets the type of relations (ideal or real gas) used in the dew point calculation [0 for ideal gas relations or 1 for real gas relations (Z calculated using Peng-Robinson EOS)]. For a full description of the conversions, see “Water Correlation” on page A-1.
- **Cross Shift:** The amount of shift applied to match the measured spectrum to the reference spectrum when using Cross Correlation.

- **Current 2F Flag:** Displays the current scrubber protection usage level: **0** = standard protection (used for non-differential units), **1** = mid protection, **2** = high protection, **3** = max protection (no usage).
- **Current Midpoint:** Current midpoint that the analyzer is using, including any peak tracking adjustments.
- **Custom Precision:** Sets the number of viewable digits to the right of the decimal point.
- **Daily Validation:** Enables or disables the autovalidation feature.
- **DC Level:** Signal level at the high end of the current ramp.
- **Dew Point:** Measured analyte concentration of last process reading as a moisture dew point.
- **Dew Point Method:** Sets the type of dew point calculation to be performed when **Calculate Dew Point** is enabled.
- **DO Alarm Setup:** Sets the functionality of the **Assignable Alarm**.
- **Dry DC Level:** Signal level at the high end of the current ramp during the dry cycle.
- **Dry Pressure mb:** Current measured dry pressure of the gas sample in millibar (mb)
- **Dry Temp C:** Current measured dry temperature of the gas sample in degrees in Celsius.
- **Ethane:** Sets the mole fraction of ethane in the dry gas mixture used when calculating the dew point temperature per ISO 18453:2006. The default value corresponds to natural gas mixture NG3 of Table A-5 on page A-12.
- **Fit Residue:** Value ranging from 0 to 1 indicating how well the measured spectrum fit the referenced spectrum, where 1 represents a perfect match.
- **Fitting Ratio:** Ratio of the measured spectrum versus the Reference 1 or Validation spectrum.
- **Fitting Ratio 2:** Ratio of the measured spectrum versus the Reference 2 spectrum, where a value of 0 indicates that the Reference 2 spectrum was not used in the calculation of concentration.
- **Fitting Ratio 3:** Ratio of the measured spectrum versus the Reference 3 spectrum, where a value of 0 indicates that the Reference 3 spectrum was not used in the calculation of concentration.
- **Fitting Ratio 4:** Ratio of the measured spectrum versus the Reference 4 spectrum, where a value of 0 indicates that the Reference 4 spectrum was not used in the calculation of concentration.

- **Fitting Ratio 5:** Ratio of the measured spectrum versus the Reference 5 spectrum, where a value of 0 indicates that the Reference 5 spectrum was not used in the calculation of concentration.
- **Fitting Ratio Dry:** Ratio of the measured spectrum versus the Reference Dry spectrum, where a value of 0 indicates that the Reference Dry spectrum was not used in the calculation of concentration.
- **Fitting Ratio Dry-1:** Ratio of the measured spectrum versus the Reference Dry spectrum shifted by 1 index value, where a value of 0 indicates that the Reference Dry spectrum shifted by 1 index value was not used in the calculation of concentration.
- **General Alarm DO:** Sets the operation of the general alarm relay digital output when a general fault alarm occurs.
- **grn ConvFactor 07:** Sets a custom conversion factor when the parameter **Concentration Unit** = 7 (grains/100scf) and this value is greater than 0.0. The default conversion factor is used when it is equal to 0.0.
- **High Alarm Setpoint:** Determines the concentration threshold above which the **Concentra High Alarm** will be triggered.
- **Hexane:** Sets the mole fraction of hexane in the dry gas mixture used when calculating the dew point temperature per ISO 18453:2006. The default value corresponds to natural gas mixture NG3 of Table A-5 on page A-12.
- **I-Butane:** Sets the mole fraction of i-butane in the dry gas mixture used when calculating the dew point temperature per ISO 18453:2006. The default value corresponds to natural gas mixture NG3 of Table A-5 on page A-12.
- **I-Pentane:** Sets the mole fraction of i-pentane in the dry gas mixture used when calculating the dew point temperature per ISO 18453:2006. The default value corresponds to natural gas mixture NG3 of Table A-5 on page A-12.
- **Keypad Watchdog:** Sets the allowable time (in seconds) that the analyzer can be on the MODE screen and the **Mode 2** (Set Parameter Mode) password screen before automatically reverting to **Mode 1** (Normal Mode).
- **Ib ConvFactor 01:** Sets a custom conversion factor when the parameter **Concentration Unit** = 1 (lbs/MMscf) and this value is greater than 0.0. The default conversion factor is used when it is equal to 0.0.
- **Logger Rate:** Sets the number of measurements included in the running average.
- **Low Alarm Setpoint:** Determines the concentration threshold below which the **Concentra Low Alarm** will be triggered.

- **Methane:** Sets the mole fraction of methane in the dry gas mixture used when calculating the dew point temperature per ISO 18453:2006. The default value corresponds to natural gas mixture NG3 of Table A-5 on page A-12.
- **mg/N ConvFactor 09:** Sets a custom conversion factor when the parameter **Concentration Unit** = 9 (mg/Nm³) and this value is greater than 0.0. The default conversion factor is used when it is equal to 0.0.
- **mg/s ConvFactor 03:** Sets a custom conversion factor when the parameter **Concentration Unit** = 3 (mg/sm³) and this value is greater than 0.0. The default conversion factor is used when it is equal to 0.0.
- **Modbus Address:** Sets the analyzer address when the analyzer is used as a Modbus slave device.
- **Modbus Mode:** Sets the communications protocol for the port selected by the **2 Way Com Port** parameter.
- **N-Butane:** Sets the mole fraction of n-butane in the dry gas mixture used when calculating the dew point temperature per ISO 18453:2006. The default value corresponds to natural gas mixture NG3 of Table A-5 on page A-12.
- **N-Pentane:** Sets the mole fraction of n-pentane in the dry gas mixture used when calculating the dew point temperature per ISO 18453:2006. The default value corresponds to natural gas mixture NG3 of Table A-5 on page A-12.
- **Neo-Pentane:** Sets the mole fraction of neo-pentane in the dry gas mixture used when calculating the dew point temperature per ISO 18453:2006. The default value corresponds to natural gas mixture NG3 of Table A-5 on page A-12.
- **New Scrub Installed:** Resets the scrubber/dryer alarm once activated, and the scrubber/dryer lifetime monitor.
- **Nitrogen:** Sets the mole fraction of nitrogen in the dry gas mixture used when calculating the dew point temperature per ISO 18453:2006. The default value corresponds to natural gas mixture NG3 of Table A-5 on page A-12.
- **Operator Parameter01 - Operator Parameter20:** Parameter indices for parameters to be viewed through the Operator Parameter section.
- **Operator Password:** Sets a password for the Operator Parameter section.
- **Password:** Required to access the system to download (i.e., change) register settings.
- **Peak Index Ref:** Peak index used for reference.

- **Peak Index Ref Dry:** Peak index (0.0 for non-differential units) used for reference from the last scrubber cycle.
- **Peak Track Index:** Peak index of the measured spectrum.
- **Peak Track Index Dry:** Peak index (0.0 for non-differential units) of the measured spectrum from the last scrubber cycle.
- **Peak Tracking:** A software utility that periodically adjusts the laser current to keep the absorption peak of the measured component at a known location.
- **Pipeline Pressure:** Sets the pipeline pressure (in mbar) in the current dew point calculation or, if enabled, displays the current pipeline pressure input through the AI Pressure Input.
- **ppbv ConvFactor 05:** Sets a custom conversion factor when the parameter **Concentration Unit** = 5 (ppbv) and this value is greater than 0.0. When it is equal to 0.0, the default conversion factor is used.
- **ppbw ConvFactor 06:** Sets a custom conversion factor when the parameter **Concentration Unit** = 6 (ppbw) and this value is greater than 0.0. When it is equal to 0.0, the default conversion factor is used.
- **ppmv ConvFactor 00:** Sets a custom conversion factor when the parameter **Concentration Unit** = 0 (ppmv) and this value is greater than 0.0. The default conversion factor is used when it is equal to 0.0.
- **ppmw ConvFactor 04:** Sets a custom conversion factor when the parameter **Concentration Unit** = 4 (ppmw) and this value is greater than 0.0. The default conversion factor is used when it is equal to 0.0.
- **Pressure:** Current measured (live) wet pressure reading of the gas sample in selected engineering units.
- **Pressure Unit:** Designates the display units for the measured absolute pressure in the cell.
- **Propane:** Sets the mole fraction of propane in the dry gas mixture used when calculating the dew point temperature per ISO 18453:2006. The default value corresponds to natural gas mixture NG3 of Table A-5 on page A-12.
- **Process Purge Time:** Sets the time in seconds that the analyzer will purge the system with process gas before starting a dry cycle when switching to the process stream after a validation.
- **R1 Stream Option:** Sets the calibration for the stream when multi-calibration is enabled.
- **Rapid Change Monitor:** Enables or disables the dynamic logger rate based on the concentration rate of change.
- **RATA:** Enables or disables user definable values that allow adjustment (without affecting the factory calibration) of the analyzer reading in the field.

- **RATA Multiplier:** User definable value that enables adjustment (without affecting the factory calibration) of the analyzer response (or slope) in the field.
- **RATA Mult Proposed:** The latest proposed RATA multiplier value calculated based on the last validation run.
- **RATA Offset:** User definable value that enables adjustment (without affecting the factory calibration) of the analyzer offset in the field.
- **RATA Offset Proposed:** The latest proposed RATA offset value calculated based on the last validation run.
- **Scrubber Days Left:** The remaining scrubber life in days. A fresh scrubber will start at a predetermined number of days and will count down to 0.
- **Scrubber Life Left:** The remaining scrubber life in percentage. A fresh scrubber will start at 100% and will decline to 0% when fully exhausted.
- **Serial Date:** Date the analyzer was calibrated.
- **Serial Number:** Serial number of the analyzer.
- **Set Time - Day:** Sets the current day for the clock driving daily validations.
- **Set Time - Hour:** Sets the current hour for the clock driving daily validations.
- **Set Time - Minute:** Sets the current minute for the clock driving daily validations.
- **Set Time - Month:** Sets the current month for the clock driving daily validations.
- **Set Time - Year:** Sets the current year for the clock driving daily validations.
- **Start Validation:** Initiates the validation cycle.
- **Status Flags:** Long integer register identifying the occurrence of various events in the analyzer, as shown in Table 3–2.

Table 3–2 Status flags

Bit	Hex Value	Status
0	00001	Current measurement valid (wet cycle active)
1	00002	Wet purging complete, wet measurement in progress
2	00004	Wet purging in progress
3	00008	Dry purging complete, dry measurement in progress
4	00010	Dry purging in progress
5	00020	Validation Mode

Table 3-2 Status flags (Continued)

Bit	Hex Value	Status
6	00040	Validation Flag 1
7	00080	Validation Flag 2
8	00100	Validation 1 Fail Flag
9	00200	Validation 2 Fail Flag

- **Stream Switch ID:** The stream ID that matches the stream being switched to by the **Stream Switch** parameter.
- **Stream Switch:** If the current value is '0', then setting to '1' allows a stream switch to occur by starting the analyzer's Process Purge Time followed by a scrubber cycle. The value will remain at '1' until the first concentration value is output at which point it will return to '0'. If the current value is '1', then this value does not accept any changes.
- **Temperature:** Current measured (live) wet temperature of the gas sample in selected engineering units.
- **Temperature Unit:** Designates the display units for the measured cell temperature.
- **Update RATA:** When set to '1' stores the latest proposed RATA multiplier and offset values in the RATA Multiplier and RATA Offset parameters, respectively.
- **user ConvFactor 08:** Sets a custom conversion factor when the parameter **Concentration Unit** = 8 (user EU Tag Part 1 and 2) and this value is greater than 0.0. The default conversion factor is used when it is equal to 0.0.
- **user EU Tag Part 1:** Sets a custom engineering unit tag name for the beginning four ASCII characters. For example: A is ASCII hex value 41, so AAAA would be 41414141, which would be 1,094,795,585 in decimal format. Refer to Table 3-3.
- **user EU Tag Part 2:** Sets a custom engineering unit tag name for the last four ASCII characters. For example: A is ASCII hex value 41, so AAAA would be 41414141, which would be 1,094,795,585 in decimal format. Refer to Table 3-3.

Table 3-3 ASCII Character Map

		Higher 4-bit (D4 to D7) of Character Code (Hexadecimal)															
		0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
Lower 4-bit (D0 to D3) of Character Code (Hexadecimal)	0 CG RAM (1)	±	!	0	P	'	P	E	E	á	'	M	B	T			
	1 CG RAM (2)	≡	.	1	A	Q	a	9	Q	a	1	'	J	T	Y	U	
	2 CG RAM (3)	7	"	Z	B	R	b	r	e	e	ó	'	ó	ó	ó		
	3 CG RAM (4)	⊥	#	3	O	S	c	s	a	a	ó	'	7	7	e	ψ	
	4 CG RAM (5)	∇	\$	4	O	T	t	a	a	t	'	'	e	7	z	o	
	5 CG RAM (6)	∇	%	5	E	e	v	a	ó	e	'	'	4	n	7		
	6 CG RAM (7)	∇	&	6	F	f	v	a	ó	'	'	4	4	0	0		
	7 CG RAM (8)	∇	'	7	G	w	w	e	ó	'	'	x	→	Δ	L	4	
	8 CG RAM (1)	∇	(8	X	x	e	ó	'	'	÷	÷	÷	÷	÷	÷	
	9 CG RAM (2)	∇)	9	I	Y	i	y	e	ó	'	'	∫	∫	∫	∫	
	A CG RAM (3)	∇	*	:	J	Z	z	e	ó	'	'	∫	∫	∫	∫	∫	
	B CG RAM (4)	∇	+	:	K	K	C	i	R	a	'	'	*	L	∇	∇	
	C CG RAM (5)	∇	,	<	L	\	l	i	∫	∫	'	'	*	∫	∫	∫	
	D CG RAM (6)	∇	-	=	n	n	n	i	∫	∫	'	'	*	∫	∫	∫	
	E CG RAM (7)	∇	.	>	N	n	n	'	∫	∫	'	'	*	∫	∫	∫	
	F CG RAM (8)	∇	/	?	O	_	o	∫	∫	'	'	*	∫	∫	∫	∫	

To find the hexadecimal value in Table 3-3, first find the character needed in the table. Trace to the reference number in the column header (c) at the top of the table, then to the row to the left (r) to create the value (cr). For example, locate the 'A' in the table. The 'A' corresponds with the value (4) in the column header at the top of the table. Next, follow the row in which 'A' is present to the value at the left of the table (1). Combined, these create the hexadecimal value of 41.

If using AMS100 software to update these values, the desired characters can be typed directly into the PC keyboard. However, only the keys on the PC keyboard are supported. For example, superscript values for engineering units, such as mg/m³, are not supported. To use a superscript value as explained in the prior example, superscript³

equates to hex 1F from Table 3–3, Modbus must be used to download the desired characters.

- **Val 1 Concentration:** Sets the concentration value of validation gas supply #1.
- **Val 2 Concentration:** Sets the concentration value of validation gas supply #2.
- **Val 1 Value:** Measured analyte concentration of last validation 1 reading in selected engineering units.
- **Val 2 Value:** Measured analyte concentration of last validation 2 reading in selected engineering units.
- **Val 1 Value ppmv:** Measured analyte concentration of last validation 1 reading in parts per million by volume (ppmv)
- **Val 2 Value ppmv:** Measured analyte concentration of last validation 2 reading in parts per million by volume (ppmv)
- **Val 1 Avg Value:** Average analyte concentration of last Validation 1 measurement period in selected engineering units.
- **Val 2 Avg Value:** Average analyte concentration of last Validation 2 measurement period in selected engineering units.
- **Val 1 Avg Value ppmv:** Average analyte concentration of last Validation 1 measurement period in parts per million by volume (ppmv).
- **Val 2 Avg Value ppmv:** Average analyte concentration of last Validation 2 measurement period in parts per million by volume (ppmv).
- **Val 1 Min Value ppmv:** Minimum analyte concentration of last Validation 1 measurement period in parts per million by volume (ppmv).
- **Val 2 Min Value ppmv:** Minimum analyte concentration of last Validation 2 measurement period in parts per million by volume (ppmv).
- **Val 1 Max Value ppmv:** Maximum analyte concentration of last Validation 1 measurement period in parts per million by volume (ppmv).
- **Val 2 Max Value ppmv:** Maximum analyte concentration of last Validation 2 measurement period in parts per million by volume (ppmv).
- **Val Attempts:** Sets the maximum number of failures of the analyzer to measure the validation gas within the set tolerances before stopping the autovalidation sequence and triggering a **Validation Fail Alarm**.
- **Val Auto DumpSpectrm:** Determines whether a **Mode 6** dump automatically occurs after each validation measurement.

- **Val Date:** Date of the last validation.
- **Validation Allowance:** Sets the tolerance ($\pm\%$) for validation measurements when **Val 1 Concentration** or **Val 2 Concentration** is set to a value greater than 0.
- **Val Duration:** Sets the total number of seconds a validation cycle will run.
- **Val Interval:** Sets the number of days between autovalidation cycles.
- **Val Perm Const Kp(A):** Sets the system constant that is determined at the factory at the time of calibration.
- **Val Perm Const Kp(B):** Sets the system constant for stream B when multi-calibration is enabled. The value is determined at the factory at the time of calibration.
- **Val Perm Rate Rp:** Sets the permeation rate in ng/min referenced on the certification for the permeation device.
- **Val Purge Period:** Sets the number of seconds the analyzer will purge the system with validation gas before starting a dry cycle upon validation initiation.
- **Val Start Time:** Sets the hour of the day for the daily autovalidation to begin.
- **Val Time:** Time of the last validation.
- **Wet Pressure mb:** Current measured (live) wet pressure reading of the gas sample in millibar (mb).
- **Wet Temp C:** Current measured (live) temperature of the gas sample in degrees Celsius.
- **Zero Level:** Signal level when the laser is turned off.
- **Zero Val Tolerance:** Used to set the maximum acceptable reading when validating with zero gas.

4 - ETHERNET COMMUNICATIONS

Configuring the Built-in Ethernet Port

The built-in Ethernet port must be properly configured to communicate on a network with a serial device. The Ethernet port has been factory set as follows:

- IP Address: 192.168.000.001
- Telnet (Set-up) Port: 9999
- Serial Data Port: 10001

The configuration is stored in nonvolatile memory and is retained without power. The configuration can be changed at any time.

If the IP address or any other setting needs to be changed, the Ethernet port **Setup Mode** can be accessed using a Telnet connection to configure the port locally or over the network.

To configure the built-in Ethernet port:

1. From your computer Windows desktop, click **Start** followed by **Run** (usually located in the lower right side of the **Start Menu**).
2. Type the following command: `telnet 192.168.000.001 9999`
3. Click **OK** to establish a Telnet connection. The following message appears:

```
MAC address XXXXXXXXXXXX (E.g., 00204A808BE8)
Software version V6.3.0.3RC3 (061110) (Version may vary by system)
```

```
Press Enter for Setup Mode
```

4. To enter **Setup Mode**, press **Enter** within 5 seconds. The configuration settings display, followed by the **Change Setup** menu.

```
Change Setup:
0 Server
1 Channel 1
5 Expert
6 Security
7 Defaults
8 Exit without save
9 Save and exit      Your choice ?
```

5. Select an option on the menu by entering the number of the option in the "Your choice?" field and pressing **Enter**.



The two menus recommended for review are "0 Server" and "1 Channel 1". Bypass the other options listed in the menu.

6. After selecting "0" for Server setup, confirm each value and press **Enter**.



Under the "0 Server" option, the most commonly changed parameters include the IP Address and Port No, however, these are not required to be changed. Please confirm with Service before changing any other parameters.

7. For "1 Channel 1," confirm the current value and press **Enter**. No parameters under this option need to be changed.

Parameters that should never be changed under "1 Channel 1" include:



- Baudrate (230400)?
- I/F Mode (4C)?
- Flow (00)?

8. When finished, save the new configuration by pressing **9** (Save and exit) and **Enter**. The port will reboot after the configuration has been stored.



All other Parameters should be left at default values unless the user is knowledgeable about configuring Ethernet.

General Information for Configuring Ethernet

For more information on configuring your computer for Ethernet connection, please refer to the Lantronix websites below.

- XPort Direct+ Demonstration Kit:
http://www.lantronix.com/pdf/XPort-Direct-Plus_QS.pdf
- Lantronix Downloads and Documentation:
<http://www.lantronix.com/support/downloads/?p=XPORTDIRECTPLS>

Appendix A: Water Correlation

Water Content

In the context of gas analyzers, water content refers to the concentration of water vapor in the gaseous phase. Water content is typically stated as mole, mass or volume fraction, which are independent of a reference state, or as mass of water per volume of gas, which is dependent on a reference state. For relatively low water content, the mole fraction of water in the gaseous phase (y_w) is typically given in dimensionless form as parts per million (ppm),

$$y_w = \frac{n_w}{n_w + n_m} \times 10^6 \text{ [ppm]} \quad , \quad (1)$$

where n_w is the number of moles of water, n_m is the number of moles of the "dry" mixture. For mass and volume fraction, the units would be ppm(m) and ppm(v) or ppmv, respectively. In the event the water content is extremely low, parts per billion (ppb) or even parts per trillion (ppt) may be used.

Water content expressed as mass of water per volume of gas is typically given in milligrams per normal cubic meter (mg/Nm³), where the letter "N" indicates normal reference conditions (typically 0 °C and 1 atm), or pounds per million standard cubic feet (lb/MMscf), where "s" indicates standard reference conditions (typically 60 °F and 1 atm). As shown in Table A-1, the definition of reference conditions varies considerably, and thus, should be specified explicitly when using units dependent on a reference state. Here, normal reference conditions are $P_N = 101325\text{Pa}$ and $T_N = 273.15\text{K}$.

The conversion of water content (WC) from mole fraction to mass per volume of gas (mg/Nm³) is given by,

$$WC = \frac{y_w}{1 - y_w} \frac{M_w P_N}{Z_N R T_N} \text{ [mg/Nm}^3\text{]} \quad , \quad (2)$$

where M_w is the molecular weight of water (18015.2 mg/mol), T_N is the temperature at normal reference conditions (K), P_N is the pressure at normal reference conditions (Pa), Z_N is the compressibility of the "dry" gas mixture at normal reference conditions, and R is the universal gas constant (8.3145 J/mol•K). For perfect gases, $Z_N = 1$ and

$$WC = \frac{y_w}{1 - y_w} \times 803745 \text{ [mg/Nm}^3\text{]} \quad . \quad (3)$$

Table A-1 Common reference conditions

T (K)	P (Pa)	Organization
273.15	100000	International Union of Pure and Applied Chemistry (IUPAC) [1]
288.15	101325	International Organization for Standardization (ISO) [2]
298.15	100000	National Bureau of Standards (NBS) [3]
288.71	100000	Society of Petroleum Engineers (SPE) [4]
293.15	101325	National Institute of Standards and Technology (NIST)
288.71	101560	Organization of the Petroleum Exporting Countries (OPEC) [5]
288.71	101325	Occupational Safety and Health Administration (OSHEA) [6]

Dew Point

In some instances, it is desired to express the water content in terms of the water “dew point” for the gas mixture. The water dew point of a gas is the temperature at which the gas is saturated with water at a given pressure. Saturation implies that the water vapor is in equilibrium with water in the liquid or solid phase (depending on which is present). When water vapor is in equilibrium with the solid (ice) phase, the dew point is often referred to as the “frost point.”

Dew Point Conversion

Various correlations and standards have been developed (some based on Raoult’s law) that are currently used in natural gas practice for converting from water dew point temperature to water content, such as ASTM 1142-95 (2006) [8], Bukacek [9], the Arden Buck method and ISO 18453:2006 [10].

Raoult’s Law

Assuming ideal gas behavior, the simplest thermodynamically based equation for calculating water content at the dew point temperature is based on Raoult’s law [7]

$$y_w P = x_w P_w^{sat}(T) \quad , \quad (4)$$

where y_w is the mole fraction of water in the vapor phase, P is the total pressure, x_w is the mole fraction of water in the liquid phase, and P_w^{sat} is the saturation (vapor) pressure of pure water at the dew point temperature T . Assuming the liquid phase is pure water, i.e., there is negligible gas solubility, $x_w = 1$ and we get

$$y_w = \frac{P_w^{sat}(T)}{P} \quad . \quad (5)$$

Expressions of this type do not take into account the composition of the gas mixture. Although Eq. (5) is of limited utility because of the simplifying assumptions on which it is based, such as perfect gas behavior, reasonable estimates of water content can be obtained for pressures up to 0.4 MPa, above which real gas effects become significant.

Arden Buck Equations

The Arden Buck equations are a group of empirical correlations that relate the saturation vapor pressure to temperature for moist air at close to atmospheric pressure. The curve fits have been optimized for more accuracy than the Goff–Gratch equation in the range –80 to 50°C. [11]



Arden Buck equations are not typically used for natural gas applications; however, results are comparable at near atmospheric pressures.

A set of several equations were developed, each of which is applicable in a different situation.

Enhancements to the method were published in 1996.[12]

A humidity conversion software (HCONL), developed by Buck Research Instruments LLC, is commonly used as a simple tool that easily converts any humidity parameter to any other humidity units.

ASTM1

ASTM 1142-95 (2006) includes two correlations, the first of which (referred to here as ASTM1) is a variation of Eq. (5) that expresses the water content in terms of the weight of saturated water vapor, or [8]

$$WC = (w \times 10^6) \frac{P_b T}{P T_b} , \quad (6)$$

where WC is the water content (lb/MMscf) at reference conditions T_b (R) and P_b (psia), w is the weight of saturated water vapor (lb/ft³), P is the pressure at which the dew point was determined (psia), and T is the observed dew point temperature (R). The reciprocal of w , or the specific volume of saturated water vapor (ft³/lb), is listed as a function of temperature in Table 1 of ASTM 1142-95 (2006) for temperatures ranging from 0 °F to 100 °F. Though not explicit in temperature due to the temperature dependence of w , given the water content, the corresponding dew point temperature can be solved for iteratively.

ASTM2

Bukacek proposed a relatively simple modified Raoult's law approach where the water content of sweet gas is calculated using the ideal expression of Eq. (5) supplemented by a deviation factor [9],

$$WC = (760.4) \frac{P_w^{sat}}{P} + 0.016016B \quad , \quad (7)$$

where WC is the water content (g/Nm^3), P_w^{sat} is the saturation vapor pressure of pure water (MPa), P is the total pressure of the system (MPa), and B is given by,

$$\log B = \frac{-1713.66}{T} + 6.69449 \quad , \quad (8)$$

where T is the dew point temperature (K). The saturation vapor pressure can be calculated using [13]

$$\ln\left(\frac{P_w^{sat}}{P_c}\right) = \frac{T_c}{T}(-7.85823\tau + 1.83991\tau^{1.5} - 11.7811\tau^3 + 22.6705\tau^{3.5} - 1539393\tau^4 + 1.77516\tau^{7.5}) \quad , \quad (9)$$

where T is the temperature (K), T_c is the critical temperature of water (647.14K), P_c is the critical pressure of water (22.064MPa), and $\tau = 1 - T/T_c$.

A simplified version of Eq. (7)

$$WC = \frac{A}{P} + B \quad , \quad (10)$$

(referred to here as ASTM2) is included in ASTM 1142-95 (2006) with coefficients A and B (referenced to $T_b = 520$ R and $P_b = 14.7$ psia) listed as a function of temperature in Table 2 for dew point temperatures ranging from -40 °F to 440 °F. Though not explicit in temperature due to the temperature dependence of A and B , given the water content, the corresponding dew point temperature can be solved for iteratively.

Although conveniently simplistic, neither ASTM method takes into account the actual gas composition. In addition, the range of data made available for the specific volume of saturated water vapor (ASTM1) or for the coefficients A and B (ASTM2) is somewhat limited.

ISO

Perhaps the most rigorous method to date is that of ISO 18453:2006. Based on an extensive study conducted by Groupe Europeen de Recherches Gazieres (GERG) [14], the ISO method uses an equation of state (EOS) approach to calculate water content from water dew point temperature. The semi-empirical Peng-Robinson (P-R) cubic EOS with repulsive and attractive terms has been found to adequately reproduce the behavior of fluids in the gas and liquid phase with the same equation. The P-R EOS for a pure component explicit in P is given by [15]

$$P(T,V) = \frac{RT}{V-b} - \frac{a(T)}{V^2 + 2bV - b^2} \quad . \quad (11)$$

The coefficients are defined as

$$b = 0.07780 \frac{RT_c}{P_c} \quad (12)$$

and

$$a(T) = \frac{0.45724R^2T_c^2}{P_c} \alpha(T_r) \quad , \quad (13)$$

where $T_r = T/T_c$ is the reduced temperature and $\alpha(T_r)$ is a non-dimensional function of the reduced temperature

$$\alpha(T_r) = [1 + \kappa(1 - T_r^{1/2})]^2 \quad , \quad (14)$$

where $\kappa = 0.37464 + 1.54226\omega - 0.26992\omega^2$ is a substance-specific constant generalized using the acentric factor ω . Values for the critical pressure, critical temperature and acentric factor are listed in Table A-2.

Table A-2 Gas composition [14]

Component	i	P_c (MPa)	T_c (K)	ω
Water (H ₂ O)	1	22.064	647.14	0.34437
Methane (CH ₄)	2	4.599	190.55	0.01140
Ethane (C ₂ H ₆)	3	4.872	305.33	0.09909
Nitrogen (N ₂)	4	3.399	126.26	0.03593
Carbon Dioxide (CO ₂)	5	7.386	304.21	0.22394
Propane (C ₃ H ₈)	6	4.246	369.85	0.15611
i-Butane (C ₄ H ₁₀)	7	3.640	407.85	0.18465
n-Butane (C ₄ H ₁₀)	8	3.784	425.14	0.19777
neo-Pentane (C ₅ H ₁₂)	9	3.196	433.75	0.19528
i-Pentane (C ₅ H ₁₂)	10	3.370	460.39	0.22606
n-Pentane (C ₅ H ₁₂)	11	3.364	469.69	0.24983
Hexane/C ₆ + (C ₆ H ₁₄)	12	3.020	507.85	0.29600

For water specifically, the α -function takes a different form in order to accurately reproduce the water vapor pressure over ice as well as liquid [14]

$$\alpha(T_r) = [1 + A_1(1 - T_r^{1/2}) + A_2(1 - T_r^{1/2})^2 + A_3(1 - T_r^{1/2})^4]^2, \quad (15)$$

where the coefficients, listed in Table A-3, take on different values depending on whether the temperature is above or below freezing.

Table A-3 Coefficients for Eq. (15) [14]

Coefficient	$223.15 \leq T < 273.16 \text{ K}$	$273.16 \leq T \leq 313.15 \text{ K}$
A_1	0.106025	0.905436
A_2	2.683845	-0.213781
A_3	-4.75638	0.26005

Application of an equation of state to a mixture requires substituting mixture parameters for those of the pure component. The mixture parameters are related to pure component parameters by means of the mixing rules [16]

$$a_m(T) = \sum_{i=1}^{nc} \sum_{j=1}^{nc} x_i x_j a_{ij}(T) \quad (16)$$

and

$$b_m = \sum_{i=1}^{nc} x_i b_i, \quad (17)$$

where nc is the number of components in the mixture. The mole fraction of each component, x_i , serves as a weight factor and the cross coefficients $a_{ij}(T)$ of the a -term

$$a_{ij}(T) = \sqrt{a_i(T)a_j(T)}[1 - k_{ij}(T)] \quad (18)$$

are corrected with a temperature-dependent binary interaction parameter [14]

$$k_{ij}(T) = k_{ij,0} + k_{ij,1} \left(\frac{T}{273.15} - 1 \right), \quad (19)$$

where the coefficients $k_{ij,0}$ and $k_{ij,1}$, listed in Table A-4, are typically determined by fitting vapor-liquid equilibrium data of binary mixtures with $k_{ij} = k_{ji}$ and $k_{ii} = k_{jj} = 0$.

Table A-4 Binary interaction parameters [14]

i	Component i	j	Component j	$k_{ij,0}$	$k_{ij,1}$
1	Water	2	Methane	0.6510	-1.3850
1	Water	3	Ethane	0.6350	-0.9300
1	Water	4	Nitrogen	0.4800	0
1	Water	5	Carbon Dioxide	0.1840	0.2360
1	Water	6	Propane	0.5300	0
1	Water	7	i-Butane	0.6900	0
1	Water	8	n-Butane	0.5000	0
1	Water	9	neo-Pentane	0.5000	0
1	Water	10	i-Pentane	0.6900	0
1	Water	11	n-Pentane	0.5000	0
1	Water	12	Hexane/C ₆ +	0.5000	0
2	Methane	3	Ethane	-0.0026	0
2	Methane	4	Nitrogen	0.0311	0
2	Methane	5	Carbon Dioxide	0.0919	0
2	Methane	6	Propane	0.0140	0
2	Methane	7	i-Butane	0.0133	0
2	Methane	8	n-Butane	0.0230	0
2	Methane	9	neo-Pentane	0.0422	0
2	Methane	10	i-Pentane	0.0256	0
2	Methane	11	n-Pentane	0.0180	0
2	Methane	12	Hexane/C ₆ +	-0.0056	0
3	Ethane	4	Nitrogen	0.0515	0
3	Ethane	5	Carbon Dioxide	0.1322	0
3	Ethane	6	Propane	0.0011	0
3	Ethane	7	i-Butane	-0.0067	0
3	Ethane	8	n-Butane	0.0096	0
3	Ethane	9	neo-Pentane	0.0230	0
3	Ethane	10	i-Pentane	0.0160	0
3	Ethane	11	n-Pentane	0.0078	0
3	Ethane	12	Hexane/C ₆ +	-0.0100	0

Table A-4 Binary interaction parameters [14] (Continued)

i	Component i	j	Component j	$k_{ij,0}$	$k_{ij,1}$
4	Nitrogen	5	Carbon Dioxide	-0.0170	0
4	Nitrogen	6	Propane	0.0852	0
4	Nitrogen	7	i-Butane	0.1033	0
4	Nitrogen	8	n-Butane	0.0800	0
4	Nitrogen	9	neo-Pentane	0.0930	0
4	Nitrogen	10	i-Pentane	0.0922	0
4	Nitrogen	11	n-Pentane	0.1000	0
4	Nitrogen	12	Hexane/C ₆ +	0.1496	0
5	Carbon Dioxide	6	Propane	0.1241	0
5	Carbon Dioxide	7	i-Butane	0.1200	0
5	Carbon Dioxide	8	n-Butane	0.1333	0
5	Carbon Dioxide	9	neo-Pentane	0.1260	0
5	Carbon Dioxide	10	i-Pentane	0.1219	0
5	Carbon Dioxide	11	n-Pentane	0.1222	0
5	Carbon Dioxide	12	Hexane/C ₆ +	0.1100	0
6	Propane	7	i-Butane	-0.0078	0
6	Propane	8	n-Butane	0.0033	0
6	Propane	9	neo-Pentane	0	0
6	Propane	10	i-Pentane	0.0111	0
6	Propane	11	n-Pentane	0.0267	0
6	Propane	12	Hexane/C ₆ +	0.0007	0
7	i-Butane	8	n-Butane	-0.0004	0
7	i-Butane	9	neo-Pentane	0	0
7	i-Butane	10	i-Pentane	0	0
7	i-Butane	11	n-Pentane	0	0
7	i-Butane	12	Hexane/C ₆ +	0	0
8	n-Butane	9	neo-Pentane	0	0
8	n-Butane	10	i-Pentane	0	0
8	n-Butane	11	n-Pentane	0.0174	0
8	n-Butane	12	Hexane/C ₆ +	-0.0056	0
9	neo-Pentane	10	i-Pentane	0	0
9	neo-Pentane	11	n-Pentane	0	0
9	neo-Pentane	12	Hexane/C ₆ +	0	0
10	i-Pentane	11	n-Pentane	0.0600	0
10	i-Pentane	12	Hexane/C ₆ +	0	0
11	n-Pentane	12	Hexane/C ₆ +	0	0

An equilibrium condition for each component can be derived in terms of the fugacity coefficient [17]

$$\phi_i^l x_i = \phi_i^v y_i \quad , \quad (20)$$

where ϕ_i^l is the fugacity coefficient of component i in the liquid phase, x_i is the mole fraction of component i in the liquid phase, ϕ_i^v is the fugacity coefficient of component i in the gaseous phase, and y_i is the mole fraction of component i in the gaseous phase. For the PR-EOS, the fugacity coefficient is defined as [17]

$$\ln \phi_i = \frac{b_i}{b_m} (Z - 1) - \ln(Z - B^*) - \frac{A^*}{2\sqrt{2}B^*} \left(\frac{b_i}{b_m} - \frac{2\sqrt{a_i(T)}}{a_m(T)} \sum_j x_j \sqrt{a_i(T)} (1 - k_{ij}) \right) \ln \left[\frac{Z + B^*(1 + \sqrt{2})}{Z + B^*(1 - \sqrt{2})} \right] \quad , \quad (21)$$

where Z is the compressibility factor for the mixture, $A^* = a_m(T)P/(RT)^2$ and $B^* = b_m P/(RT)$.

The compressibility factor is calculated from an equivalent form of Eq. (10) implicit in the compressibility factor [17]

$$Z^3 - (1 - B^*)Z^2 + (A^* - 2B^* - 3B^{*2})Z - A^*B^* + B^{*2} + B^{*3} = 0 \quad . \quad (22)$$

Given the mole fractions of the components of the gaseous mixture, y_i , the dew point temperature is solved for iteratively by means of successive substitution using the following procedure:

1. Guess T .
2. Estimate the initial equilibrium ratios $K_i = \phi_i^l / \phi_i^v$ using the Wilson approximation $K_i = (P_{c_i}/P) \exp[5.373(1 + \omega_i)(1 - T^{-1}r_i)]$ [18].
3. Estimate the initial liquid mole fractions $x_i = y_i / K_i$.
4. Calculate Z using Eq. (22) and ϕ_i^v using Eq. (20) with the vapor mole fractions, y_i .
5. Calculate Z using Eq. (22) and ϕ_i^l using Eq. (20) with the liquid mole fractions, x_i .
6. Recalculate the liquid mole fractions $x_i' = x_i(\phi_i^v / \phi_i^l)$.
7. Repeat steps 5 & 6 until $x_i' - x_i \cong 0$.
8. Adjust T and repeat steps 2-7 until $\sum_i x_i' \cong 1$.

Method Comparisons for Natural Gas

Measured dew point temperatures versus water content from the GERG report [14] for two pressures, 5bar and 100bar, are shown in Figure A-1, Figure A-2, Figure A-3 and Figure A-4 along with calculated results using the ASTM1,

ASTM2 and ISO methods described above. The gas mixtures NG1, NG3, NG4 and NG7 are specified in Table A-5.

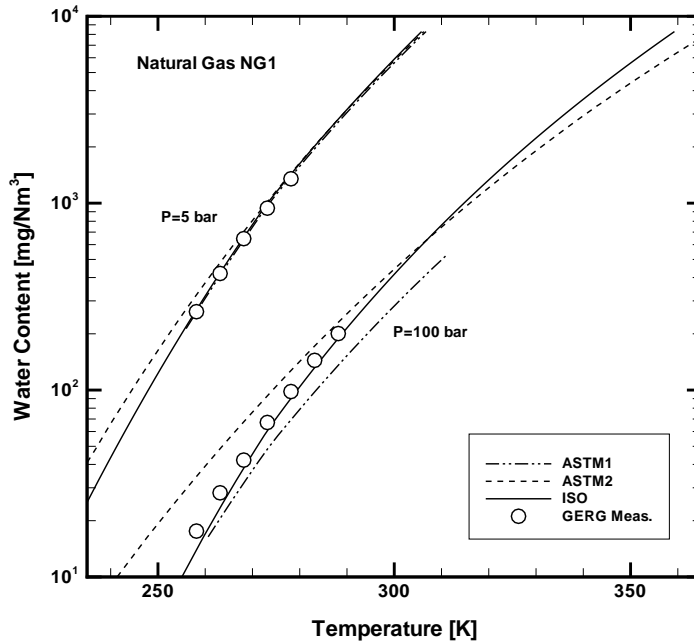


Figure A-1 Comparison of calculation results for ASTM1 [8], ASTM2 [9] and ISO [10] methods with experimental data from the GERG report [14] for mixture NG1

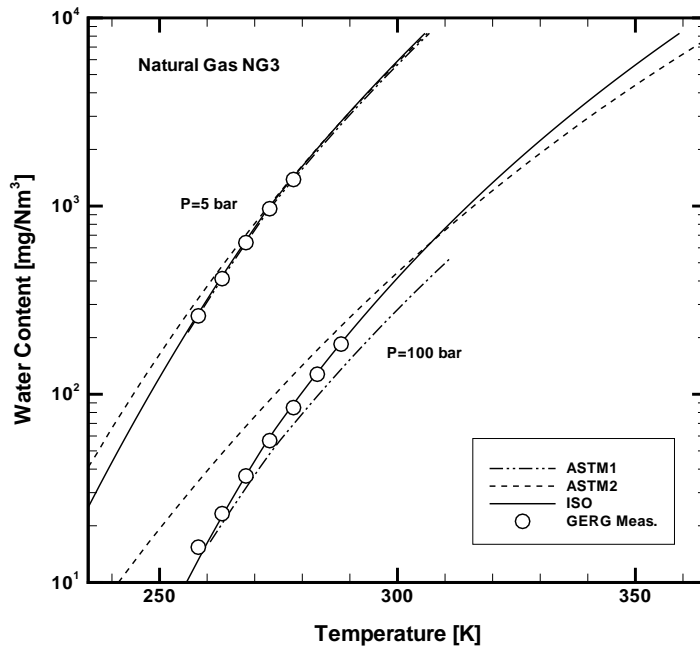


Figure A-2 Comparison of calculation results for ASTM1 [8], ASTM2 [9] and ISO [10] methods with experimental data from the GERG report [14] for mixture NG3

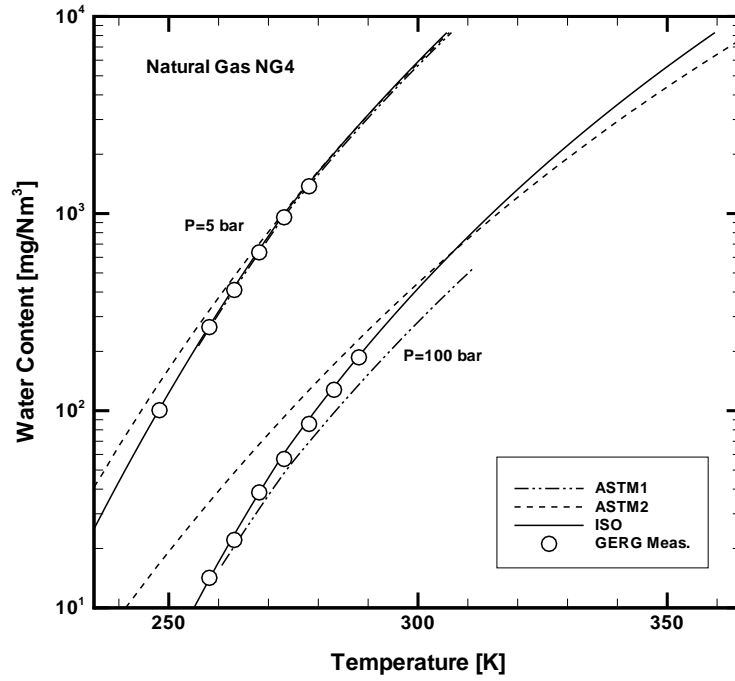


Figure A-3 Comparison of calculation results for ASTM1 [8], ASTM2 [9] and ISO [10] methods with experimental data from the GERG report [14] for mixture NG4

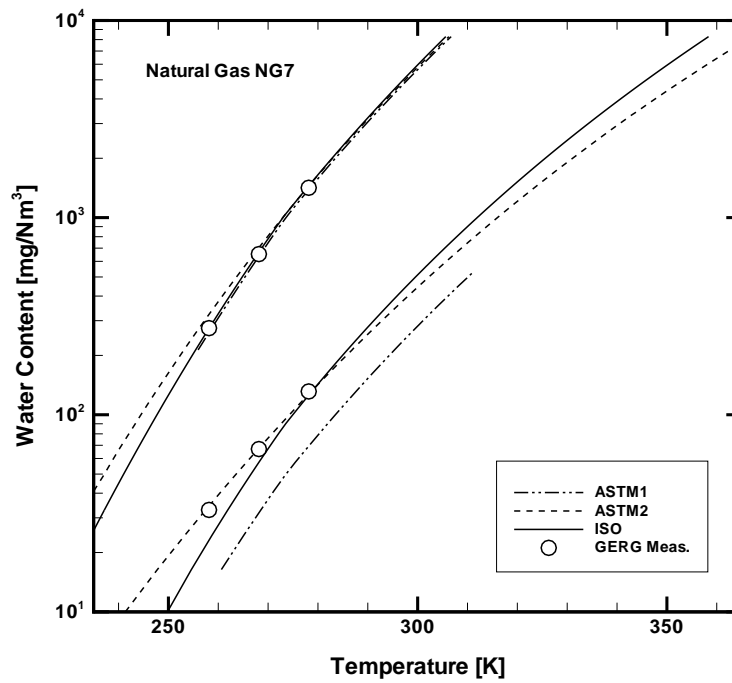


Figure A-4 Comparison of calculation results for ASTM1 [8], ASTM2 [9] and ISO [10] methods with experimental data from the GERG report [14] for mixture NG7

Table A-5 Experimental gas compositions [14]

Component	NG1	NG3	NG4	NG7
Methane (CH ₄)	0.98210	0.88204	0.86483	0.70148
Ethane (C ₂ H ₆)	0.00564	0.08360	0.06203	0.02520
Nitrogen (N ₂)	0.00840	0.00912	0.04871	0.01499
Carbon Dioxide (CO ₂)	0.00109	0.00000	0.00167	0.25126
Propane (C ₃ H ₈)	0.00189	0.01763	0.01552	0.00394
i-Butane (C ₄ H ₁₀)	0.00029	0.00293	0.00214	0.00067
n-Butane (C ₄ H ₁₀)	0.00038	0.00441	0.00315	0.00074
neo-Pentane (C ₅ H ₁₂)	0.00001	0.00003	0.00002	0.00003
i-Pentane (C ₅ H ₁₂)	0.00007	0.00020	0.00061	0.00029
n-Pentane (C ₅ H ₁₂)	0.00006	0.00004	0.00067	0.00022
Hexane/C ₆ + (C ₆ H ₁₄)	0.00007	0.00000	0.00064	0.00118

The ASTM1 method agrees well with the experimental data at low pressure (5 bar) but deviates significantly at higher pressure (100 bar), especially at higher temperatures where the calculated dew points are always too high. Given that the ASTM1 method is based on ideal gas assumptions, it is expected that real gas behavior typical of the higher pressures would not be sufficiently reproduced.

Being of similar origin as the ASTM1 method, the ASTM2 method exhibits similar behavior, albeit with even less agreement, especially at lower temperatures where the calculated dew points are always too low (with the exception of the CO₂-rich NG7 mixture at high pressure). Thus, if water content calculated by the ASTM2 method is used to control a drying process, water condensation may occur due to prematurely reaching the prescribed dew point. Discrepancies between the two ASTM methods is most likely due to the fact that data for a simple binary methane-water system was used in the development of the ASTM2 method [9].

The experimental water content data for the mixtures NG1, NG3, NG4 and NG7 at 60 bar are summarized in Figure A-5. Relative deviations between the courses tend to increase with decreasing dew point temperature. These deviations (~5K between NG4 and NG7 at 34mg/Nm³) illustrate the importance of accounting for the gas composition, especially when performing calculations with low water content at moderate to high pressure. Of the three methods discussed, only the ISO method takes into account the actual gas composition.

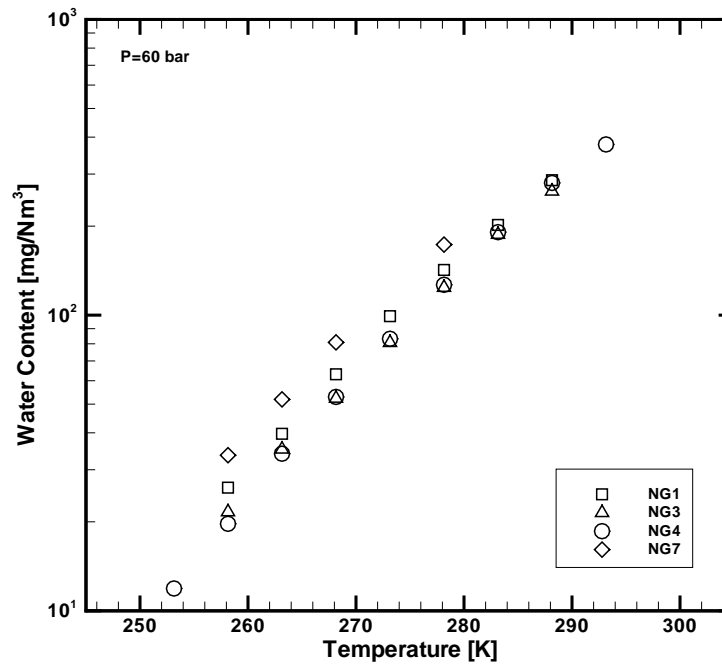


Figure A-5 Courses of measured water contents at 60 bar for natural gas mixtures NG1, NG3, NG4 and NG7

The ISO method is applicable to natural gas mixtures with compositions within the limits listed in Table A-6. Dew point temperatures calculated from water contents were validated to be generally within $\pm 2\text{K}$ for pressures $0.5 \leq P \leq 10\text{MPa}$ and dew point temperatures $258.15 \leq T \leq 278.15\text{K}$ [14]. Due to the solid thermodynamic basis on which the method was developed, an extended working range of $0.1 \leq P \leq 30\text{MPa}$ and $223.15 \leq T \leq 313.15\text{K}$ is also considered valid [10]. Beyond the extended working range, however, the uncertainty in calculated dew point temperature is unknown.

In summary, for moderate to high water contents at low pressures, all three correlations produce acceptable results. Although somewhat more difficult to implement, the ISO method is arguably the more accurate of the methods (especially for low water contents and high pressures) and provides a great deal more range and flexibility.

The Arden Buck Method Comparison

The Arden Buck method was developed for air at near-atmospheric pressure and can be used for air and nitrogen backgrounds. The Arden Buck method can be used as an approximation of dew point in natural gas streams with very high levels of methane and inert gases, but as heavier hydrocarbons and CO_2 concentrations increase, the Arden Buck method is unable to compensate for the interaction of the various molecules. Errors as high as 10°C will be reported in typical natural gas streams at typical pipeline pressures. Therefore, the use of the Arden Buck method should generally be avoided for natural gas streams.

Table A-6 Range of composition applicable to ISO method [10]

Compound	mol %
Methane (CH ₄)	≥ 40.0
Ethane (C ₂ H ₆)	≤ 20.0
Nitrogen (N ₂)	≤ 55.0
Carbon Dioxide (CO ₂)	≤ 30.0
Propane (C ₃ H ₈)	≤ 4.5
i-Butane (C ₄ H ₁₀)	≤ 1.5
n-Butane (C ₄ H ₁₀)	≤ 1.5
neo-Pentane (C ₅ H ₁₂)	≤ 1.5
i-Pentane (C ₅ H ₁₂)	≤ 1.5
n-Pentane (C ₅ H ₁₂)	≤ 1.5
Hexane/C ₆ + (C ₆ H ₁₄)	≤ 1.5

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Appendix B: Validation of Trace Moisture Measurements

The information contained in this chapter is provided for systems designed to detect moisture. Please disregard if this does not apply to your analyzer configuration.



The permeation rate and resultant water content of the validation flow have been carefully calibrated at the factory (refer to the system drawings for the calibrated output of the validation flow). DO NOT adjust the pressure regulator, flow controllers or temperature of the sample conditioning system or the calibration of the validation flow will be lost. If you suspect the settings of the sample conditioning system have been altered, contact your factory sales representative.

Validation Methods

Endress+Hauser uses one of two methods to validate low moisture measurements; a permeation validation system and a dynamic dilution.

Permeation validation systems provide a convenient and reliable method of validating the performance of the analyzer, without the need for elaborate blending systems and certified standards that might be impossible to obtain in the field. The analyzer accuracy and repeatability is not based on, certified or tested using the installed permeation device, however. Endress+Hauser has found that permeation devices generally do not generate more stable, repeatable or accurate trace moisture mixes than the dynamic dilution stations used in our factory to calibrate the analyzer.

In a dynamic dilution, a certified blend of gas can be diluted using precision flow controllers to produce the desired concentration of trace moisture in the actual sample gas.

Permeation Validation for Trace Moisture Analyzers (0-10 ppm H₂O)



The analyzer accuracy and repeatability is not based on, certified or tested using the installed permeation device. Endress+Hauser has found that permeation devices generally do not generate more stable, repeatable or accurate trace moisture mixtures than the dynamic dilution stations used in our factory to calibrate the analyzer. Permeation validation systems do provide a convenient and reliable method of validating the performance of the analyzer, without the need for elaborate blending systems and certified standards that might be impossible to obtain in the field.

The concentration measured during calibration, C_p , is related to the certified permeation rate of the device, R_p , by a system constant, K_p , using the equation:

$$K_p = C_p/R_p$$

This equation requires that the following conditions be met:

- Sample temperature is stable and equal to the temperature at calibration
- Sample flow is stable and equal to the flow at calibration
- Sample pressure at the permeation device is stable and equal to the pressure at calibration



*Due to the required conditions, the sample flow pressure regulator, flow control valve and back pressure regulator are factory set and should not be adjusted in the field. The flow components in the sample system are marked with red tags and the message: **FACTORY SET - DO NOT FIELD ADJUST**. The components have been set to give the required flow rate at the conditions described in the drawings provided with the analyzer. Changing any of these settings voids the certification of the permeation system and changes the measured concentration during validation.*



The sample flow flowmeters are NOT intended to be used for setting the flows in the field. The measurement accuracy of the flowmeters is not sufficient to reproduce the factory flow rates in the event the flow rates are inadvertently changed or require a change.

Setting the K_p Value

The System Constant K_p is determined at the factory when the analyzer is calibrated. Using the system constant, the permeation device can be replaced with another permeation device using a different permeation rate, and the correct new permeation concentration will be calculated by the analyzer software. The System Constant K_p will be consistent over the life of the analyzer provided the temperature, sample flow rate and pressure of the system are not changed from the factory settings.

Recalculating the System Constant K_p

Use the procedure in this section to recalculate the System Constant K_p in the field when the following conditions have occurred:

- The pressure or flow control devices in the sample system are inadvertently changed
- The sample background composition differs greatly from that specified for factory calibration

To recalculate the system constant

In some cases it may not be possible to reproduce the correct validation concentration C_p . In such cases, the system constant will need to be recalculated using the following procedure.



DO NOT CHANGE ANY OTHER PARAMETER. Doing so may cause the analyzer to stop functioning or provide an inaccurate measurement.



To recalculate the system constant K_p , the analyzer must be reading a correct and accurate value within the measured range. Contact the Service if there is any reason to believe the analyzer is not working correctly or making an accurate measurement.



Verify that the analyzer and permeation device have stabilized. Allow a minimum of **8 hours**, preferably overnight, before beginning this procedure.

1. Press **#7** and allow the analyzer to validate for at least one hour before proceeding.
2. Calculate the average (mean) validation measurement value C_p .
3. Calculate the new K_p ($K_p = C_p/R_p$).
4. Calculate the Standard Deviation of the mean C_p σ .
5. Calculate the Validation Allowance as $3\sigma / C_p * 100$.

6. Press **#2**, enter the password and press the * key.
7. Continue pressing the * key until the Validation Allowance parameter displays.
8. Enter the Validation Allowance calculated above and press the * key.
9. Continue pressing the * key until the Val Perm Constant K_p parameter displays, and enter the new K_p calculated above.
10. Enter the new K_p calculated above and press the * key.
11. Press **#1** to return to Normal Mode.
12. Press **#7** to ensure that the analyzer will continue to provide the correct Validation Concentration +/- the Validation Allowance.

Validation of Trace Moisture or Ammonia Measurements Using Permeation Devices

For trace moisture systems, Endress+Hauser employs a patented G-CAL[®] permeation tube.

The permeation device is designed to continuously release a fixed rate of analyte, approximately 2018NG/M, at 50°C. Refer to Figure B-1 for a schematic diagram of the permeation tube. The analyte released is continuously mixed with the dry process gas at 3000 sccm during validation mode (refer to **"Mode 7: (Measure Val 1 Mode)"** on page 2-9). This will result in a calibration mixture of C_p in parts per million (ppm) by volume, as long as return pressure is at atmospheric pressure.

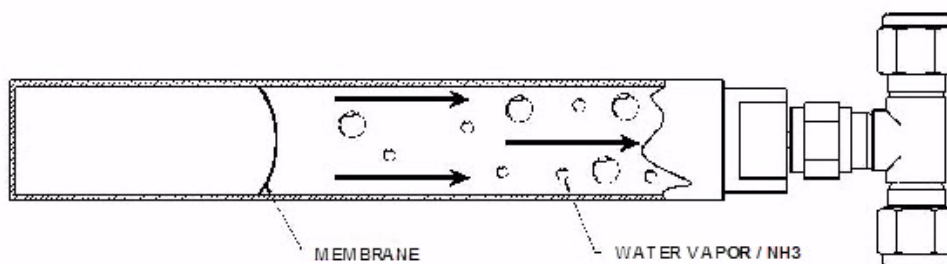


Figure B-1 Schematic of permeation tube

The permeation device connects to a "T" assembly between port 6 and 3 of the six-way valve (refer to Figure B-2). During normal operating conditions, a portion of the process gas return from the sample cell flows through one end of the "T" and carries the excess moisture or analyte released from the permeation assembly back to vent. When the system is switched to validation (refer to **"Mode 7: (Measure Val 1 Mode)"** on page 2-9), the six-way valve changes positions allowing the dry process gas (flowing at 3000 sccm) through the "T" in the opposite direction, carrying the mixed gas into the sample cell.

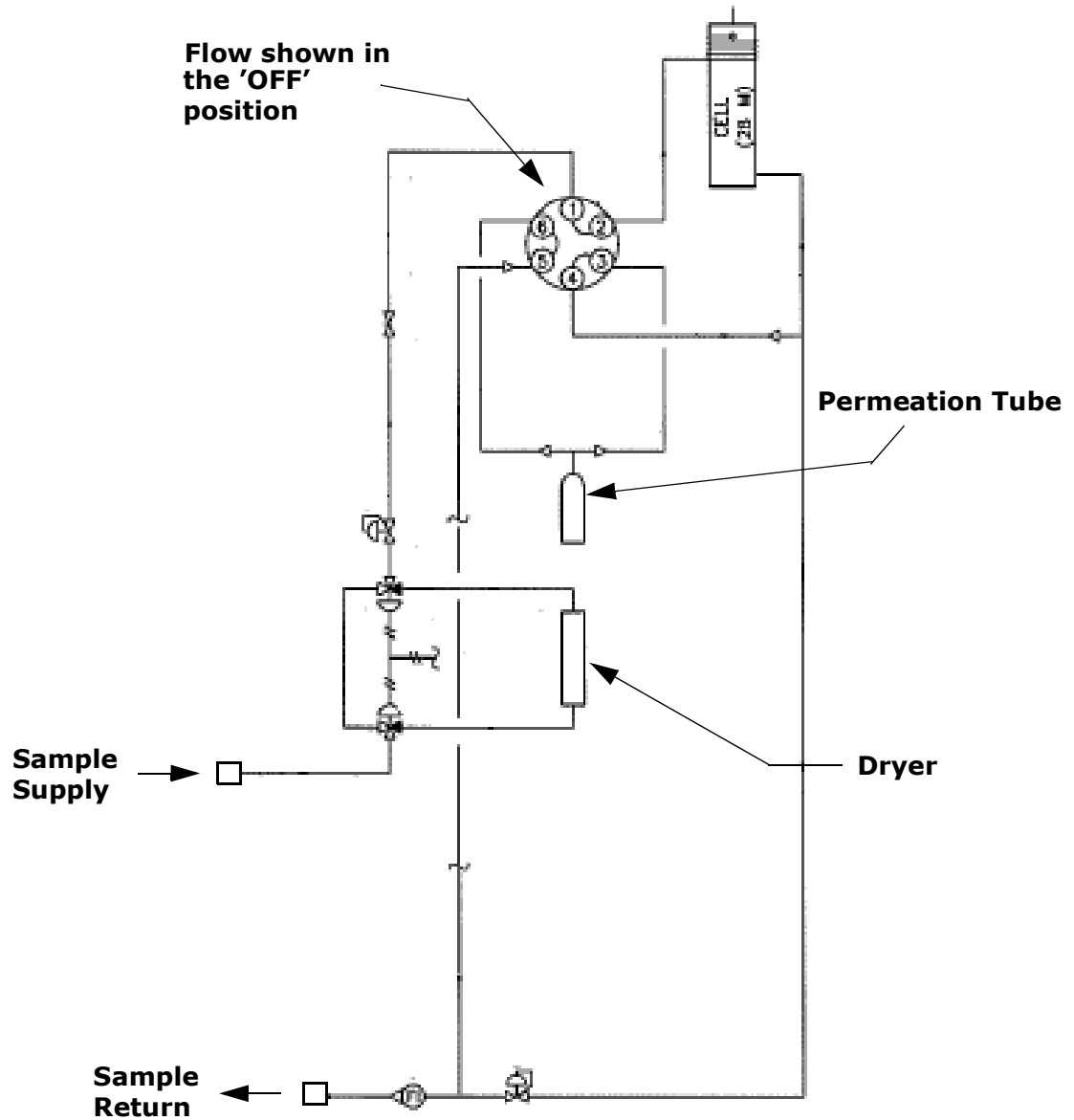


Figure B-2 Typical sample system for differential measurement with permeation tube validation capability

The concentration of pollutant obtained in ppm by volume may be computed using the following formula:

$$C = \frac{KxP}{F} \quad K (\text{Water}) = 1.358$$

where:

- C = concentration of ppm in volume
- F = carrier gas flow rate in ML/minute at 1atm and 25C
- P = permeation rate of the G-CAL assembly in nanograms/minute at the temperature of the G-CAL (environment temperature)

The entire flow system is maintained at constant elevated temperature (typically 50 to 60°C). The constant temperature not only minimizes species adsorption/desorption and prevents condensation, but in combination with the regulated sample supply pressure and controlled flow rates, ensures a constant mixture of C_p in parts per million (ppm) by volume.



The entire analyzer system is calibrated for operation at the enclosure temperature and sample flow rate specified. Measurements should be considered valid only when the enclosure is at the specified temperature and sample flow rate. After opening the sample system enclosure door to check settings, allow at least 1 to 2 hours for the temperature to re-stabilize before validating.



To replace the permeation device, refer to the SCS Operating Instruction for instructions.

Appendix C: Troubleshooting

This section presents recommendations and solutions such as excessive sampling gas temperatures and pressures, and reset procedures. If your analyzer does not appear to be hampered by one of these related problems, refer to Table C-1 at the end of this chapter before contacting Endress+Hauser for service.

Excessive Sampling Gas Temperatures and Pressures

The embedded software is designed to produce accurate measurements only within the allowable cell operating range (refer to the calibration report or system drawings).



The cell temperature operating range for analyzers that are equipped with heated enclosures is equal to the enclosure temperature setpoint ± 5 °C.

Pressures and temperatures outside this range will trigger a **Pressure Low Alarm**, **Pressure High Alarm**, **Temp Low Alarm**, or **Temp High Alarm** fault.



If the pressure, temperature, or any other readings on the LCD appear suspect, they should be checked against the specifications (refer to the calibration report or system drawings).

Peak Tracking Reset Procedure

The analyzer's software is equipped with a peak tracking function that keeps the laser scan centered on the absorption peak. Under some circumstances, the peak tracking function can get lost and lock onto the wrong peak. If the **PeakTk Restart Alarm** is displayed, the peak tracking function should be reset.

To reset the Peak Tracking function:

1. Press the **#** key followed by the **2** key.

<SET PARAMETER MODE>
Enter password:

FS 5.16-XXXX

The LCD prompts for a numeric password. Enter the user password (**3142**) on the keypad, then press the * key to enter the number to enter **Mode 2**.

```
<SET PARAMETER MODE>
Process Purge Time
60
Enter a value (secs)
```

2. Starting with the first parameter that displays, press the * key to cycle through the screens until the **Peak Tracking** parameter displays.

```
<SET PARAMETER MODE>
Peak Tracking
1
0:Off 1:On 2:Rst
```

3. Press **2** (RST or Reset) followed by the * key. The peak tracking function will return the current analyzer midpoint to the factory default midpoint, and then automatically revert the parameter value to its setting before the reset was initiated. In most cases, the peak tracking should be set to **1** for on.
4. Press the * key to cycle through the screens until the **General Alarm DO** parameter displays.

```
<SET PARAMETER MODE>
General Alarm DO
2
0:L 1:NonL 2:Reset
```

5. Press **2** (RESET) followed by the * key. The General Fault relay and any active alarms will be reset to the 'Normal' state. After the relay resets, this parameter will automatically revert to the setting before the reset was initiated.
6. Press the mode key # followed by **1** to return to **Mode 1** (Normal Mode).

Instrument Issues

If the instrument does not appear to be hampered by issues described in this chapter, refer to Table C-1 before contacting your sales representative for service.

Table C-1 Potential instrument issues and their solutions

Symptom	Response
Non-Operation (at start up)	Refer to the Operating Instruction.
Non-Operation (after start up)	Contact a factory sales representative for service information.
Laser Power Low Alarm	Press # 6 to capture diagnostic data and send the file to Endress+Hauser.
	Refer to the Operating Instruction.
Pressure Low Alarm or Pressure High Alarm fault	Refer to the Operating Instruction.
Temp Low Alarm or Temp High Alarm fault	Refer to the Operating Instruction.
Front panel display is not lit and no characters appear	Refer to the Operating Instruction.
Strange characters appear on front panel display	Refer to the Operating Instruction.
Pressing keys on front panel do not have specified effect	Refer to the Operating Instruction.
System stuck in Fit Delta Exceeds Limit restart for greater than 30 minutes	Contact a factory sales representative for service information.
Not getting enough flow to the sample cell	Refer to the Operating Instruction.
No reading on device connected to current loop	Refer to the Operating Instruction.
Current loop is stuck at 4 mA or 20 mA	Check display for error message. If alarm has been triggered, reset the alarm.
	Refer to the Operating Instruction.
Reading seems to always be high by a fixed amount	Capture diagnostic data and send the file to Endress+Hauser (see "To read diagnostic data with HyperTerminal" on page 3-5).
Reading seems to always be high by a fixed percentage	Capture diagnostic data and send the file to Endress+Hauser (see "To read diagnostic data with HyperTerminal" on page 3-5).
	Check that Peak Tracking is enabled (see "To change parameters in Mode 2" on page 2-16).

Table C-1 Potential instrument issues and their solutions (Continued)

Symptom	Response
Reading displays 0.0 or seems relatively low	Capture diagnostic data and send the file to Endress+Hauser (see "To read diagnostic data with HyperTerminal" on page 3-5).
Reading is erratic or seems incorrect	Refer to the Operating Instruction to check for contamination in the sample system.
	Capture diagnostic data and send the file to Endress+Hauser (see "To read diagnostic data with HyperTerminal" on page 3-5).
Reading goes to "0"	If 4-20 mA Alarm Action is set to 1 , look on display for an error message (see "To change parameters in Mode 2" on page 2-16).
	Refer to the Operating Instruction.
Reading goes to full scale	If 4-20 mA Alarm Action is set to 2 , look on display for an error message (see "To change parameters in Mode 2" on page 2-16).
	Refer to the Operating Instruction.
Serial output is displaying garbled data	Refer to the Operating Instruction.
Serial output is providing no data	Refer to the Operating Instruction.
LCD does not update. Unit is locked up for more than 5 minutes.	Refer to the Operating Instruction.

Service

For Service, refer to our website (<https://endress.com/contact>) for the list of local sales channels in your area.

Service Repair Order

If returning the unit is required, obtain a **Service Repair Order (SRO) Number** from Sales channel representative before returning the analyzer to the factory. Your representative can determine whether the analyzer can be serviced on site or should be returned to the factory. All returns should be shipped to:

Endress+Hauser
 11027 Arrow Rte.
 Rancho Cucamonga, CA 91730-4866
 United States of America
 1-909-948-4100

Before contacting Service

Before contacting Service, prepare the following information to send with your inquiry:

- Diagnostic downloads using the procedures provided in “**Receiving Serial Data (Customer Port Output)**” on page 3-1 or using AMS100 software from Endress+Hauser.

When capturing this data, please include the following information to expedite your request:

- Analyzer Serial Number (SN) in the filename of the download, e.g., Diagnostic Data Download SN XXXX, where 'XXXX' is the SN
- Mode 6 (#6) download of the process sample
- Mode 6 (#6) download of the validation gas, if the analyzer is designed to be connected to the sample port
- Parameter list in the captured data
- Mode 1 (#1) data in the captured data (approximately 5 minutes)



The Mode 6 (#6) process spectral data, the parameter list, the validation gas spectral data and the 5 minutes of Mode 1 (#1) data can all be provided in the same .txt file.

With your download information, please also include:

- Contact information
- Description of the problem or questions

Access to the information above will greatly expedite our response to your technical request.

Service Repair Order (SRO)

If returning the unit is required, obtain a **Service Repair Order (SRO) Number** from Customer Service before returning the analyzer to the factory. Your service representative can determine whether the analyzer can be serviced on site or should be returned to the factory. All returns should be shipped to:

11027 Arrow Rte.
Rancho Cucamonga, CA 91730-4866
United States of America
1-909-948-4100

Disclaimers

Endress+Hauser accepts no responsibility for consequential damages arising from the use of this equipment. Liability is limited to replacement and/or repair of defective components.

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Equipment Warranty

For a period of 18 months from date of shipment or 12 months in operation, whichever comes first, Endress+Hauser warrants that all products sold by it shall be free from defects in material and workmanship under normal use and service when correctly installed and maintained. Endress+Hauser's sole liability and Customer's sole and exclusive remedy for a breach of warranty is limited to Endress+Hauser's repair or replacement (at Endress+Hauser's sole option) of the product or part thereof which is returned at Customer's expense to Endress+Hauser's plant. This warranty shall apply only if Customer notifies Endress+Hauser in writing of the defective product promptly after the discovery of the defect and within the warranty period. Products may only be returned by Customer when accompanied by a return authorization reference number (SRO) issued by Endress+Hauser. Freight expenses for products returned by Customer will be prepaid by Customer. Endress+Hauser shall pay for shipment back to Customer for products repaired under warranty. For products returned for repair that are not covered under warranty, Endress+Hauser's standard repair charges shall be applicable in addition to all shipping expenses.

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GP01177C/66/EN/01.21

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