DensityPRO+

Gamma Density System with Remote Transmitter
User Guide
P/N 717819

Revision C

Part of Thermo Fisher Scientific

Thermo SCIENTIFIC

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Revision History

Revision Level	Date	Comments
Rev. 1.0	07-01	Initial release.
Rev. A	03-05	Name change.
Rev. B	09-07	Per ECO 5987.
Rev. C	03-08	Per ECO 6210.

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Chapter 1 Introduction

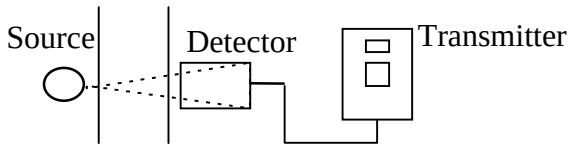
The DensityPRO+ gamma density system with remote transmitter is designed to provide reliable, accurate process material density measurements for a wide variety of challenging applications. The gauge is mounted outside of the process vessel and never contacts the process material. The gauge can measure the density of almost any liquid, slurry, emulsion, or solution.

The gauge can convert the basic density measurement into a variety of output measurements as appropriate for specific applications, e.g., bulk density or solids content per unit volume. Given a temperature input, the gauge can compensate the density measurement relative to a user-specified reference temperature. If a flow input is provided, the gauge can calculate mass flow. The setup menus guide you through the configuration process to help you quickly complete the gauge setup.

Description

The *gauge* has three main parts: a *source*, a *detector*, and a *transmitter*. The source and detector are mounted on opposite sides of the pipe or vessel containing the process material. The transmitter contains the microprocessor (CPU) board and the input/output (I/O) boards and can be mounted some distance away from the detector in a location more convenient for the user.

The radioisotope source emits gamma radiation that passes through the process material. The detector measures the energy of the radiation arriving at the detector after passing through the process material (and vessel walls). The gauge determines the density of the process material by measuring the attenuation (energy reduction) of the gamma ray beam as it passes through the process material.



Source

A Cesium (Cs-137) radioisotope source is used for most applications. A Cobalt (Co-60) source is available for applications requiring a higher energy source. The radioisotope is bound in ceramic pellets and double-encapsulated in a pair of sealed stainless-steel containers. The resulting source capsule is highly resistant to vibration and mechanical shock.

The source capsule is further enclosed in the source head, a lead-filled, welded steel housing. A shaped opening in the lead shielding directs the gamma radiation beam through the process material towards the detector. Outside of the beam path, the energy escaping the source head is very low and well within prescribed limits. Closing the source shutter allows the beam to be "turned off" (the shutter blocks the radiation) during installation or servicing of the gauge. All source housings meet or exceed the safety requirements of the U.S. Nuclear Regulatory Commission (NRC) and Agreement State regulations. More information is available in the Gamma Radiation Safety Guide (717904).

Detector

The gauge uses either an *ionization chamber* or *scintillator* type detector to measure the gamma radiation reaching the detector from the source.

An ionization chamber is a sealed, temperature-stabilized chamber filled with a relatively dense gas. Radiation entering the chamber ionizes the gas, allowing current to flow between electrodes in the chamber. The detector amplifies this signal and sends it to the transmitter. The ionization chamber detector can withstand vibration and other harsh conditions.

The scintillator detector consists of a special plastic scintillator material, a photomultiplier tube, and associated electronics. When radiation strikes the plastic scintillator material, small flashes of light are emitted. As the density of the process material increases, the process material absorbs more of the gamma radiation and the scintillator material generates fewer light pulses. A photomultiplier tube and the associated detector electronics convert the light pulses into electrical pulses that are sent to transmitter for processing to determine the process material density and related measurement values.

The plastic scintillator used in the gauge is very efficient at converting the incident gamma radiation into light. The scintillator detector is suitable when more precision or greater sensitivity is required or when a lower-activity source must be used.

Transmitter

The DensityPRO+ *transmitter* uses the signal from the detector to calculate the process material density and related measurement values. These values can be displayed, sent to serial ports, or used to drive current outputs and alarms. The transmitter also monitors system performance and generates system fault and warning alarms.

The transmitter is available in either a non-metallic (NEMA 4X) enclosure or a heavy cast aluminum (NEMA 7/NEMA 4) explosion-proof enclosure. The NEMA 4X is certified (FM/CSA) for use in Division 2 hazardous locations while the NEMA 7 enclosure is certified (FM/CSA) for use in Division 1 hazardous locations.

Note: Refer to the equipment tag on the gauge to verify the hazardous location certifications for your gauge.

Measurement Calculation

After the transmitter calculates the process material density, it can convert the data into a number of forms. For a slurry consisting of carrier and solid components, the gauge can provide measurements based on the ratio of solids to carrier. Similar measurements can be made for emulsions that consist of two different fluids and for solutions that consist of a material (the solute) dissolved in a fluid (the solvent).

If flow data is provided as an input, the gauge can generate mass flow measurements. The gauge can accept a 4-20 mA current input from a magnetic flow sensor or from Thermo's VersaFLO™ fixed or portable flow meters.

For applications that require temperature compensation, the gauge can accept a temperature input to compensate the density measurement for changes in process temperature.

Communications and Measurement Display

Communications with the gauge are accomplished via the integral keypad (NEMA 4X transmitter only) or via the RS-232 or RS-485 serial ports. The integral keypad on the NEMA 4X transmitter is normally used as the primary means of communication with the gauge. Menu selections, commands, and parameter values are entered using the keypad.

The RS-232 or RS-485 serial ports can be used to communicate with the gauge using a remote terminal, a PC with terminal emulation software, or a Thermo Scientific Hand-Held Terminal (HHT). Each of these options provides the functional equivalent of the NEMA 4X transmitter's integral keypad and display.

Both the NEMA 4X and NEMA 7 transmitters include a four-line by 20-character display. The four-line display (20 characters per line) shows either one menu item or up to eight readouts in alternation (four at a time).

The HART communication protocol is supported over the 4-20 mA current output with an optional daughter board. You communicate with the gauge using the standard Fisher Rosemount 275 HART handheld communicator. Refer to the "DensityPRO+ HART Operation Manual" (P/N 717816) for detailed instructions.

Inputs and Outputs

The characteristics of the input and output options for the gauge are summarized in Table 1-1. The gauge provides RS-485 and RS-232 serial communication ports, a 4-20 mA current output and two contact closure inputs. The contact closure inputs can be programmed to activate any system command based on a user-provided input. System options include up to six relays, additional 4-20 mA current outputs, and contact closure inputs.

Table 1-1 Input and Output Characteristics

Input/Output Characteristics		
Type	**Characteristics**	**Comments**
Transmitter input power	**DC Input Power** 24 Vdc (20-28 V), 12 W standard 12 Vdc (9-15 V), 15 W optional **AC Input Power** 110/220 Vac (100-240 V), 50/60 Hz, 25 VA optional	12 Vdc option is for safe areas only (no FM/CSA approvals) See Appendix C – Specification for Detector Input Power Options
Current output	3.8-20.5 mA DC (adjustable range) Can be configured as: 1) Isolated, Self-Powered, or 2) Isolated, Loop-Powered, user must supply the 24 Vdc loop power input. Max Load: 700 ohms	Default range is 4-20 mA DC. One current output is standard, up to two additional current outputs can be provided. Self-Powered configuration is standard. Reconfigure as Loop-Powered by removing a jumper.
Serial communications	RS-232: One terminal block RS-485: One terminal block and one RJ11 (Phone) Jack	Full duplex communication with remote terminal or PC. Half-duplex party-line communication to host computer or Hand-Held Terminal (HHT).
HART communications	HART protocol supported over the 4-20 mA current output.	Optional daughter board required.
Relays	Two relays (optional) on each I/O Board. Form C SPDT, Isolated, 8 A, 220 Vac.	Up to six relays maximum, two per I/O board. Assign process alarms to control (open/close) relays.
Contact closure inputs	Two contact closure inputs provided on each I/O board.	Execute commands based on user-provided contact opening or closure input to the gauge.
Flow input	4-20 mA current input	Current output from a flow sensor can be input to the gauge. The gauge uses this input to compute mass-flow readouts.
Temp. comp. input	Thermo Scientific Temp Comp Board - 0-10 mA current input User Temp Sensor - 4-20 mA current input	Current output from a temperature sensor can be input to the gauge. This input is used to compensate density measurement for temperature effects.
Display	Four lines, backlit, 20 characters per line (NEMA 4X Transmitter only)	English-language setup menus. Up to eight measurement readouts displayed four at a time in alternation.

Features

Dynamic Menu System

The setup menus guide you through the configuration of the gauge. The “Set up density, den. alarms, & flow” menu group includes all of the basic parameters and commands required to quickly configure your gauge. Additional menu groups provide specialized parameters and commands allowing the gauge to be tailored to a wide variety of applications.

Direct-entry menu shortcuts are also provided, allowing experienced users to access menu items and commands directly, bypassing the menu system.

Instantaneous Response

Our Dynamic Process Tracking (DPT) ensures that there is no lag time in the system response to significant changes in process density. When changes occur, the DPT feature reduces the normal averaging time constant by a factor of eight, ensuring a rapid, yet smooth output response. When the process stabilizes, a longer time constant is applied to reduce the fluctuations inherent in radiation-based measurements. In this way, process density changes are immediately reflected in the transmitter output, while the effects of statistical variations in the radiation measurement are greatly reduced.

Multiple Readouts

Select up to eight measurement values for display. Available measurement types include density, bulk density, solids concentration, carrier concentration, ratio of solids to carrier, bulk mass flow, bulk volume flow, and the rate of change of any these measurements.

Extensive Alarms

You can set up to 16 process alarms in addition to system fault alarms and warning alarms.

Totalizers and Batch Control

You can set up four independent totalizers to count time, flow output, or relay signals at any rate. If your gauge has relays installed, each totalizer can close a relay (for an external counter, etc.) at user-specified count intervals. The totalizers can also close relays when particular counts are reached (for batch or sample control).

Output Signals

You can assign any measurement to the 4-20 mA current output, or the measurement values can be sent to a remote terminal or host computer as serial data. One current output is provided on the standard I/O board. Two additional I/O boards can be provided as options with one 4-20 mA current output per board.

Two relay outputs are optional on each of the I/O boards. Each I/O board also includes two contact closure inputs that can be used to activate any system command based on a user-provided input (open or closed).

How to Use This Manual

This guide provides detailed instructions for configuring and operating your gauge.

Refer to the installation guide (717818) for information on the installation and wiring of your gauge.

Setting Up the Gauge

Chapter 2 "Getting Started" provides basic information about using the setup menus and how to enter or modify the setup parameter values. The menu items are grouped into seven top-level categories. Chapters 3 through 9 provide detailed information on the menu items in each of these seven categories.

Chapter 3 "Set Up Density, Den. Alarms, & Flow" describes the steps required for the initial set up of the gauge. For many applications, the "Set up density…" menu includes all of the items required to configure the gauge. This menu provides the means to:

- Set up the primary measurement
- Set up process alarms
- Perform the Standardization measurement
- Perform Calibration measurement

Chapter 4 "Set Up Additional Measurements" explains how to set up measurements in addition to the primary measurement. Up to seven additional measurements can be defined.

Chapter 5 "Gauge Fine Tuning" describes the "Gauge fine tuning" menu groups for adjusting the measurement time constant, for setting up temperature compensation and/or flow input, and for performing gauge standardization and calibration.

Chapter 6 "Current Output, Alarms & Totalizers" describes how to assign the current output and process alarms to measurements other than the primary measurement, other alarm-related options, and how to set up totalizers.

Chapter 7 "Action Items" describes the various commands available under the "Action items" menu. The commands are grouped by function:

- Common action items
- Alarm commands
- Hold commands
- Serial port commands

Chapter 8 "Serial Ports, Contact Inputs, Special Fcts" explains the various options for configuring the serial communication ports and how to assign commands to the contact closure inputs. The special purpose menu items are described in "Special functions."

Chapter 9 "Security, Diagnostics, and Service Menus" describes the security, diagnostic, and service menus.

Appendix A "Solution Characterization" explains how to find and set up custom solution characterizations for applications that require them.

Appendix B "Attenuation Coefficients" lists fine-tuning attenuation coefficients for most elements.

Additional Information

Refer to the "DensityPRO+ HART Operation Manual" (717816) for detailed instructions for the set up and operation of the gauge via the HART protocol.

Refer to the "Model 9733/9734 Hand-Held Terminal Operation Manual" (717797) for details on communicating with the gauge using the Thermo Scientific HHT.

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Chapter 2 Getting Started

This chapter provides information on setting up communications with the gauge, describes how to use the built-in menu system to enter data and commands to set up the gauge, and provides an overview of the menu structure.

Warning: You must have a specific license to commission the gauge. Refer to Chapter 2 of the installation guide (717818).

Communicating with the Gauge

The integral keypad and display on the NEMA 4X transmitter are normally used to communicate with the gauge. Alternately, the RS-232 and RS-485 serial ports support communications with the gauge via a remote terminal, a PC with terminal emulation software, or a Thermo Scientific HHT. Each of these options provides the functional equivalent of the NEMA 4X transmitter's keypad and display.

The NEMA 7 (explosion-proof) transmitter does not have a keypad, so the RS-232 or RS-485 serial ports or HART must be used to communicate with the gauge. Refer to the wiring diagram in the installation manual for serial port wiring details.

Note: The Model 9734/9733 HHT requires an 8 Vdc power source. The RJ-11 connector for the RS-485 port on the gauge (located on the CPU board in the transmitter) includes two wires for the RS-485 communications and two wires for the 8 V supply.

The Model 9734/9733 Hand-Held Terminal can be plugged directly into the RJ-11 port (in non-hazardous locations) to communicate with the gauge.

Serial Communications Setup

The serial port on a personal computer (e.g., COM1 or COM2) can be connected to the gauge's RS-232 port directly. An RS-485-to-RS-232 adapter is required to connect a PC to the gauge's RS-485 port.

The default communication settings for the gauge are 7 data bits, even parity, 1 stop bit (7-E-1), and 9600 baud. See "Serial Ports" on page 8-2 for additional details on setting up serial communications.

The Model 9734 HHT and the optional TMTComm software both provide the capability to upload the gauge setup parameters to the HHT or to a PC file and to download a previously saved file to the gauge.

HART Communications

The HART communications protocol is supported over the 4-20 mA current output and requires an optional daughter board. As practical, the HART menu structure mirrors the menu structure as implemented in the gauge (and as described in this manual).

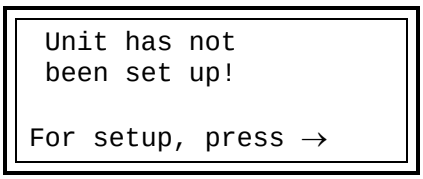
Once the optional HART board is installed, the gauge enters a special mode of operation. In this operation mode, all user-entered RS-232 selections are overridden and the RS-232 setup menus are disabled. The HART interface provides access to the basic set-up functions including:

- Primary Measurement Setup
- Process Alarms
- Additional Measurements
- Current Output Settings
- Gauge Fine Tuning
- Action Items (i.e. gauge restart, erase memory)

You communicate with the gauge using the standard Fisher Rosemount 275 HART handheld communicator. Refer to the "DensityPRO+ HART Operation Manual" (P/N 717816) for detailed instructions.

Measurement Display

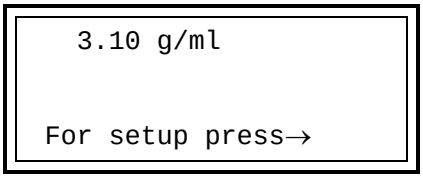
The first time power is applied to a gauge, the following message is displayed on the transmitter.



If the transmitter display is blank after you apply power to the gauge, check the following:

1. Try adjusting the display contrast.
   - For the NEMA 4X transmitter (with keypad), press ↑ or ↓ on the keypad several times to increase or decrease the contrast.
   - For the NEMA 7 XP transmitter (no keypad), communications must first be established with the gauge via the RS-232 or RS-485 serial ports. Then use the menu-based commands, "Dec LCD" or "Inc LCD" to decrease or to increase the display contrast, respectively. (Refer to the section "Common Action Items" on page 7-2 for more detailed information.)
2. Verify the power supply at the source.
3. Disconnect all power to the transmitter, open the transmitter and verify:
   - The power supply is properly seated on the main board and is properly wired, refer to the installation guide (717818).
   - The ribbon cable from the transmitter display is properly seated on the CPU board.
   - All boards are properly seated on the transmitter main board.
4. If the display still appears blank, contact Thermo Fisher.

Once the gauge has been set up, the measurement display will show the primary (density or density-related) measurement along with any additional measurements that have been defined. An example of a density measurement readout is illustrated below.



The measurement display is shown continuously, except when the setup menus are being accessed. The *displayed* measurement values are updated approximately once every two seconds. Measurements are updated at a much faster rate internally by the software. All measurements continue to be updated even when they are not being displayed.

By default, the fourth line displays the "For setup press →" prompt or alarm/warning messages when they occur. Up to six measurements can be displayed; the display alternates between showing measurements 1-3 and measurements 4-6. A maximum of eight measurements can be displayed (four at a time) by disabling the "For setup press →" prompt on the fourth line, see "Special Functions" on page 8-10.

Entering Data and Commands

Use the arrow keys to move through the menus to reach a menu item or use the direct entry technique to access the desired menu item in a single step. Some menu items direct you to use the left/right arrow keys to select from a list of the available parameters, while other menu items require you to enter a numeric value directly.

Note: A "Bad entry values" message is displayed if you enter values that the gauge cannot understand. If this happens, the gauge will display the bad entry information when you enter the setup menus.

Use the Arrow Keys to Navigate the Setup Menus

Use the arrow keys (←, →,↑, and ↓) to scroll through the menus, access HELP menu items, change selections, and execute commands. Each menu item will indicate the function of the arrow keys for that menu item.

The → key is used to enter the setup menus and to step through the top-level menu headings. Press the ↓ key to enter a menu and scroll through the menu items. In many cases, you can use the ↑ key to return to the previous menu item or to scroll through the menu items in the reverse direction. The → key is also used to scroll through the list of options for a menu. Use the ← key to return to the previous option. When the correct option is displayed, press ↓ to select that option and go to the next menu item.

Entering Numbers

Use the number keys to enter data values. Use the "•" (period) key for the decimal point and the "–" key to indicate a negative number. After keying in a number, press ↓ to indicate the end of the number entry.

Decimal entries may be made in scientific notation by pressing the "•" key a second time during an entry to indicate the start of the exponent.

To enter: `4.567E6`
Press: **`4.567.6`**

If you are entering data from a terminal keyboard, you can type either "E" or "e" before entering the exponent value, or you can also use "•" as shown above.

Exiting the Menus and Saving Your Entries

To exit the setup menus at any time, press the **Exit Setup** key on the transmitter keypad (or on the Hand-Held Terminal) or press the "**X**" key on a terminal keyboard. This will save any changes made to entries in the menus and return to the measurement display.

Note: When you press EXIT SETUP, your entries or changes are saved and used by the gauge. If you do not exit the setup menus, any entries or changes are stored and used by the gauge automatically after five minutes of inactivity.

After you have configured the gauge and the configuration settings have been saved, the gauge retains the configuration settings even when power is turned off.

Setup Menus

The setup menus provide a step-by-step procedure for entering the data required to operate the gauge. The dynamic menu system controls which menu items are displayed, so that only menu selections pertinent to your application are presented. Read the HELP screens provided at appropriate points within the menus.

In each menu item, the data value that can be entered or changed will be flashing. Enter the requested parameter in each menu item as it is displayed to ensure other related menu items are displayed. For example, to set up an alarm, you must enter a value for the "Set point" menu item in order to activate the rest of the "Alarm setup" menu.

Note: The appearance of the menu items as described in this manual may vary slightly from the actual display on your gauge. The appearance of many menu items (words and numbers) varies dynamically with context and will depend on the parameter values and selections you enter during setup.

If no entries are made for more than five minutes while using the setup menus, the display times out and returns to the measurement display. Any changes or entries you have made are saved and used by the gauge software. To continue with the setup procedure, use the arrow keys to return to your previous place in the menus.

Reset Entries to Factory Defaults

If anything other than the "Unit has not been set up!" message is displayed when power is applied, the gauge has already been (at least partially) set up. If you are unsure about what settings have been entered, or if the gauge has been moved to a new location, you

may want to reinitialize the gauge to the factory default settings and set up the gauge from the beginning.

Use command 82 “Erase all entries (except comm setup)” to reset all user entries to the factory default settings, except for the communication settings. Use command 74 “Erase all entries” to reset all entries including the communications settings to the factory defaults. See “Common Action Items” on page 7-2).

Service Only Menu Items

The menu structure has two “layers” of menu items, the user layer and the service layer. The default, user layer is adequate for most applications, while the service layer provides a number of additional, special purpose menu items. These additional tools (service only items) can be enabled using the “Special functions” menu as described in Chapter 8 (see page 8-10).

Direct Entry

To use direct entry, you must know the direct entry code or item identifier. Items with six-digit direct entry codes (or item identifiers) are data entry values. Items with 1, 2, or 3 digit identifiers are commands. To find the keyboard code for a particular menu item:

1. Scroll to the menu item of interest.
2. For menu items that are not floating point number entry items, you simply press the period, “•” key to display the direct entry (keyboard) code information screen.
3. For floating point entries (numbers such as 5.250) press the “•” (period) key followed by the ↑ key to display the direct entry code screen. (The ↑ key indicates that you are not entering a decimal number, rather you want to view the direct entry code screen.)

Use the direct entry method with caution. When entering or changing a parameter value for one menu item, it may be necessary to also enter or modify the value of other associated menu items. The menus are structured to ensure that all required parameter values are entered. The direct entry method provides access to individual menu items with no guidance as to whether there are additional parameters that must also be modified when a given parameter is modified.

Note: Most menu items display a slightly different “message” when accessed by direct entry than the message shown in the setup menus. Direct entry allows access to a single menu item, you are not able to scroll to the item that would normally appear next in the menus.

Example: Finding a Direct Entry Code (item identifier)

One of the first menu items in the "Set up density, den. alarms & flow" menu (see Chapter 3) is shown below.

```
Sensor uses
5202 source head

     NEXT↓ CHANGE→
```

Pressing the period "•" key displays the information screen shown below.

```
Value is 6
Item is data entry
Keyboard code 005002
{HEX = 050C} Press ↓
```

The keyboard code 005002, is the number used for direct entry. Press ↓ to return to the "sensor uses…source head" menu item.

An example of a decimal (floating point) data entry item in the "Set up density, den. alarms & flow" menu is shown below.

```
Pipe inside diameter
4.000 in

           NEXT↓
```

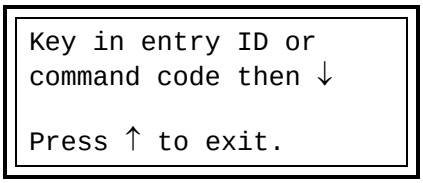
To view the direct entry code for this menu item, press the period "•" key followed by the ↑ key. The keypad code display, shown below, indicates the current value for this data entry item is 4.00 and that the (decimal) direct entry code is `048003`.

```
Value is 4.000
Item is data entry
keypad code 048003
{HEX = 300F} Press ↓
```

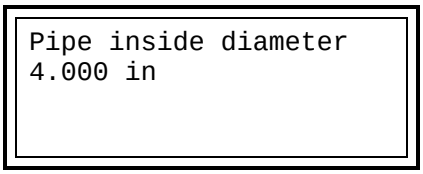
Example: Using Direct Entry

Use the direct entry code found in the above example to view and/or modify the value for the "Pipe inside diameter" menu item.

1. From the measurement display, press the EXIT SETUP key on the transmitter keypad or the "x" key on a remote terminal keyboard. The following screen is displayed:



2. Enter the direct entry code `048003`, then press the ↓ key. The following menu item is displayed. (The actual value shown is dependent on your gauge setup.)



3. If the value shown (4.00 in) is correct, press the EXIT SETUP key to keep the current value and return to the measurement display. Otherwise, enter the correct value, and press the ↓ key.
4. Verify the entered level is now correct (enter the new number if incorrect), and press the EXIT SETUP key. The new value for the "pipe inside diameter" has been stored and is now being used by the gauge software.

Overview of Setup Menus

The setup menus will guide you through the procedure to set up the gauge. Enter the value for each applicable menu item when it is displayed, otherwise related menu items may not be displayed. For instance, in the "Alarm setup" submenu, you must enter a value for the alarm set point to activate the rest of the alarm setup menu.

Table 2-1 provides an overview of the setup menu structure. The eight top-level menu headings are shown as they are displayed on the four-line display and in the order that they appear in the menu structure. Press → to step through the menu headings in the order shown.

Tables 2-2 through 2-9 summarize the functions included under each of the top-level headings and indicate the chapter/page number where more detailed descriptions of the menu items can be found in this manual.

Note: The menu items shown in the menu tables throughout this manual are provided as an example of what you will see when using the gauge. The actual appearance (words and numbers) varies dynamically with context.

Some menu items are not always displayed. For example, if your gauge does not have relays installed, the "Set up density, den. alarms, & flow" menu item heading will read "Set up density & flow." Alarm-related menu items are only displayed if relays are installed or if these menu items are specifically enabled from the "Special Functions" menu, see page 8-10.

Table 2-1 Top-Level Menu Headings

Menu Headings	Comments
Set up density, den. alarms, & flow↓ **←Exit setup.** **Other functions→**	See Table 2-2 and Chapter 3. This menu includes all the items needed to perform the basic setup of the gauge.
Set up additional measurements (readouts)↓ **Other functions→**	See Table 2-3 and Chapter 4. Allows you to define up to seven additional measurements.
Gauge fine tuning (time constant, STD, CAL, etc.)↓ **Other functions→**	See Table 2-4 and Chapter 5. Contains three menu groups, the "Time constant" menu (controls the amount of averaging applied to the measurement values), the "Standardization" menu, and the "Calibration" menu.
Modify or re-assign current output.↓ **Other functions→**	See Table 2-5 and Chapter 6. Define the maximum and minimum values for the current output. Current output can be assigned to a measurement other than the primary (level) measurement.
Set up fault alarms or change process alarm assignments.↓ **Other functions→**	See Table 2-6 and Chapter 6.
Action items: (erase memory, clear alarms hold output, etc.)↓ **Other functions→**	See Table 2-7 and Chapter 7.
Set up serial ports, contact INPUT, or special functions↓ **Other functions→**	See Table 2-8 and Chapter 8.
Security, service and diagnostic functions.↓ **Exit setup→**	See Table 2-9 and Chapter 9.

Table 2-2 Set Up Density, Den. Alarms, & Flow (Chapter 3)	
Menu Items	**Comments**
Sensor uses…source head	Page 3-5. Specify source head used with your gauge. This entry determines the "geometry" factor for the gauge.
Material type and associated parameters	Page 3-5. Specify material type as slurry, solution, emulsion, or single phase.
Pipe inside diameter	Page 3-9. Specify inside diameter of process pipe, used by the gauge in the compute calculation.
Process temperature compensation setup→	Page 3-6 and page 5-3. Set up temperature compensation if required.
Select primary measurement/units	Page 3-7. Select the primary measurement and specify the measurement units.
Measurement range for current output	Page 3-9. Specify tank level corresponding to the maximum and minimum (default 20 mA/4 mA) current output values.
Set up alarm 1→	Page 3-10. Submenu to define process alarm. Displayed if relays are installed.
Flow input setup→	Page 3-12 and page 5-11. Set up gauge to accept flow input signal. Also available under "Gauge fine tuning" menus.
Standardization	Page 3-12. Define the standard configuration and measure the standardization value. Also available under "Gauge fine tuning" menus.
Density gauge calibration→	Page 3-15. A calibration measurement is required if "single phase" material type is selected or if standardization is deferred. Also available under "Gauge fine tuning" menus.

Table 2-3 Set Up Additional Measurements (Chapter 4)	
Menu Items	**Comments**
NOTE: Meas. #1 is the primary measurement	Measurement #1 is assigned to the primary measurement by default. Use the "Set up density…" menu, Table 2-2, to change the primary measurement setup.
Assign & set up measurement 2→	Page 4-3. Assign a readout to Measurement #2.
Select measurement/ specify units	Page 4-3. Select measurement readout of density, bulk density, etc., and specify desired measurement units.
Density units = g/ml To change press→	Page 4-3. Select
Set up alarm 2 (Alarm point, etc.)→	Page 4-5. The "Set up alarm #" submenu will be displayed here if an alarm has been assigned to the measurement.
Highest expected reading: 0.000 g/ml	Page 4-6. To enable the "Display scaling" menu items, enter a value greater than 9999 for the "highest expected reading" value.
Note: After measurement #2 has been set up, you will then be prompted to "Assign & set up measurement #3," and so on.	

Table 2-4 Gauge Fine Tuning (Chapter 5)	
Menu Items	**Comments**
Time constant setup	Page 5-1. Menu items allow you to specify the system (averaging) time constants for normal and alternate modes.
Process temperature compensation setup	Page 5-3.
Sensor head standardization	Page 5-7. Includes menu items related to the standardization measurement.
Density gauge calibration	Page 5-10. Menu items for calibration measurements. This submenu is also available under the "Set up density…" menu, see Table 2-2.
Flow input setup	5-11

Table 2-5 Modify or Reassign Current Output(s) (Chapter 6)	
Menu Items	**Comments**
Current output span	Page 6-1. Specify maximum and minimum current output values.
Assign measurement(s) to current output(s)	Page 6-1. Specify which measurement is assigned to the current output. The primary (density) measurement is assigned to the current output by default.
Correction factors for current output(s) at max and min	Page 6-1. Scale factors allow the current output to be adjusted to compensate for any small differences between systems.
Current output hold value (% of scale)	Page 6-1. The current output hold command will hold the current output at the value specified for this "hold value."

Table 2-6 Set Up Fault Alarms / Process Alarm Assignments (Chapter 6)	
Menu Items	**Comments**
Set up for alarms to execute commands	Page 6-3. Assign up to three pairs of commands to be executed when process alarms are set/cleared.
Assign alarms to measurements	Page 6-5. Assign alarms to additional measurements, by default all process alarms are assigned to the primary measurement.
Assign "relays" to warning alarms & fault alarms	Page 6-5. Specify alarm indicators for the warning and fault alarms.
Assign "relays" to mode alarms	Page 6-6. Specify alarm indicators for the mode alarms.

Table 2-7 Action Items (Chapter 7)	
Menu Items	**Comments**
Common action items (clear memory, etc.)	Page 7-2. "Common" commands – restart system, clear memory, clear holds, etc.
Alarm action items (View, clear, etc.)	Page 7-3. View alarm status/history, clear alarms, disable alarms, etc.
"Hold" action items (hold reading, etc.)	Page 7-4. "Hold" related commands – clear all holds, hold current output, and hold density.
Serial port related action items	Page 7-5. Special purpose commands related to the RS-232 and RS-485 ports.

Table 2-8 Serial Ports, Contact Inputs, Special Functions (0)	
Menu Items	**Comments**
Modify port 1 RS-232 configuration	Page 8-3. Specify baud rate, word length, and parity for the RS-232 serial port.
Modify port 2 RS-485 configuration	Page 8-3. Specify baud rate, word length, and parity for the RS-485 serial port. Also specify unit number for "party line" communications.
Set up port 1 RS-232 data transmission (data streaming)	Page 8-4. Set up data streaming for the RS-232 port.
Set up port 2 RS-485 data transmission (data streaming)	Page 8-4. Set up data streaming for the RS-232 port.
Assign commands to execute on contact open/close 1	Page 8-9. Specify commands to be executed based on user-supplied open/close to the contact closure input # 1.
Assign commands to execute on contact open/close 2	Page 8-9. Specify commands to be executed based on user-supplied open/close to the contact closure input # 2.
Special functions	Page 8-10. Includes commands to enable/disable a variety of special purpose functions such as relay delay times, relay latching, service only items, etc.

Table 2-9 Security, Service, and Diagnostic Functions (Chapter 9)	
Menu Items	**Comments**
Security items: (password, etc.)	Page 9-1. Security-related items – allows you to specify password for access to setup menus.
Diagnostics: system test, related items	Page 9-2. Perform system self-test, view alarm status, and view various values of various internal system parameters.
User service & related items	Page 9-6. Includes various "Hold" commands that can be useful for diagnostic purposes, along with the system restart and clear memory commands.
Factory service & related items	Page 9-7. Available only if service-only items are enabled in "Special functions" menu.

Chapter 3 Set Up Density, Den. Alarms, & Flow

This chapter describes the "Set up density, density alarms, & flow" menu. This menu chain provides all the menu items required for the basic setup of the gauge.

The menu prompts you to enter information about your process material, pipe size, display units, etc. In particular, menu items prompt you to:

- Specify the source head model (page 3-5).
- Specify the material type that best defines your process material (page 3-5).
  - Slurry: A mixture of liquid carrier and suspended solids. Enter the specific gravities of the slurry's liquid and solid components.
  - Solution: A material (solute) dissolved in a liquid solvent. A solution's components do not displace each other, so its volume typically differs from the added volumes of its solvent and solute. You will be prompted to enter the solvent's specific gravity and information to characterize the solution.
  - Single phase: A material, whose makeup is either unknown or unimportant, for which you want to measure the overall density.
  - Emulsion: A suspension of two liquids that displace each other instead of forming a solution; for example, oil and water. The gauge treats an emulsion like a slurry in which the "carrier" component is called fluid_1 and the "solids" component is called fluid_2.
- Select the primary measurement and units (page 3-6).
- Enter the pipe inside diameter (ID) and the units for the pipe ID (page 3-9).
- Enter the values of the primary measurement that correspond to the maximum and minimum values for the current output (page 3-9).
- Set the decimal point position for the primary measurement readout (page 3-9).
- Set up process alarm(s) for the primary measurement (page 3-10).
- Select the flow input settings (if any) to be used. Note: you must define the flow input source before you can set up a flow-related measurement readout.
- Perform the standardization measurement (page 3-10) that provides the gauge with a standard configuration reference point.
- Perform calibration measurement(s), if necessary, to fine tune the gauge for your particular process material (page 3-15).

Set Up the Density Measurement

The first time you apply power to the gauge, the following message is shown on the measurement display.

```
 Unit has not
 been set up!

For setup, press →
```

If the "Unit has not been set up!" message is not displayed then the gauge has already been (at least partially) set up. If you are unsure about what settings have been entered, or if the gauge has been moved to a new location, you may want to reinitialize the gauge to the factory default settings and set up the gauge from the beginning.

Use command 82 "Erase all entries (except comm setup)," to clear all user entries except for the communication settings. Use command 74 "Erase all entries," to reset all entries including the communications settings to the factory defaults. See "Common Action Items" on page 7-2).

Note: The "Unit has not been set up!" message changes to "Unit has not been STANDARDIZED" if you set the pipe diameter to a non-zero value and exit without standardizing the gauge.

After standardization, if calibration is necessary (or if standardization is deferred), the message "Unit has not been calibrated!" is displayed.

From the measurement display, press → once to move to the "Set up density…" menu shown below. Press ↓ to enter the "Set up density…" menu chain, or press → again to step to the next top level menu heading. Once you enter a menu group, use the arrow keys as directed to step through the menu items.

```
Set up density
& flow ↓
←Exit setup.
  Other functions →
```

Note: If relays are installed, this menu item reads "Set up density, den. alarms, & flow."

Removing power from the gauge does not disturb the saved settings. Settings are saved immediately when you press EXIT SETUP, or they are saved automatically five minutes after you stop using the keypad.

Set Up Density Menu

The table below provides an overview of the "Set up density…" menu chain. The remainder of this chapter describes these menu items in more detail.

"Set Up Density" Menu Items	
Display	**Comments**
Set up density, den. alarms & flow↓ **←Exit setup.** **Other functions→**	From the measurement display, press → to move to the "Set up density..." menu. Press ↓ to access the "Set up density…" menu items. **Note: The software detects whether output relays are installed. If no relays are present, the menu will display "Set up density & flow."**
General HELP text.→ **{Information on how to set up this gauge}** **NEXT→**	HELP screens are provided throughout the menus to assist you with the setup procedures. Press → to access the HELP screens or press ↓ to proceed to the next menu item.
Sensor uses 5202 source head **NEXT↓ CHANGE→**	Press → to scroll through list of source head models. Select the model used on your gauge. The source head model is used to set a "geometry factor" to tune the gauge's performance.
Material type is slurry **CONTINUE↓ CHANGE→**	Press → to scroll through list of material types: slurry, solution, single phase, or emulsion. See page 3-5 for more information.
Carrier gravity .9982 g/cc **NEXT↓**	The wording of this menu item depends on the "material type" selection in the previous item. For slurries, enter the specific gravity of the carrier liquid. For solutions, enter the solvent gravity and so on. See page 3-5.
Solids gravity 3.000 g/cc **NEXT↓**	The wording of this menu item depends on the "material type" selection in the menu item above. For slurries, enter the specific gravity of the suspended solids. For solutions, set up the solution characterization and so on. See page 3-5.
Process temperature compensation setup→ **NEXT↓**	This submenu is displayed if the material type is solution or emulsion or if material type is slurry and the solids gravity is less than 2.0. Set up to compensate density measurement for changes in process temperature. See pages 3-6 and 5-3.
Primary measurement: density **To change, press→** **NEXT↓**	Select primary measurement. Available measurements depend on selection of material type, see page 3-7.
Allow display of All units. Change to: **Metric or English→** **NEXT↓**	Select the desired units "system" using the → key. The default, ALL, includes both English and Metric units. English units are - in, ft, and yd. Metric units are - mm, cm, and M.

"Set Up Density" Menu Items (cont.)	
Display	**Comments**
Density units = g/ml To change, press→ NEXT↓	Press → to scroll through and select desired units for the primary measurement. The available units depend on previous menu item selection of ALL, English, or Metric units.
Size units = in To change to ft, yd, M, cm, or mm press→ NEXT↓	Press → to scroll through and select desired units for the inside diameter of the process pipe. The available units depend on selection of ALL, English, or Metric units in a previous menu item.
Pipe inside diameter 4.000 in NEXT↓	Enter the value for the inside diameter of the process pipe in the units selected in the previous item.
Meas #1 reading for 20.00 mA output: 3.000 g/ml NEXT↓	Meas #1 is associated with the primary measurement (density). The current output is associated with Meas #1 by default. Enter primary measurement (density) value at which the current output will be the maximum.
Meas #1 reading for 4.000 mA output: 2.000 g/ml NEXT↓	Enter primary measurement (density) value at which the current output will be the minimum. Default current range is 4.0 to 20.0 mA. To change default range or to assign the current output to a different measurement, see page 6-1.
Position of decimal in readout 1 000.0 {g/ml density} NEXT↓ ←CHANGE→	Press ← or → to select the desired position for the decimal point for the display of the measurement #1 readout. A maximum of four digits can be displayed.
Set up alarm 1 (Alarm point, etc.)→ NEXT↓	Press → to enter the alarm setup submenu and specify process alarm #1 for the primary measurement. After defining alarm #1, the submenu for alarm #2 will be displayed and so on. See page 3-10.
Flow INPUT setup → NEXT↓	Press → to enter the "Flow INPUT setup" submenu. The flow input parameters must be set up before flow-related measurements are available. See page 3-12.

Following the "Flow INPUT setup" submenu, menu items are displayed relating to the standardization and calibration of the gauge, refer to pages 3-12 and 3-15, respectively, for more information on these procedures.

Sensor Uses…Source Head

Following the help screen, the first item in the "Set up density…" menu chain asks you to specify the source head model. The gauge tunes its response using a "geometry factor" associated with the gauge head model selected. Press → until the correct source head model is displayed, then press ↓ to accept the value. The following source head models can be selected:

- 5190 source head
- 5191 head
- 5176 head
- 5200 head
- 5201 head
- 5202 head
- 5203 or 5204 head
- 5211 head
- user's geometry factor
- Z-pipe
- one-piece insertion head (also called a sugar pan or tank probe)

If your gauge head type is not listed, select "user's geometry factor." An additional menu item is then displayed to let you enter a custom geometry factor. Call Thermo Fisher for help in determining the geometry factor for your gauge head type. The default user's geometry factor is 0.85.

Material Type

Use this menu item to select the *material type* that best matches your process material, slurry, solution, single phase, or emulsion.

Note: If you only want to measure the overall density of the process material, you can select "Single phase," regardless of the material's makeup.

The basic setup does not include gamma ray attenuation coefficients. The default settings are usually adequate, however, you should change attenuation coefficients if your source is not Cs-137 or in other special situations. See Appendix B.

After a material type is selected, additional menu items are displayed to enter the required specific gravity values for that material type as described below.

Slurry

For a slurry, enter the following values:

- Carrier gravity: the specific gravity of your carrier liquid in g/cc. The default value is .9982, correct for water at 20° C (68° F).
- Solids gravity: the dry, solid density of your suspended solids in g/cc. The default is 3.0 g/cc. For example, a 1 cc block of solid basalt has about 3.0 grams of mass.

Solution

For a solution, enter the following values:

- Solvent gravity: the specific gravity of your solvent liquid in g/cc. The default value is .9982, correct for water at 20° C (68° F).
- Solution characterization: a setting that relates the solution's density to its concentration, using a polynomial formula. You can select one of several aqueous solutions for which the gauge has built-in polynomials. Each built-in solution is listed with the concentration range over which the setting can be used. For example, if you select "D-Fructose 0-60%," the gauge can measure fructose concentrations up to 60 percent in water.

  If your solution is not listed in the menu, see Appendix A "Solution Characterization," for information about entering a user-defined solution characterization polynomial or break point table.

Single Phase

You can select "single phase" if it is either unnecessary or impossible to describe your process material as a slurry, emulsion, or solution.

For example foam plastic, a mixture of plastic and gas, might be measured as a single-phase material if the gas in the mixture has little effect on the measurement, other than to vary the material's density.

Emulsion

For an emulsion, enter the following values:

- Fluid_1 gravity: the specific gravity of your carrier liquid in g/cc. The default value is .9982, correct for water at 20° C (68° F).
- Fluid_2 gravity: the specific gravity of your suspended liquid in g/cc. For example, 0.88 is a typical specific gravity for petroleum. The default is 3 g/cc.

Process Temperature Compensation

For certain materials, temperature compensation is required to provide accurate density measurements as the process temperature changes. Temperature compensation is often required for solutions and emulsions, and in some cases for slurries, if the solids gravity is less than 2.0. In these cases, the "Process temperature compensation setup" submenu is displayed in the "Set up density…" menu chain.

Note: To use temperature compensation, specify material densities that are correct at a reference temperature outside of the expected process temperature range. The default reference temperature value is 20° C (68° F).

If temperature compensation is not used, enter specific gravity values that are correct at the normal operating temperature of your process.

If you plan to use temperature compensation, set it up before standardizing if your standard configuration is affected by temperature.

The “Process temperature compensation setup” submenu is always available under the “Gauge fine tuning” menu. Refer to “Process Temperature Compensation Setup Menu” on page 5-3 for details on setting up temperature compensation.

Set Up Primary Measurement

Select the type of measurement that you want to make. By default, this measurement is displayed as readout #1 and is used as the measurement for the current output signal. The primary measurement cannot involve mass or flow. Mass or flow related measurements can be assigned as additional measurements. See page 5-11 for information on setting up the flow input and see Chapter 4 for details of setting up additional measurements.

Primary Measurement Type

Select from the measurements listed below as appropriate for the material type.

- Density: The ratio of mass to volume. For example, a material has a density of 500 g/l, if 1 liter weighs 500 g on a balance scale.
- Bulk Density: If the material type is “solution” or “single-phase” and temperature compensation is being used, the density value is compensated for temperature and the value displayed is the density as it would be at the reference temperature. In this case, select bulk density to measure and display the uncompensated density of the material at the process temperature.
- If material type is Slurry:
  - Solids content/vol: The concentration, or mass of solids suspended in a volume of slurry. For example, a slurry has a solids concentration of 270 g/l if 1 liter of slurry contains 270 g of suspended solids.
  - Carrier content/vol: The concentration, or mass of carrier in a volume of slurry. For example, a slurry has a carrier concentration of 910 g/l if 1 liter of slurry contains 910 g of carrier liquid.
  - Solids/carrier: The ratio of suspended solids mass to the volume of liquid that carries it. For example, a slurry has a solids to carrier ratio of 2 lbs/gal if 2 pounds of solids are mixed with every one gallon of carrier. (In some applications, this measurement is called pounds of sand added because it measures the mass of solids added to a volume of carrier. This differs from solids concentration, which measures the mass contained in a volume of slurry.)
  - Percent by weight solids (carrier): The percentage of a component that makes up the process material’s mass. For example, a slurry is 30 percent by weight solids if each kilogram of material contains 300 grams of suspended solids.
  - Percent by volume solids (carrier): The percentage of a component that makes up the process material’s volume. For example, a slurry is 80 percent by volume liquid if each liter of material contains 800 ml of liquid carrier.
- If material type is Solution:
  - Solute content/vol: The concentration, or mass of solute dissolved in a volume of solution. Similar to solids content/vol for slurries.
  - Solvent content/vol: The concentration, or mass of solvent in a volume of solution. Similar to carrier content/vol for slurries.

  - Solute/solvent: Similar to the solids to carrier ratio for slurries.
  - Percent by weight solvent (solute): Similar to "Percent by weight solids (carrier)" for slurries.
  - Percent by volume solvent (solute): Similar to "Percent by volume solids (carrier)" for slurries.
- If material type is Emulsion:
  - Fluid_2 content/vol: The concentration, or mass of fluid_2 suspended in a volume of emulsion. Similar to solids content/vol for slurries.
  - Fluid_1 content/vol: The concentration, or mass of fluid_1 in a volume of emulsion. Similar to carrier content/vol for slurries.
  - Fluid_2/Fluid_1: Similar to the solids to carrier ratio for slurries.
  - Percent by weight fluid_2 (fluid_1): Similar to "Percent by weight solids (carrier)."
  - Percent by volume fluid_2 (fluid_1): Similar to "Percent by volume solids (carrier)."

Note: The gauge will be calibrated in terms of the primary measurement. The calibration will be more accurate if you select a primary measurement that can be accurately verified by measuring samples.

Allow Display of…Units

The default selection, *All*, enables both *English* and *Metric* units for the unit selection menu items. Select either *English* or *Metric* to display only the corresponding subset of the available units.

Measurement Units

The complete list of units for the primary measurement display is provided below:

- g/ml grams per milliliter
- lb/US gal pounds per US liquid gallon
- lb/UK gal pounds per UK or imperial gallon
- lb/cu ft pounds per cubic foot
- ston/cu yd short tons (2000 lbs) per cubic yard
- lton/cu yd long tons (2240 lbs) per cubic yard
- g/l grams per liter
- oz/cu in ounces per cubic inch
- lb/cu in pounds per cubic inch
- g/cu in grams per cubic inch
- lb/cu yd pounds per cubic yard
- deg API degrees, American Petroleum Institute
- deg Be (L) degrees, Baumé, light scale
- deg Be (H) degrees, Baumé, heavy scale
- deg Tw degrees, Twaddle

Pipe Size

To accurately determine the density of the process material, the gauge needs to know the inside diameter of the process pipe. Enter the following parameters:

- Size units: The units that will be used to specify the pipe inside diameter.
- Pipe inside diameter: The pipe inside diameter in the selected units.

If your gauge head installation uses a Z-pipe mount, be sure to select "Z-pipe" in the "Sensor head is…" menu item as described above.

Measurement Range for Current Output

By default, the 4-20 mA current output is assigned to the primary or density measurement (Measurement #1). The *Measurement #1 reading* menu items prompt you to specify the density measurement values corresponding to the maximum and minimum current output values.

Note: The range for the primary measurement value specified for the current output does not affect the range of the measurement values that are displayed.

The operational range for current output can be set anywhere within the range from 3.8 to 20.5 mA. The default range for the current output is 4-20 mA. The "Fault Low" and "Fault High" current output levels are 3.6 mA or less and 20.8 mA or greater, respectively. (See page 6-1 to modify the default current output range).

Meas #1 Reading for 4.000 mA Output:

Enter the value for the density measurement value corresponding to the minimum current output value. The default value for the minimum current output is 4.0 mA.

Meas #1 Reading for 20.00 mA Output:

Enter the value for the density measurement value corresponding to the maximum current output. The default value for the maximum current output is 20.0 mA.

Display Scaling

Specifying a value > 9999 for the maximum current output reading enables the "Display scaling" menu items. Display scaling allows, for example, values in the range from 0 to 100,000 to be scaled by a factor of 100 to a range of 0 to 1000. This prevents the displayed values from exceeding the limits of the four-digit numerical display. (See page 4-6 for more information on display scaling.)

Position of Decimal (density)

Press ← and → to move the decimal point in the example display. This sets the decimal point position for the primary measurement readout. The decimal point position only affects how the measurement value is displayed. It has no effect on the precision of the internal value of the measurement computed by the gauge.

How to Set Up Alarms

Note: If no relays are installed, the "Set up alarm" menu is not displayed. Process alarm can still be defined to perform functions other than controlling relays, such as flashing the display. See "Special Functions" on page 8-10 for details on enabling the alarm menus when no relays are installed.

This menu subgroup allows you to assign and set up a *process alarm* for the primary measurement (meas # 1) selected in a previous menu item. A total of 16 process alarms can be defined. After each alarm is set up, you will be prompted to set up the next alarm, (alarm 2, 3) up to a maximum of 16 alarms. It is advisable to keep a written record of the setup (assigned measurement, set point, clear point, and alarm action) for each alarm you define.

By default, all process alarms are assigned to measurement #1 (density). After you set up additional measurements (see Chapter 4), you can also assign process alarms to these measurements. The procedure for entering the alarm parameters is described below.

"Set Up Alarm 1" Menu

To set up an alarm, you must define the *set point* (where the alarm is activated) and *clear point* (where the alarm is cleared), and assign an *alarm indicator* (what happens when the alarm is activated).

The following table summarizes the menu items in the "Set up alarm" menu subgroup of the "Set up density, den. alarms, & flow" menu. More detailed explanation of process alarms and alarm-related menu items is provided in the sections following the table.

"Set Up Alarm" Menu	
Display	**Comments**
Set up alarm 1 **(Alarm point, etc.)→** **NEXT↓**	Menu is normally available only if relays are installed. Press → to access alarm menu or ↓ to skip alarm set up. After alarm 1 is set up, menu to set up alarm 2 will be available, and so on.
←Exit alarm 1 setup **Alarm 1 set point** **2.000 g/ml** **NEXT↓ HELP→**	Enter set point - the measurement value at which the alarm is activated. **Note: You must enter a set point to activate the rest of the Set up Alarm menu.**
Alarm 1 clear based **on clr point** **Chng to "dead band"→** **Continue as is.↓**	Select a clear point or dead band configuration. A clear point is the exact measurement value at which the alarm is cleared. A dead band specifies the span between the set point and the implicit clear point.
Alarm 1 clear point **2.500 g/ml** **{Makes alarm "Low"** **limit} NEXT↓ HELP→**	Enter desired clear point value: the level at which the alarm will be cleared. If dead band is selected, enter the span of the dead band relative to the set point.

"Set Up Alarm" Menu (cont.)	
Display	**Comments**
Alarm 1: g/ml is indicated by controlling relay 1 NEXT↓ CHANGE→	Select the action used to indicate that alarm 1 has been triggered. The default is "Nothing." Other selections include controlling relays, flashing the measurement display, and setting current output to zero or to maximum.
Relay 1 turns on when alarm occurs. Change to "off"→ ←Exit alarm 1 setup.	Displayed if "controlling relay 1" is selected as the alarm indicator. By default, relays are turned on when an alarm is activated and turned off when alarm clears. Change to "off" to reverse this behavior.
Set up alarm 2 (Alarm point, etc.)→ NEXT↓	After you set up an alarm, the menu to set up the next alarm (up to 16 max.) will be displayed. Press → to set up the next alarm, or press ↓ to go on to the next menu item.

Alarms: Set Point & Clear Point / Dead Band

An alarm is defined with either a set point/clear point configuration or a set point/dead band configuration. The set point defines the measurement value at which the alarm is activated. The clear point or dead band defines the measurement value at which the alarm is cleared (alarm ceases).

A clear point sets a fixed measurement value at which the alarm clears. The value of the clear point is independent of the set point and remains the same even if the set point is moved.

A dead band defines a fixed distance between the set point and an implicit clear point. If the set point is moved, the implicit clear point moves also, maintaining the distance from the set point specified by the dead band. For example, if a set point was defined at 2.5 g/ml and the dead band was set at 1.0 g/ml, the implicit clear point would be at 3.5 g/ml. Changing the set point from 2.5 g/ml to 3.0 g/ml move the implied clear point from 3.5 g/ml to 4.5 g/ml. The relative distance between the implied clear point and the set point remains fixed at 1.0 g/ml, the dead band value.

Use a clear point configuration if you want to be able to change the alarm set point in the future without affecting the alarm clear point. Alternately, use a dead band configuration if you want the alarm clear point to remain at a fixed distance relative to the set point.

High Limit and Low Limit Alarms

An alarm is activated when the measurement value reaches the specified set point. The relative values assigned to the set point and the clear point determine whether the alarm is a *low limit* alarm or a *high limit* alarm.

If the set point value is less than the clear point value (or if the dead band value is positive), the alarm is a *low limit* alarm. In this case, the alarm is activated as the measurement value decreases below the set point value. The alarm stays active until the measurement value again increases above the clear point value.

Similarly, if the set point value is greater than the clear point (or the dead band value is negative), the alarm is a *high limit* alarm. In this case, the alarm is activated when the measurement value increases beyond the set point value. The alarm stays active until the measurement value again decreases below the clear point value.

Alarm Indicators

The "Alarm 1 is indicated by…" menu item allows you to specify the action used to indicate that alarm 1 has been triggered. The default is "Nothing." Other selections are:

- *Controlling relay 1* - Turn relay 1 on while the alarm is active. This selection is repeated for relays 2 through 4, if installed.
- *Meas #1 dspy flash* - Flash measurement number 1 on the display while the alarm is active. This selection is repeated for each measurement that has been defined up to meas #8 (maximum of 8 measurements can be defined).
- *Out1 to FAULT LOW* - hold current output 1 at the FAULT LOW level (3.6 mA or less) while the alarm is active. This selection is repeated for current outputs 2 and 3, if installed.
- *Out1 to FAULT HIGH* - hold current output 1 at the FAULT HIGH level (20.8 mA or greater) value while the alarm is active. This selection is repeated for current outputs 2 and 3, if installed.
- *#1 act on ALM action* - executes the command assigned as the #1action when the alarm is activated if an alarm action has been assigned. This selection is repeated for #2 and #3 actions, if these alarm actions have been assigned. See page 6-3 for details on assigning commands to alarms.

Set Up Flow Input

The gauge can accept a 4-20 mA current input signal from an external flow meter. The "Flow input setup" menu prompts you for the parameters required to set up the flow input and the units for volume and mass flow measurements.

The "Flow input setup" menu is also available under the "Gauge fine tuning" menu chain. See page 5-11 for detailed information on setting up the flow input.

Once the flow input has been set up, flow-related measurements can be defined using the "Set up additional measurements" menu chain, see page 4-1. Once a flow-related measurement has been set up, the "Set up & control totalizers" menu chain will be displayed in the top-level menus (see page 6-8).

Standardization

The *standardization* process takes a radiation measurement for a *standard process configuration* to establish a *reference point* for the gauge. During the standardization cycle, the gauge averages the detector signal. The default cycle time lasts about 17 minutes (see page 5-9). This averaged detector signal provides a very repeatable measurement of the signal produced in the standard configuration.

Once the standardization measurement has been completed, it can be repeated at a later time to compensate for any changes, such as increased attenuation due to process material buildup on the pipe walls. The gauge can then adjust the calibration value(s) based on the new standardization value. It is not necessary to repeat the calibration measurements, since the calibration values are stored as a ratio of the calibration-to-standardization measurement values. The calibration values are adjusted automatically whenever a new standardization is performed.

Standardize on: Pipe…

The standard configuration must be a known repeatable configuration, such as an empty pipe, or a pipe full of reference fluid. The reference fluid is the process carrier for slurries, the solvent for solutions, or "fluid_1" for emulsions.

Note: The accuracy of the gauge depends on how accurately you set up the gauge for standardization.

If you plan to use temperature compensation and if temperature has significant effect on your process, set up temperature compensation before "standardizing with the pipe full."

For best performance for a gauge with an ion chamber detector, enter the correct "Hi-Meg" value for the detector before standardizing, see page 5-2.

To perform the standardization cycle:

1. Put your gauge head and pipe in one of the following standard configurations. Use the exact same standard configuration every time you standardize.
   - *Pipe full of carrier (solvent, fluid_1, ref fluid)* - Fill the pipe with pure carrier for slurries, pure solvent for solutions, or pure "fluid_1" for emulsions. For single-phase processes, you might need to use a reference fluid that is completely different from your process material.
   - *Pipe empty* - Standardizing on an empty pipe is suitable for certain applications when using a scintillation detector on small to medium pipes, and sometimes when using an ionization detector on small pipes.
   - *Full with block* - Some installations come with a density reference block to be placed in the beam path during standardization. If one is provided for your gauge, use it with a pipe full of reference fluid (such as pure carrier) if so directed.
   - *Empty with block* - Similar to "full with block." Use this selection if you have a reference block and are directed to use it with an empty pipe.
2. Turn on (open) the source shutter.
3. Verify that the "Standardize on…" menu item is set to the right condition: pipe full of carrier, pipe empty, etc.
4. Move to the "Start STANDARDIZE cycle" menu item under the "Set up density…" menu and press → to start the cycle.

After beginning the standardization, a menu is displayed that allows you to abort the standardization measurement, to continue with the setup menus, or return to the measurement display where a countdown timer will display the time remaining in the

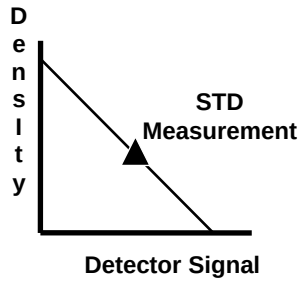
standardization cycle. When standardization is complete, the standardization menu will display the configuration used for the last standardization cycle.

Note: If you perform standardization on "pipe full of carrier (solvent, etc.)," the gauge will provide a readout of the process density immediately after standardization. The gauge uses the density specified for the carrier (solvent, or fluid_1) as the reference density.

If any other standard configuration is used, including "pipe full of ref fluid" for single phase materials, you must perform at least one calibration measurement (and specify the density of the material during the calibration cycle) before the gauge can provide a readout of the process density.

Standardization Used as Default Calibration Value

When standardization is performed on "pipe full of carrier" for slurries ("pipe full of solvent" for solutions or "pipe full of fluid_1" for emulsions), the gauge uses the standardization measurement and the value for the "carrier gravity" as a default calibration (CAL) point to convert the detector signal to a density value as illustrated in the diagram below.



For some applications, this default CAL point may provide adequate measurement accuracy without performing any additional calibration measurements. For example, if the standardization is performed on a pipe full of clean carrier (for a slurry material type) and solids concentration is selected as the primary measurement, the measurement readout should be reasonably accurate.

Note: Even if your gauge does not need calibration, it may still be necessary to re-standardize the gauge periodically. For more information about when to standardize, see page 5-8.

Deferring Standardization

As you first set up the gauge, it may not be convenient or even possible to empty the pipe or to fill the pipe with reference fluid to perform the standardization cycle. In this case, you can select "Defer standardization" in the "Standardize on…" menu item, and then proceed to the calibration procedure.

Note: If you "defer standardization," you must perform at least one calibration measurement before the gauge can provide a readout of the process density.

It is recommended that you set up a standard configuration and perform standardization as soon as possible and then update the standardization measurement as needed. This is

generally much easier than having to repeat the calibration measurement(s) when changing conditions affect the measurement.

Calibration

Unless standardization is performed on “pipe full of carrier” for slurries (“pipe full of solvent” for solutions or “pipe full of fluid_1” for emulsions), you must perform a calibration measurement using the “Density gauge calibration” menus under the “Set up density…” menu group.

If a calibration measurement is required, the message “Unit has not been calibrated!” will be displayed. Even if calibration is not required, the default calibration based on the standardization value may not provide sufficient accuracy.

When calibration is required, a one-point (single point) calibration measurement will be adequate for many applications. The calibration measurement should be performed on actual process material with a density near the nominal process density expected during normal operation. In general, it is necessary to take samples of the process material to determine the process density at the time of the calibration measurement.

A one-point calibration provides a reference measurement at one density in the range of interest. The gauge is able to measure other density values by calculating the change in density corresponding to the change in the detector signal using information about the source head (geometry factor), the pipe dimension, and the process material

If greater measurement accuracy is required, a two-point calibration measurement can be performed. The second calibration measurement applies a “slope” correction factor to the calculation used by the gauge to convert the detector signal to the material density.

When using a two-point calibration, try to perform the first-point calibration on process material with a density near one end (high or low) of the operational density range. Then perform the second calibration measurement on process material with a density near the opposite end of the range.

Note: If temperature compensation is active when you calibrate on a solution or single-phase material, determine the density of the process sample(s) at the reference temperature.

The calibration density value must be entered in terms of the measurement type and units selected for the primary measurement. For example, if solids concentration with units of “lb/gal” is the primary measurement, the calibration “density” is actually solids concentration in lb/gal.

Density Gauge Calibration Menus

The following table shows the menu items in the “Density gauge calibration” menu chain. Note that this submenu is available under both the “Set up density…” and the “Gauge fine tuning” menus.

"Density Gauge Calibration" Menu	
Display	**Comments**
Density gauge calibration → **NEXT↓**	Press → to enter the "Density gauge calibration" menus.
Choose CAL PT 1 **Change CAL PT 2 →** **Continue as is. ↓**	Select either calibration point 1 or calibration point 2. If you perform a two-point calibration, try to perform the calibration measurements on process densities near the low and high ends of the density range of interest.
CAL cycle time: **8 x time constant** **{time constant is 128 sec}** **NEXT↓ HELP→**	Specify the number of time constant periods used for the calibration measurement. CAL cycle time = N x time constant. Default value for N = 8, default value for time constant is 128 sec => cal cycle time is ~17 minutes.
CAL density point 1 **3.000 g/ml** **NEXT↓ HELP→**	A non-zero value for the density must be entered before the rest of the calibration menu items are displayed. If the exact density value is not known at the time of the calibration, enter an approximate value, then modify the value later.
Note: If the CAL density point value is changed after the "Use latest CAL value" command has been executed (see below), you must execute a CMD 6 (Process and Store) before the gauge will use the new CAL density value. See page 2-4 for details on using direct entry to access menu items and commands. **If CAL PT 2 was selected, the above menu item will read "CAL density point 2."**	
Start calibration cycle. **NEXT↓ EXECUTE CMD→**	Press → to begin the calibration cycle. When calibration is complete, the message "CAL PT Pending" will be shown on the measurement display.
**** CAL/STD ratio** **(from latest CAL)** **.7255** **NEXT↓**	Ratio of the last calibration measurement to the standardization value. This menu item is displayed until the command to "Use the latest CAL value" is executed. (See the next menu item.)
Use latest CAL value for CAL point 1. **←Exit this menu.** **NEXT↓ EXECUTE CMD→**	Press → to use the latest CAL value for CAL point 1. If a two-point calibration is selected, this menu item will read "Use latest CAL value for CAL point 2."
Atten. coef of carrier **8.600E-2 sqcm/gm** **NEXT↓**	Only displayed if one-point calibration is selected. Gauge uses an assumed attenuation coefficient to calculate the density value from the detector signal. This value can be used to improve the measurement accuracy.
Atten. coef of solids **7.700E-2 sqcm/gm** **NEXT↓**	Only displayed if one-point calibration is selected. Same as previous item, but for the other component of the process material.
Density slope correction factor: **1.000** **NEXT↓**	If a two-point calibration is selected, a "density slope correction factor" is computed based on the CAL 2 point. This value can be entered manually rather than actually performing the second calibration measurement.

One-Point Calibration (CAL 1)

Use the following procedure to perform a one-point calibration.

Note: The calibration measurement will replace any previous CAL 1 point. The accuracy of the gauge's density measurement depends on how accurately you can determine the actual density of the process material.

1. It is recommended that the standardization measurement be performed prior to performing the calibration measurement if at all possible.
2. Fill the pipe with process material at a density in the range of interest. Keep the process density as stable as possible during the calibration measurement, and be ready to take samples of the material during the calibration cycle.
3. Enter an approximate value for the "CAL density" to enable the remainder of the calibration menu items.
4. Move to the "Start calibration cycle" menu item, and press → to start the cycle.

   By default, the calibration cycle lasts about 17 minutes. After beginning the calibration, a menu item is displayed that lets you abort the calibration measurement, continue with the setup menus, or return to the measurement display where a countdown timer will display the time remaining in the calibration cycle.
5. During the cycle, take several samples of the process material and determine the average of the sample densities.
6. When the calibration cycle is complete, the message "CAL PT pending" will be shown on the measurement display. Return to the "Density gauge calibration" menu (if necessary) and step down to the "CAL density point" menu item. Enter the actual density of the samples you took.
7. The message "CAL PT pending" will be displayed and the calibration point will not used by the gauge until the "Use latest CAL value for CAL point 1" command is executed.

Two-Point Calibration (CAL 2)

The reference measurement provided by a one-point calibration (CAL PT 1) allows the gauge to compute based on the change in the detector signal using information about the source head (geometry factor), the pipe dimension, and the process material (attenuation coefficients, see page 3-19). For the best possible accuracy, you can perform a second calibration measurement (CAL PT 2) at another density in the range of interest. Calibrating at another density can help the gauge measure accurately over the entire range of interest.

Note: The CAL PT 2 measurement and density value is used to calculate a slope correction for the gauge response curve. The gauge uses this slope correction and the CAL 1 measurement to compute the final density value.

The process densities for a two-point calibration should be selected at opposite ends (maximum and minimum) of the density range of interest. If the difference between the process densities at the calibration points is too small, the measurement accuracy can actually be degraded by the second CAL measurement rather than improved.

The procedure for the second calibration point is essentially the same as for a one-point calibration.

1. Prepare to calibrate and take samples as you did for CAL 1 (in the previous section), but fill the pipe with process material of a different density. It can be either more or less dense than for CAL 1, but make it as different as is practical within the range of interest.
2. Start the calibration cycle and take samples exactly as you did for CAL 1.
3. When the cycle is finished, return to the "Density gauge calibration" menu (if necessary) and step down to the "CAL density point 2" menu item. Enter the actual density of the samples you took.

Note: When you execute the "Use latest CAL value for CAL point 2" command, the gauge calculates the "density slope" value and applies this correction factor to the density measurements.

CAL Cycle Time

This menu item adjusts the number of time constant periods used for the calibration cycle. The default CAL cycle is eight time constant periods. If the default 128-second time constant is used, calibration lasts about 17 minutes.

If you shorten the CAL cycle time, the precision of the calibration measurement is reduced. This can result in reduced measurement accuracy. Setting the CAL cycle to less than two time constants causes the cycle to abort automatically.

CAL Density

If the exact density value is not known at the time of the calibration, enter an approximate value, then enter the actual density value at a later time.

If a two-point calibration has been selected, this menu item will read "CAL density point 1" and the subsequent menu item will read "CAL density point 2."

The "density" value entered for this menu item must be in terms of the measurement type and units that has been selected for the primary measurement (e.g., solids content/vol in kgram/liter).

Process Temperature Learned…

If you have set up temperature compensation, this menu item displays the process temperature that was measured during the most recent CAL cycle. This value is only displayed until the "Use latest CAL value" command is executed. The gauge uses this value for either the first or second CAL point when you execute the corresponding "Use latest CAL value…" command.

CAL #1 Temperature

If you have set up temperature compensation, this menu item displays the process temperature that is in use for the first calibration point.

CAL #2 Temperature

If you have set up temperature compensation and done a second-point calibration, this menu item displays the process temperature that is in use for the second calibration point.

CAL/STD Ratio

This menu item shows the CAL/STD ratio of the latest calibration measurement. This menu item is displayed until the "Use latest CAL value" command is executed.

Use Latest CAL Value

Execute this command to accept the latest calibration measurement for the selected calibration point, CAL PT 1 or CAL PT 2, and use the value entered for the "CAL density" menu item.

Once this command has been executed, changing the "CAL density" value will have no effect on the gauge's measurement value until a CMD 6 (process and store data) is executed.

Attenuation Coefficients

In order for the gauge to calculate the density based on the detector signal, the gauge must assume a value for the attenuation coefficient for each component of the process material (for example, carrier and solids for slurries, solvent and solute for solutions). The attenuation coefficient is a measure of how well a material blocks gamma rays.

For typical slurries using a Cs-137 source, the default coefficients of 0.086 for the carrier (water) and 0.077 for solids (good for many minerals) generally provide good results. If you use a Co-60 source, however, you should change the coefficients to 0.065 for the carrier (water) and 0.058 for solids (minerals).

For applications, you may need to fine tune the gauge by entering coefficients specific to your process material. In particular, you may need to adjust the attenuation coefficients if any of the following conditions are true for your application:

- only a very narrow range of density values are of interest
- the carrier is not water
- the process material contains a significant amount of hydrogen
- the process material contains a significant amount of elements with an atomic number greater than 56 (Barium has an atomic number of 56)

Appendix B lists the attenuation coefficients for the individual elements and describes how to determine the attenuation coefficient for a process component from the attenuation coefficients of the individual elements. Contact Thermo Fisher if you need help determining the correct attenuation coefficient for your process material.

Density Slope Correction Factor

This menu item displays the density slope correction factor. This value is normally computed based on the value for "CAL density point 2" and the CAL 2 calibration

measurement. In some cases, it may be useful to adjust this value manually to match the gauge's output to a sample density rather than actually performing a CAL 2 measurement.

Note: If the CAL 1 density value is not accurate, adjusting this factor to match the gauge's output to a second sample density may actually degrade the overall measurement accuracy.

For best performance the CAL1 and CAL 2 calibration measurements should be performed on process material with density values at the opposite ends of the operating range. If the calibration measurements are performed on material densities that are too close together, the CAL 2 point may degrade the density measurement accuracy.

Chapter 4 Set Up Additional Measurements

The primary measurement (measurement 1) is set up using the "Set up density…" menu as described in Chapter 3. Up to seven additional measurements can be defined using the "Set up additional measurements" menu.

Process alarms can be assigned to the additional measurements just as for the primary measurement. In addition, the additional measurements can be assigned to the current output(s) instead of the primary (density) measurement, depending on the needs of your application. See Chapter 6 for information on assigning alarms, relays, and current outputs to measurements.

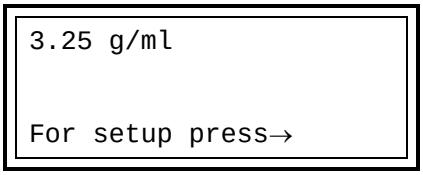
Measurement Display

In the default configuration, up to six measurements can be shown on the four-line display, alternating between the display of measurements 1-3 and measurements 4-6. The fourth line displays the instruction "For setup, press →."

Measurements exceeding the number of display lines are shown in alternation. For example, to display four measurements, measurements 1 and 2 are shown continuously, while measurements 3 and 4 are shown in alternation on the third line.

The "For setup press →" message can be suppressed allowing a total of eight measurements to be displayed, four at a time. See "Special Functions" on page 8-10 for instructions on how to disable the "For setup…" message. You still press the → key from the measurement display to access the setup menus even when the "For setup press →" message is disabled.

An example measurement display is shown below.



"Set Up Additional Measurements" Menu

The first time you access the "Set up additional measurements" menu, the "Assign & set up measurement 2" menu will appear. Measurement 1 is assigned to the primary measurement by default. After measurement 2 is set up, you will then be able to "Assign & set up measurement 3," and so on, up to a maximum of eight measurements.

Note: It is good practice to make a list of all the measurements you set up and keep the list for future reference.

The following table provides an overview of the "Set up additional measurements" menu items.

"Set Up Additional Measurements" Menu	
Display	**Comments**
Set up additional measurements (readouts).↓ Other functions→	You can assign up to seven measurements in addition to the primary (density) measurement. Press ↓ to set up additional measurements.
NOTE: Meas. #1 is the primary measurement See "density setup" to modify. NEXT↓	Measurement 1 is assigned to the density measurement by default. Normally, you must use the "Set up density…" menu to change the primary measurement setup as described in Chapter 3.
Assign & set up measurement 2→ NEXT↓	Press → to assign a readout to measurement 2. After measurement 2 is set up, this menu item will read "Modify setup of measurement 2".
Reading represented by measurement 2 is bulk density NEXT↓ CHANGE→	Press → to select the readout type. Select from density, bulk density, etc. You must select a measurement before the rest of the menu items will be displayed.
Bulk density units = g/ml To change, press→ NEXT↓	Press → to select the units for the selected readout.
Set up alarm 2 (Alarm point, etc.)→ NEXT↓	The "Set up alarm #" submenu will be displayed here if an alarm has been assigned to the measurement. See "Set Up Alarm…" on page 4-5.
Do display mea 2 bulk density Change to "Do not"→ NEXT↓	Select "Do not" to disable display of the measurement 2 readout on the measurement display.
Note: If two or more current outputs are installed, output #2 is assigned to measurement #2 by default. In this case, the "Meas #2 reading for 20.00 (4.00) mA output" menu items will be displayed rather than the "Highest expected reading."	
Highest expected reading: 0.000 g/ml NEXT↓	To enable the "display scaling" menu items, enter a value greater than 9999 for the "highest expected reading" value. See page 4-6 for details on display scaling.
Position of decimal in readout 2 000.0 {g/ml} | NEXT↓ ←CHANGE→	Use the arrow keys to select the position of the decimal point in the value displayed for the measurement readout. The readout value is limited to four digits plus the decimal point.
←Exit from: Modify setup of measurement 2 liter	Press ← to exit the "Modify setup of measurement 2" submenu.
Note: After measurement 2 has been set up, you will then be prompted to "Assign & set up measurement 3," and so on.	

Select Measurement Type

The first step in setting up an additional measurement is to specify the desired measurement type in the "Reading represented by measurement # is" menu item. In addition to the usual density related measurements (see page 3-7), you can select among the measurements listed below for up to seven additional readout displays.

For any material type, you can select:

- bulk mass flow
- bulk volume flow
- velocity ft/s — velocity in feet per second
- velocity M/s — velocity in meters per second
- temperature (deg C) — temperature in deg. Celsius (if temp comp is used)
- temperature (deg F) — temperature in deg. Fahrenheit (if temp comp is used)

Note: Flow related measurements are not available until the "Flow INPUT setup" has been completed.

Temperature readouts are only available if you have selected a temperature input in the "Process temperature compensation setup" menu (see pages 3-6 and 5-3).

If the material type is "slurry," you can also select:

- solids mass flow
- carrier mass flow
- solids volume flow
- carrier volume flow
- bulk solids flow

If the material type is "solution," you can also select:

- solute mass flow
- solvent mass flow
- solute volume flow
- solvent volume flow
- bulk solute flow

If the material type is "single phase," you can also select

- Fluid_2 mass flow
- Fluid_1 mass flow
- Fluid_2 volume flow
- Fluid_1 volume flow
- bulk solute flow

Rate Measurement

The rate measurement computes the time rate of change for the selected measurement. The rate can be computed for any measurement once it has been set up.

Display	Comments
Rate readout will be rate of: g/ml/time NEXT↓ CHANGE→	Select a measurement (density in this example) for which to compute the rate of change. Measurement number for rate should be greater than the number of the base measurement.
Smallest change for rate compute 0.000 g/ml 1.563E-2 assumed NEXT↓	Rate will not be computed until the change in the measurement exceeds the value entered here. Once rate has been computed, it is recomputed when the change threshold is exceeded or when the expected time for the change threshold to be exceeded has elapsed.
Rate smoothing factor 1.000 {0.01=smoothest} {0.01 to 1.0} NEXT↓	Smoothing factor for rate measurement. A value of 1.0 corresponds to no smoothing (current estimate is displayed), a value of 0.01 corresponds to the most smoothing (longest effective averaging time).
Rate time code g/ml/s Continue↓ Change→	Select the reference time interval for the rate measurement. Select: s (seconds), m (minutes), h (hours), or d (days).

The "Smallest change for rate" menu item sets a threshold for the minimum change required before a rate value is computed. Once a rate value has been computed (i.e., the change in the measurement exceeds the threshold), a new rate is computed when the threshold is again exceeded, or at the time when the change in the measurement *should* have exceeded the threshold based on the last computed rate estimate. This allows the estimated rate to settle back towards zero if the change in the process measurement stops.

The "Rate smooth factor" menu item determines the degree of smoothing applied to reduce fluctuations in the rate measurement via exponential averaging. A factor of 1.0 corresponds to no smoothing (estimated rate equals the last computed rate). Use a smaller rate smooth factor if the measurement tends to fluctuate rapidly, resulting in noisy rate readouts. The minimum factor is 0.01 and corresponds to the greatest amount of smoothing.

The "Rate time code" lets you select the time interval associated with the rate measurement. For example, you can measure the change in density per second, per minute, etc. Select from the following set of time intervals:

- s seconds
- m minutes
- h hours
- d days

Special Measurements

If you select the "special" measurement type, you are prompted to enter the four-digit code for the measurement. These special measurements are typically used for diagnostic purposes.

Display	Comments
The next menu item is displayed only if "Service only items" are enabled.	
`Special code for measurement 2 1048 see manual NEXT↓`	Enter four-digit special measurement code. Typically used only for diagnostic purposes.

Special Equations

There are three, three-digit "special measurement codes" that invoke the *special equations* function. The special equations (measurement codes 147, 148, and 149) allow the value from the flow measurement (based on the 4-20 mA flow input) to be combined with a function of the density measurement from the gauge, f(density), to create a new measurement value. The special equations have the following form.

$$\text{Value} = M_1 / M_2$$

where

$$M_1 = A_1 * f(\text{density}) + B_1 * \text{Flow} + C_1 * f(\text{density}) * \text{Flow} + D_1,$$

$$M_2 = A_2 * f(\text{density}) + B_2 * \text{Flow} + C_2 * f(\text{density}) * \text{Flow} + D_2, \text{ and}$$

A_1, B_1,C_1, D_1, A_2, B_2, C_2, and D_2, are user-entered constants.

Note: The values for density and flow measurements are converted from the user defined units to CGS units (centimeter, gram, seconds) before being used in the Special Equations.

The default values for the user-entered coefficients are all zero, except $D_2 = 1$ so that the denominator value, M_2, will not be zero. The function of density, f(density), depends on the special measurement code as follows:

Measurement Code	f(density)
147	f(density) = density
148	f(density) = sqrt(density)
149	$f(\text{density}) = (\text{density})^2$

Set Up Alarm…

The primary measurement is automatically assigned to measurement 1. Other (additional) measurements must be assigned to a measurement number before a process alarm can be assigned. Once you have assigned an alarm to a measurement (see page 6-5), the "Set up Alarm" menu items will be displayed under the appropriate "Modify setup of measurement #" menu.

Thus, setting up an alarm for a measurement other than the primary measurement is a three-step process.

1. Set up the measurement using the "Assign and set up measurement #" menus as described in the preceding sections.
2. Assign an alarm to the measurement using the "Assign alarms to measurements" menu items as described in on page 6-5.
3. Return to the "Modify set up of measurement #" menu under the "Set up additional measurement" menus to set up the alarm parameters.

For details on setting up alarms and a description of the alarm parameters (set point, clear point, dead band, etc.), refer to "How to Set Up Alarms" on page 3-10. This section describes how to set up an alarm for the primary measurement. The alarm setup procedure and parameters are the same for other measurements.

Do or Do Not Display

Use this menu item to select whether to display the measurement value. If you select "Do not display," the measurement value will not be shown on the measurement display, but you can still use the measurement to drive alarms or current output.

Display	Comments
Do display mea 2 volume liter Change to "Do not"→ NEXT↓	Select "Do not" to disable the display of the measurement 2 readout on the measurement display.

Display Scaling

Measurement readout values are displayed using four numeric digits and a decimal point. The menu items described in this section allow you to scale the displayed readout values. The display scaling menu items are enabled when a value >9999 is entered for the "Highest expected reading" menu item.

For example, if you set up a flow measurement and expect readings in the range of 30,000 to 40,000 gallons per day, you can scale the readout by a factor of 1000 so that the range of the flow readout is 30.00 to 40.00. Display scaling does *not* change the units displayed for the readout; however, you can set up a custom units message.

Note: If the measurement has been assigned to drive the current output, the "Meas # reading for 20.00 mA output" and "Meas # reading for 4.000 mA output" menu items are displayed instead of the "highest expected reading" and the "lowest expected reading" menu items. For display scaling purposes, these menu items are equivalent.

Display scaling only affects the displayed readout value, not the actual measurement value computed by the gauge. The actual, unscaled values are used for any alarms you assign to this measurement.

Display	Comments
Highest expected reading: **4.000E4 gal/d** **NEXT↓**	Enter a value >9999 to enable the display scaling. For example to scale the flow readout of 40,000 to 40.00, enter 40000 for the highest expected reading.
Lowest expected reading: **0.000 gal/d** **NEXT↓**	To scale the readout by a constant factor, you do not need to enter a value for this parameter. Enter a value for the lowest expected reading only if you want to interpolate between the range entered for the "expected reading" values and the range entered for the "scale readout" values.
Scale actual 4.000E4 { gal/d } **to high end readout of 40.00 NEXT↓ HELP→**	Enter value to be displayed when the measurement value equals the highest expected reading value. In our example, we wish to scale 40000 gal/d to 40.00.
Scale actual 0.000 { gal/d } **to low end readout of 0.000 NEXT↓**	Enter a value for this parameter only if you want to interpolate between the range entered for the "expected reading" values and the range entered for the "scale readout" values.
Set up custom units messages→ **NEXT↓S**	Press → and follow the menu instructions to set up a custom units message for the scaled display readout.

Highest Expected Reading

If you expect the maximum measurement readout to exceed four digits (value greater than 9999), enter an estimate of the maximum measurement value in the "Highest expected reading" menu item. If you set a highest expected reading value of 10,000 or greater (more than four digits), three additional menu items will be displayed allowing you to set up *display scaling* so the gauge's display will be meaningful throughout the expected range.

The value for the highest expected reading is not critical, just pick a convenient number with the correct order of magnitude. If the actual measurement happens to exceed the range you expect, the readout will still display the correct, scaled measurement value, as long as the scaled value can be displayed in four digits. In our example where 40,000 liters is scaled by a factor of 1000 to read 40.00 on the display, if the gauge measures 43,875 liters, the displayed value would be 43.88. Any value up to 99,990 could be displayed correctly, that is, divided by 1000 and displayed as 99.99.

Lowest Expected Reading

This menu item is displayed if you set a highest expected reading value greater than 9999 for a measurement. To scale the displayed value by a constant factor, e.g., displayed value = actual value/10, leave this parameter and the "Scale actual {lowest expected reading} to low end readout" parameter set to zero. If you scale both the highest expected reading and the lowest expected reading, the gauge performs an interpolation to scale the actual measured value from the range specified by the highest and lowest expected readings to the range specified by the "Scale…high end and low end readout" values.

Scale Actual (highest expected reading) to High End Readout

This menu item is displayed if you set a highest expected reading value greater than 9999 for a measurement. Enter the desired readout value to be displayed for the highest expected reading.

For example, to scale a highest expected reading value of 40,000 to a display value of 40.00, enter 40.00 for the high-end readout value.

Scale Actual (lowest expected reading) to Low End Readout

This menu item is displayed if you set a highest expected reading value greater than 9999 for a measurement. Enter the desired readout value to be displayed for the lowest expected reading. To scale the displayed value by a constant factor, e.g., displayed value = actual value / 1000, leave this parameter and the "Lowest expected reading" parameter set to zero. If you scale both the highest expected reading and the lowest expected reading, the gauge performs an interpolation to scale the actual measured value from the range specified by the highest and lowest expected readings to the range specified by the "Scale…high end and low end readout" values.

Set Up Custom Units Messages

This menu item is displayed if you set a highest expected reading value greater than 9999 for a measurement. By default, the original units will be displayed for the scaled value on the measurement display. The "Set up custom units messages" menu items allow you to set up a user-defined units message up to ten characters long.

In this example, the flow measurement with units of gallons/day was scaled by a factor of 1000, so the displayed value has units of "kilo-gallons/day." Thus, you might want to set up a custom units message to read "kgal/d." Up to eight custom messages can be defined using any combination of ASCII characters up to ten characters in length. Refer to "Custom Units Messages" on page 8-12 for details.

Chapter 5 Gauge Fine Tuning

After completing the basic setup, you can use the "Gauge fine tuning {time constant, STD, CAL, etc}" menu to modify the gauge time constant, or to perform additional standardization or calibration cycles. The three submenus under the "Gauge fine tuning" menu are:

- Time constant setup
- Process temperature compensation setup
- Sensor head standardization
- Density gauge calibration
- Flow input setup

Each of these submenus is described in the following sections.

Time Constant Setup Menu

This menu lets you modify the gauge time constant and related items.

Display	Comments
Time constant setup→ **NEXT↓**	Press → to enter the "Time constant setup" menus.
Density signal time constant 128 sec **NEXT↓ HELP→**	The time constant value determines the amount of averaging applied to the primary measurement. The larger the time constant the less variability (due to randomness inherent in counting radiation events) in the measurement.
Do not disable dynamic tracking **Change to "Do"→** **Continue as-is.↓**	**Service only item.** Allows dynamic tracking to be disabled for diagnostic purposes. Leave enabled (Do not disable) during normal operation.
Source half life 30.00 yr **NEXT↓**	**Service only item.** Specifies the half-life of the source. The default value, 30.0 years, corresponds to the half-life for Cs-137 (30.17 years). The half-life for Co-60 is 5.27 years,
Density signal time constant (alternate) 8 sec **NEXT↓ HELP→**	Enter the value for the alternate time constant.
Switch to alternate time constant: 8s **←Exit this menu.** **NEXT↓ EXECUTE CMD→**	Command to switch to the alternate time constant. This menu item "toggles" between the commands "switch to alternate" (CMD 53) and "switch to normal" time constant (CMD 54).
←Exit from: Time constant setup **NEXT↓**	Press ← to exit the "Time constant set up" submenu.

Density Signal Time Constant

A certain amount of noise or fluctuation is inherent in any radiation-based measurement. The effectiveness of the gauge's filtering to reduce the effect of statistical variations in the radiation measurement depends on the (primary) time constant. Increase the density signal time constant to improve the measurement stability at the expense of increasing the response time of the gauge to process changes. Decrease the time constant to improve the gauge's response at the expense of increased measurement fluctuations.

Note: The default setting for the time constant is 128 seconds. The time constant also determines the cycle time for standardization and calibration.

Alternate Density Signal Time Constant

Use this menu item to set up an alternate time constant (default value is eight seconds). The alternate time constant is typically set to a much shorter time than the primary time constant. During periods when the process is known to be changing, switching from the primary time constant to the shorter, alternate time constant will make measurements more responsive (but less stable). Switch back to the longer time constant when the process has again stabilized to increase the measurement stability.

Note: Do not confuse the alternate time constant with the built-in Dynamic Process Tracking (DPT). The DPT time constant is automatically used when a sudden change in the process is detected. The DPT time constant is a factor of eight smaller (faster) than the time constant in use, whether it is the primary or alternate time constant.

Switch To…Time Constant

The alternate time constant is not used for any gauge function until you select it using the "Switch to alternate time constant" command. This command toggles between "Switch to primary time constant" and "Switch to alternate time constant" each time the command is executed.

Detector Hi-Meg Value

This menu item is displayed if your V/I/Pulse interface board is set up for an ionization detector. The Hi-Meg value refers to the detector's Hi-Meg resistor value, which is written on a label attached to the circuit board inside the detector housing. The Hi-Meg value affects the detector sensitivity and is used by the gauge in its measurement calculations.

Note: If you have more than one gauge, be sure to use the Hi-Meg value that is correct for the gauge you are setting up. The value varies from detector to detector.

Source Half-Life

This menu item is only displayed if the "service only items" have been enabled. Enter the value for the source half-life value in years. This value is used by the gauge to adjust the standardization value for source decay. The default value is 30 years, corresponding to the half-life of Cs^{137}. If you use a Co^{60} source, change this value to 5.3 years.

Process Temperature Compensation Setup Menu

The density of materials varies with temperature. For many applications, this variation is insignificant, but in some cases the process temperature can be an important factor. In particular, temperature compensation may be required for solutions or emulsions, and in some cases for slurries, if the solids gravity is less than 2.0. In these cases, the "Process temperature compensation setup" menu is displayed in the "Set up density…" menu chain. The "Process temperature compensation setup" menu is always available under the "Gauge fine tuning" menu.

Note: If you use temperature compensation, the material density values you enter in the "Set up density…" menu (page 3-5) must be correct at the reference temperature (page 5-5).

Temperature Input Source

Use this menu item to select the source of the temperature input signal.

- Not used: Temperature compensation will not be performed. If this option is selected, the remaining temperature compensation menu items are not displayed.
- 100-ohm American RTD: Select this option if the optional Thermo Scientific temperature signal amplifier/temperature sensor (RTD) is installed.
- Manual entry: Manual entry of the process temperature may be useful if the process temperature changes only seasonally.
- Via serial port: Allows the process temperature to be input using the RS-485 or RS-232 serial port. Specify which serial port to use and the parameter number to interpret as the temperature input. If the RS-485 port is selected, the unit number of the gauge that will send the temperature data must also be specified. For more information about serial port settings, see "Serial Ports" on page 8-2.
- Customer sensor: Any temperature sensor with a 4-20 mA current output can be used to provide a temperature input to the gauge. Connect the temperature sensor's current output to pins 4 and 5 on connector J1A on the V/I/Pulse interface board in the transmitter. (Refer to the Wiring Diagram for details.)

Special Temperature Probe Polynomial

If you select "Customer sensor" for temperature input, the gauge prompts you for to enter four polynomial coefficients (A, B, C, D). The gauge uses these coefficients to convert the *sensor current signal* to the *temperature measurement* according to the formula:

$$\text{Temperature (°C)} = A + Bx + Cx^2 + Dx^3$$

where:

x is the 4-20 mA current output signal from the temperature sensor. (The input impedance is 205 ohms.)

A is the temperature measurement in °C that corresponds to a 0 mA input. (Use extrapolation to determine this temperature if the input never actually reaches 0 mA.)

B is the slope of the Temperature (°C) vs. Current Out (mA) response curve of the temperature sensor. If response is linear over the operating range the higher order coefficients are not required.

C, D are the higher order coefficients that can be defined if a linear approximation to the temperature sensor's response curve is not adequate. In many cases, C and D can be set to zero.

For example, if the coefficients C and D are set to zero, A = 15, and B = 5, the temperature measurement (°C) will be

Temperature (°C) = 15 + 5*x*, where *x* is the current signal in mA.

A 4 mA input would correspond to a temperature of 15 + (5 x 4) = 35° C.

A 20 mA input would correspond to a temperature of 15 + (5 x 20) = 115° C.

Temperature Compensation Polynomials

The gauge uses polynomial equations to compute the change in density of the process material(s) as a function of the change in temperature, relative to the reference temperature. You will be prompted to define temperature compensation polynomials based on the material type selected in the "Set up density…" menu.

For a slurry, you will be prompted to set up:

- Carrier polynomial: specifies the density change of the carrier as the process temperature changes.
- Solids polynomial: specifies the density change of the suspended solids as the process temperature changes.

For a solution, you will be prompted to set up:

- Solvent polynomial: specifies the density change of the solvent as the process temperature changes.
- Solution polynomial: specifies the density change of the entire solution (solvent and solute combined) as the process temperature changes.

For a single phase material, you will be prompted to set up:

- Reference fluid polynomial: specifies the density change of the reference fluid used for the standard configuration as the temperature changes (if you "standardize on" pipe full of reference fluid).
- Product polynomial: specified the density change of your actual process material as the process material changes.

For an emulsion, you will be prompted to set up:

- Fluid_1 polynomial: For an emulsion, this gives the density change of fluid_1 (carrier) as the process temperature changes.
- Fluid_2 polynomial: For an emulsion, this gives the density change of fluid_2 (suspended liquid) as the process temperature.

Predefined Temperature Polynomials

The gauge includes a predefined temperature compensation polynomial that can be selected for a water-based carrier (slurry), solvent (solution), reference fluid (single phase), of fluid_1 (emulsion). This polynomial (H20, <90 C, REF 20) is suitable for water at temperatures less than 90° C with a reference temperature of 20° C.

If "solution" is selected as the material type, predefined temperature compensation polynomials are provided for sugar solutions at four different concentrations, 10%, 25%, 50%, or 75%. These polynomials are suitable for the stated concentrations of sugar in water at temperatures below 90° C with a reference temperature of 20° C.

For all other cases, a "user defined" polynomial must be entered for the temperature compensation polynomial, see page 5-5.

Reference Temperature

The gauge performs all of its temperature compensation calculations relative to the *reference temperature*. The default reference temperature is 20° C (68° F).

In this manual, the density of a material at the reference temperature is called its *reference* density. The density values specified in the "Set up density…" menu are used as the reference densities. For example, the carrier gravity and the solids gravity values are used as when the material type is a slurry.

Note: The reference temperature must be outside the expected range of process temperatures. For example, if your process temperature can vary from 15° C to 50° C, you should select a reference temperature outside of that range. Typically, the reference temperature is selected below the temperature range of interest.

When using temperature compensation, the component densities must be specified at the reference temperature. For example, the density of water is 0.9982 at the default reference temperature of 20° C. If you change the reference temperature to 4° C, you should change the carrier gravity to 1.00.

User-Defined Temperature Polynomials

For "User-defined" temperature compensation polynomials, the gauge prompts you to enter three coefficients (A, B, C). These coefficients specify the relationship between the change in the density of the process material and the change in the process temperature relative to the reference temperature using the following equation:

$$\Delta d = A\,\Delta T + B\,\Delta T^2 + C\,\Delta T^3$$

where:

- Δd is the change in density due to the change in temperature relative to the reference temperature.
- ΔT is the difference between the process temperature and the reference temperature.

A is the slope of the "density change (Δd) vs. temperature change (ΔT)" response curve. If the response is linear over the temperature of interest range the higher order coefficients (B and C) are not required.

B, C are the higher order coefficients that can be defined if a linear approximation to the "density change (Δd) vs. temperature change (ΔT)" response curve is not adequate.

In many cases, a linear approximation to the "density change (Δd) vs. temperature change (ΔT)" response curve is adequate and it is only necessary to define the "A" coefficient. The higher order coefficients, B and C, can be set to zero.

Finding Coefficients

For many processes it is adequate to measure the density of a sample at two temperatures and find the slope of the density change (coefficient A).

If coefficients are required for a second- or third-order temperature compensation polynomial, Thermo Fisher can often determine the coefficients for you. To determine these coefficients, information about the process material composition will be needed. It is likely that density measurements will also be required at one or more sample concentrations, both at the reference temperature and at two or three different temperatures within the range of interest.

Note: If your process material's temperature density response formula is non-linear (higher order coefficient B & C are non-zero), you must calculate new coefficients if you ever change the reference temperature.

If your process material is not prone to settling or separation (for example, a solution), you can use the gauge itself to measure sample densities. Temporarily set the gauge to read out density and temperature *with all temperature compensation coefficients set to zero.* Stop the process with the pipe full and let the material cool down through the range of interest while you record temperatures and corresponding densities. Also record the density at the reference temperature.

Note: Remember that the polynomial equation is based on the change in the density relative to the reference density and the change in the temperature relative to the reference temperature, not on the measured values of the density and temperature.

Do Not/Do Use Temp Comp on STD Cycle

After you have defined the temperature compensation polynomials, the "Do not/do use temp comp (eq #1) on STD cycle" menu item is displayed.

If you standardize with the pipe full and the temperature is different than the reference temperature, the density during the standardization measurement may be significantly different from the reference density value (e.g., the carrier gravity for a slurry) that is assumed to correspond to the standardization. To correct for this, after you set up temperature compensation, you can select "Do use temp comp (eq #1) on STD cycle."

With this setting, the gauge uses the process temperature measured at the end of the standardization cycle and the temperature compensation polynomial to normalize the STD measurement to what it would have been at the reference temperature.

Temperature Offset Correction

Installation differences and other factors might cause the gauge temperature readout to be somewhat higher or lower than the actual process material temperature at the gauge head. You can compensate for this by entering a temperature offset correction.

For example, if the gauge consistently reads 2° C over the actual process temperature, enter an offset correction of –2° C.

Sensor Head Standardization

The "Sensor head standardization" menu provides the same menu items as found under the "Set up density…" menu (see page 3-12) to specify the standard configuration and to perform the standardization measurement. Additional menu items are provided that allow you to adjust the length of the standardization cycle and how the standardization value is compensated to account for the reduced source level due to radioactive decay.

Standardization Menu

"Sensor Head Standardization" Menu	
Display	**Comments**
Sensor head Standardization→ **NEXT**	Press → to enter the "Standardization" submenu.
Standardize on: pipe full of carrier To change, press→ **NEXT↓**	The standard configuration must be a known repeatable configuration such as or a pipe full of carrier (solvent, etc.), or an empty pipe.
Note: If the standardization measurement has already been performed, the following menu item will be displayed rather than the previous menu item.	
Last STD cycle was: full of carrier** **NEXT↓**	Read-only menu item. Indicates status of the last standardization cycle – none, empty or deferred.
STD cycle time: 8 X time constant {time constant is 128 sec} NEXT↓ HELP→	Specify the number of time constant periods used for the standardization measurement. STD cycle time = N x time constant. Default value for N = 8, default value for time constant is 128 sec.
Time since last Standardization: 3.456 weeks **NEXT↓**	Indicates the time in weeks since the last standardization cycle was performed.

"Sensor Head Standardization" Menu (cont.)	
Display	**Comments**
Gauge is ON **7 days per week** **NEXT↓**	Enter the average amount of time in days that the gauge will be powered on during a week. While the gauge is on, it tracks elapsed time to adjust the standardization value for source decay. This value allows the gauge to compensate for periods when power is not applied to the gauge.
Start standardize **cycle (tank empty)** **←Exit this menu.** **NEXT↓ EXECUTE CMD→**	The "normal" standardization command (CMD 103). Press → to begin the standardization measurement.

When To Standardize

The standardization measurement establishes a reference measurement for a standard (repeatable) process configuration. During the standardization cycle, the gauge averages the detector signal. Once the standardization measurement has been completed, it can be repeated at a later time to compensate for any changes in the gauge/process pipe configuration, such as increased attenuation due to process material buildup on the pipe walls. The gauge then uses the new standardization value to adjust the calibration value(s). It is not necessary to repeat the calibration measurements, since the calibration values are stored as a ratio of the calibration-to-standardization measurement values.

Whenever the standardization measurement is repeated, the gauge calibration points are adjusted based on the new standardization value. The question of how often standardization should be performed depends largely on your particular process.

A consistent error in the density measurement might indicate that it is time to standardize again. It is generally a good idea to re-standardize the gauge when one or more of the following conditions occur:

- Pipe wear caused by corrosive or abrasive materials
- Buildup of process material in the pipe
- Cleaning or spontaneous breakup of built-up material in the pipe
- Repairs or changes to the pipe or gauge head mount
- Shifting or realignment of the gauge head mount whether by accident or on purpose (the source and detector must be aligned and securely mounted)
- Repair or replacement of source or detector parts and wiring
- Installation or removal of nearby nuclear gauges

The gauge's measurement accuracy might seem to be off if there is debris (e.g., spilled process material) between the source and the pipe. If debris is present, you should remove the debris rather than re-standardizing the gauge.

Warning: Do not place your hand between the source and the pipe. Use a brush or other tool to remove any accumulated debris.

Standardize on: Pipe…

Select the standard configuration for the standardization measurement: pipe full of carrier (solvent, fluid_1,or ref fluid), pipe empty, pipe full with block, pipe empty with block, or defer standardization. To preserve any calibration measurement(s) that have been made, the same standard configuration must be used as when the gauge was first standardized. (See page 3-10 for additional information.)

Standardization (STD) Cycle Time

The default standardization cycle averages the measured radiation level over eight time constant periods. When using the default time constant (128 seconds), the standardization cycle lasts about 17 minutes (8 x 128 seconds). The duration of the standardization cycle can be changed by altering the density signal time constant (see page 5-2), or by changing the number of time constant periods used.

Note: The standardization cycle time must be set to at least two time constant periods or the gauge will automatically abort the standardization cycle.

The precision of the measured radiation level improves as the measurement time is increased. Since any error in the standardization value will result in a corresponding error in the measurement readouts, it is recommended that the default standardization cycle time not be shortened.

Time Since Last Standardization

This menu item displays the amount of time (in weeks) since the last standardization cycle was performed. The STD value is automatically adjusted to account for the reduced source level due to the radioactive decay of the source. Whenever a standardization measurement is performed, the gauge resets the source decay counter.

The accuracy of the "time since last standardization" is not particularly important if you use a Cs^{137} source (30 year half-life) and standardize periodically. If you use a Co^{60} source, however, source decay will have a greater effect due to the shorter half-life (5.3 years). Make sure the source half-life value is set correctly (see page 5-2).

Gauge Is On…Days Per Week

The gauge maintains a counter (time since last standardization) to adjust the STD value for the effects of source decay. By default, the counter assumes that power is applied to the gauge continuously, 24 hours/day, seven days/week. If the gauge is shut down periodically (on weekends for example), an error will accumulate in the counter over time. To improve the decay counter accuracy, enter the number of days per week that power will be applied to the transmitter for the "gauge is on…" parameter.

Start STANDARDIZE Cycle

Use this menu item to start a normal standardization using the settings described in the previous sections. The procedure is the same as for your first standardization when setting up the gauge. See page 3-10.

Standardization Service Only Menu Items

The following menu items are only displayed in the "Sensor head standardization" menu when the "Service only items" are enabled (see "Special Functions" on page 8-10). These tools are useful in certain situations, but are not generally required.

"Sensor Head Standardization" Menu [Service Only Items]	
Display	**Comments**
`Max. allowable STD value difference: .5000 % NEXT↓`	Specify the maximum allowable difference between the STD value measured during a "qualify" standardization cycle (see next menu item) and the STD value currently in use.
`Start standardize cycle {Qualify value} ←Exit this menu. NEXT↓ EXECUTE CMD→`	Performs a standardization measurement, but will not use the new value if it differs from the current value by more than the allowable difference specified in the previous menu item.
`Start standardize cycle {Hold value} ←Exit this menu. NEXT↓ EXECUTE CMD→`	Perform a standardization measurement, but "hold" the measured value instead of replacing the STD value in use. Execute the "Use latest STD value" command below to apply the "held" standardization value.
`STD value from latest cycle: **4.550E4 NEXT↓`	This is the detector signal value from the most recent standardization cycle. A large change in the STD value may indicate a problem with the gauge or an anomalous condition (e.g., extraneous radiation sources) during the standardization measurement.
`STD value in use: 4.550E4 (read only) NEXT↓`	The STD value currently in use. This value will differ from the latest STD value if several weeks have passed since you last standardized the gauge (source decay correction), or if you used the "Start STANDARDIZE cycle {Hold value}" command but did not execute "Use latest STD value."
`Use latest STD value. ←Exit this menu. NEXT↓ EXECUTE CMD→`	Copy the STD value from the latest cycle to replace the value in use. (This is done automatically if you use the normal STANDARDIZE command.)
`Data/ref cnt ratio 0.000 (6.000 in use) NEXT↓`	This value affects the control of the high voltage (gain) applied to the photomultiplier tube in the detector. Do not change this unless instructed to do so by Thermo Fisher. Enter 0.0 to use the default value (6.000).

Density Gauge Calibration

The "Density gauge calibration" menu provided under the "Gauge fine tuning" menu is exactly the same as what is found under the "Set up density…" menu. This menu lets you calibrate the gauge to fine tune its response to your process material's density. Refer to "Calibration" on page 3-15 for detailed instructions on calibrating your gauge.

Flow Input Setup

This menu is also available under the "Set up density…" menu chain.

"Flow INPUT Setup" Menu	
Display	**Comments**
Flow INPUT setup→ **NEXT↓**	Press → to set up the flow input menu.
Flow INPUT from: **none** **To change, press →** **NEXT↓**	Press → to select source for the flow input: "none" or "current input."
Flow volume units: **liter** **NEXT↓ CHANGE→**	Press → to select the volume units for the flow measurement (flow = volume/time). The number of available units depends on selection of All, Metric, or English units in previous menu item.
Volume flow time units: minutes {liter/m} **NEXT↓ CHANGE→**	Press → to select the time units for the flow measurement (flow = volume/time). The number of available units includes seconds, minutes, hours, and days.
Mass flow units: Kgram **NEXT↓ CHANGE→**	Press → to select the mass units for the flow measurement (flow = volume/time). The number of available units depends on selection of All, Metric, or English units in previous menu item.
Mass flow time units: minutes {Kgram/m} **NEXT↓ CHANGE→**	Press → to select the time units for the flow measurement (flow = volume/time). Available units include seconds, minutes, hours, and days.
Flow signal time constant 4 sec **NEXT↓**	The flow signal time constant determines the amount of averaging applied to the flow signal input.
Minimum flow input: 4.000 mA **NEXT↓**	Specify the minimum value for the range of the flow current input signal, default value is 4.0 mA.
Maximum flow input: 20.00 mA **NEXT↓**	Specify the maximum value for the range of the flow current input signal, default value is 20.0 mA.
Flow input at 4.000 mA: 20.00 lit/m **NEXT↓**	Specify the flow rate corresponding to the minimum current input value. Note the flow rate must be specified in the same units as selected in the earlier menu item.
Flow input at 20.00 mA: 30.00 lit/m **NEXT↓**	Specify the flow rate corresponding to the maximum current input value. Note the flow rate must be specified in the same units as selected in the earlier menu item.

Flow Input From

Select “current input” if you have connected a flow sensor with a 4-20 mA current output to the flow input terminals of the DensityPRO+ gauge. Refer to the DensityPRO+ Installation Manual and the Wiring Diagram for wiring details.

Volume Flow

Volume flow is measured as volume per unit of time. The complete list of available volume units is given below:

- ml (cu cm) milliliters or cubic centimeters
- cubic Meter 1 cubic meter = 1000 liters
- cubic inch 1 cubic inch = 16.39 ml
- cubic foot 1 cubic foot = 28.32 liters
- cu yard 1 cubic yard = 764.6 liters
- US Gallon 1 US gallon (liquid) = 3.785 liters
- UK Gallon 4.546 liters = 1.2 US gallons
- Mega Gallon 1,000,000 US gallons
- Beer Gallon 4.62 liters
- liter 1 liter = 1000 milliliters
- acre foot 43560 cubic feet
- US pint 473.2 ml, 1/2 US quart
- US quart 946.3 ml, 1/4 US liquid gallon
- US oz 29.57 ml, 1/16 US pint
- acre inch 3630 cubic feet
- K Gallon 1000 US liquid gallons
- UK quart 1137 ml, 1/4 UK gallon
- UK pint 568.3 ml, 1/2 UK quart
- UK oz 28.41 ml, 1/20 UK pint
- Oil Barrel 159 liters, 42 US liquid gallons
- Beer Barrel 117.3 liters, 31.0 US gallons
- US Barrel 119.2 liters, 31.5 US liquid gallons
- UK Barrel 163.7 liters, 36 UK gallons

A separate menu item is provided for setting the time units. Select seconds (s), minutes (m), hours (h), days (d), weeks (w), months (M), or years (y).

Mass Flow

Select units for mass flow measurement:

- gram
- Kgram kilograms (kg)
- pound
- metric ton 1000 kg
- short ton 2000 pounds
- long ton 2240 pounds
- oz avoirdupois ounces

A separate menu item is provided for setting the time units. See the list of units given above.

Flow Signal Time Constant

Specify the time constant used to filter the flow input signal. The default of 4.0 seconds is usually adequate.

Minimum Flow Input

Specify the minimum value for the current output signal that will be produced by the flow meter (and input to the gauge) for your process. The default value is 4.0 mA.

Maximum Flow Input

Specify the maximum value for the current output signal that will be produced by the flow meter (and input to the gauge) for your process. The default value is 20.0 mA.

Flow Input at Min.

Specify the flow rate corresponding to the minimum flow (current input) value. Note the flow rate must be specified in the same units as selected in the earlier menu items.

Flow Input at Max.

Specify the flow rate corresponding to the maximum flow (current input) value. Note the flow rate must be specified in the same units as selected in the earlier menu items.

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Chapter 6 Current Output, Alarms & Totalizers

This chapter describes the menu items under the "Modify or reassign current output" menu in the following section and the "Set up fault alarms or change process alarm assignments" menu beginning on page 6-3.

Modify or Reassign Current Output

Use the "Modify or reassign current output" menu to:

- specify which measurement should drive the current output(s) in normal mode
- specify which measurement should drive the current output(s) in alternate mode
- implement correction factors on each current output
- define a current output hold value which is different from the default of 50 percent of scale

The primary measurement (density) is assigned to the current output(s) in both normal mode and alternate mode by default. To assign a measurement other than the primary measurement to a current output, the measurement must first be set up using the "Set up additional measurements" menu (see page 4-1).

Then, as described in this section, use the "Modify or reassign current output" menu to assign the current output to the desired measurement. Finally, to specify the measurement range for the current output, return to the "Set up additional measurements" menu, enter the setup menu for the desired measurement number, and enter the measurement values corresponding to the maximum and minimum current output values.

Two different measurements can be assigned to control the current output, with one measurement assigned to the current output in normal mode and the second measurement assigned to the current output in alternate mode. The current output can be set up to switch from normal mode to alternate mode when an alarm is triggered (see "Set Up for Alarms to Execute Commands" on page 6-3). You can also directly enter a command to force a switch between normal and alternate modes (see "Common Action Items" on page 7-2).

For example, if you were interested in monitoring a density range of 2.0-3.0 g/ml during one portion of the process and a density range of 3.0-3.5 g/ml during another part of the process, you could set up the measurements and current output as follows:

- Set up measurement 1 (the primary measurement) as density and assign it to drive the current output in normal mode with a density range of 2.0-3.0 g/ml.
- Also set up measurement 2 as density, but assign measurement 2 to drive the current output in alternate mode with a density range of 3.0-3.5 g/ml. The measurement values corresponding to the maximum and minimum current output values are entered in the "Set up additional measurements" menu.

"Modify or Re-Assign Current Output" Menu	
Display	**Comments**
Modify or re-assign current output↓ **Other functions→**	Press ↓ to access "Current output" menu items. Press → to scroll to other menus.
Maximum current output 20.00 mA (4.000 to 20.00) **NEXT↓**	The maximum current output value ranges from the minimum current output value (4.000mA by default) to 20.00mA. The default value for the maximum current output is 20.00mA.
Minimum current output 4.00 mA (.0001 to 20.00) **NEXT↓**	The minimum current output value ranges from .0001mA to the maximum current output (20.00mA by default). The default value for the minimum current output is 4.000 mA. **Note: Enter a value of exactly 0.0 to reset the minimum current output to the default value of 4.000 mA. This value should be set to 2.0 mA or greater.**
Note: If two or more measurements have been set up, the next two menu items will be displayed. These menu items will be repeated for each current output installed.	
Mea 1: g/ml is sent to current out 1 in normal mode. NEXT↓ CHANGE→	Assign measurement to the current output in normal mode. Select from the primary measurement (Mea 1) and any measurements set up using the "Set up additional measurements" menu.
Mea 1: g/ml is sent to current out 1 in alternate mode. NEXT↓ CHANGE→	Assign measurement to the current output in alternate mode. Select from the primary measurement (Mea 1) and any measurements set up using the "Set up additional measurements" menu.
Correction factor for current output 1 at maximum: 1.000 **NEXT→**	Fine tune the maximum current output value to correct for any variation among systems. (The maximum current output value is scaled by this value.)
Correction factor for current output 1 at minimum: 1.000 **NEXT→**	Fine tune the minimum current output value to correct for any variation among systems. (The minimum current output value is scaled by this value.)
Current output hold mode value 50.00 % of scale **NEXT↓**	Enter desired value for mid-range hold value for the current output. Value is entered as a percentage of the maximum current output value. The default is 50 percent.

Set Up Fault Alarms or Change Process Alarm Assignments

Note: If no relays are installed in your gauge, the "Set up fault alarms or change process alarm assignments" menu will not be displayed in the menus. Use the "Special Functions" menu (page 8-10) to enable alarm-related functions so you can set up a non-relay display alarm or other indicator.

The "Set up fault alarms…" menu provides four submenus which allow you to:

- Set up commands to be executed when a process alarm is set/cleared
- Assign process alarms to monitor specific measurements
- Assign relays to warning and fault alarms
- Assign relays to mode alarms

Set Up for Alarms to Execute Commands

Use these menu items to assign commands for up to three pairs of alarm actions. Each alarm action pair consists of a command to be executed when an alarm is activated (set) and a second command to be executed when the alarm is cleared. Once an alarm action pair has been defined, the alarm action is added to the list of alarm indicators in the "Set up alarm" menu items and can be assigned as an alarm indicator for a specific alarm.

1. To assign a command action set to a process measurement alarm, you must have set up the measurement and have assigned an alarm to the measurement.
2. To assign a command action set to a fault, warning, or mode alarm, use the menu items described in the "Assign Alarms to Measurements" menu on page 6-5.
3. Assign "Relays" to Fault, Warning & Mode Alarms" section on page 6-6.

Note: Due to the limited display space, the "alarm indicated by" selection in the "Set up alarm" menu can not display the full command name. The alarm action pairs are referred to as "#1 act on ALM action," and so forth. It is recommended that you write down each command action pairs that you assign for future reference.

"Set Up for Alarms to Execute Commands" Menu	
Display	**Comments**

`Set up for alarms to execute commands→`
 	
`NEXT↓`
	Menu subgroup heading. Press → to access menu items, press ↓ to scroll to next "Alarms" menu subgroup.

`#1 act on ALM SET is "Do nothing" command`
 	
`Continue↓ Change→`
	Press → to scroll through the list of commands. Select the action (command) to be executed when alarm is activated. Selecting a command other than "Do nothing" makes action set #1 available for assignment to specific alarm conditions.

`#1 act on ALM CLR is "Do nothing" command`
 	
`Continue↓ Change→`
	Select the command to be executed when the alarm clears. Typically a command is selected to undo the effects of the command executed when the alarm is activated.

Note: The above two menu items are repeated for alarm action sets #2 and #3.	

Alarm Commands

The following commands can be assigned as alarm actions:

- Do nothing
- Finish gauge STD/CAL early
- Hold current output at 50.00% of scale
- Clear all alarms
- Start calibration cycle
- Hold current output(s) at maximum (normally 20 mA)
- Hold current output(s) at minimum (normally 4 mA)
- Clear all holds
- Hold current output(s) at FAULT HIGH
- Clear batch relays and totalizers
- Stop data stream on port 1 (RS-232)
- Restart data stream on port 1 (RS-232)
- Stop data stream on port 2 (RS-485)
- Restart data stream on port 2 (RS-485)
- Show custom message on line 4
- Stop custom message on line 4
- Switch current output(s) to alternate mode
- Switch current output(s) to normal mode
- Switch display to alternate mode
- Switch display to normal mode
- Inhibit Totalizer 1 (2,3,4)
- Hold current output(s) at FAULT LOW
- Enable Totalizer 1 (2,3,4)
- Zero Totalizer 1 (2,3,4)
- Save relay log data to NVRAM
- Update data output to port 1, RS-232
- Update data output to port 2, RS-485
- Add Totalizer 2 to Totalizer 3
- Add Ref data to totalizer
- Sub(tract) Ref data from totalizer
- Load Ref data into totalizer
- Inhibit all totalizers
- Enable all totalizers
- Subtract Totalizer 2 from Totalizer 3
- Clear all totalizers but do not enable

Assign Alarms to Measurements

Use the "Assign alarms to measurements" menu to assign alarms to monitor specific measurements. This menu item will only be displayed if you have set up at least one measurement in addition to the primary measurement using the "Additional measurements" menu (see page 4-1).

By default, all 16 alarms are assigned to the primary measurement - measurement 1.

"Assign Alarms to Measurements" Menu	
Display	**Comments**
Assign alarms to measurements→ **NEXT↓**	Menu subgroup heading. Press → to access menu items, press ↓ to scroll to next "Alarms" menu subgroup. Only displayed if you have set up one or more additional measurements (other than primary).
#1 alarm monitors measurement 1 g/ml **Continue↓ Change→**	Press → to scroll through the list of measurements that have been set up until the one you want appears. Message on third line indicates the measurement type corresponding to the measurement number.
Note: By default, all 16 process alarms are assigned to the measurement 1 (the primary measurement). The previous menu item is repeated for alarms 2 – 16.	
#16 alarm monitors measurement 1 g/ml **Continue↓ Change→**	Scroll through the list of measurements that have been set up until the one you want appears.

Assign "Relays" to Fault, Warning & Mode Alarms

Alarm indicators can also be assigned to fault/warning and mode alarms. By default, the alarm indicator is always set to "Nothing," that is, you must specify the desired alarm indicator for each alarm. In some cases, for example, when the Standardization or Calibration modes are active, a warning message will be displayed even if no other alarm indicator has been assigned. The status and history of alarms can be reviewed using the "view alarm status" and "view alarm history," see "Diagnostics: System Test, Related Items" on page 9-2.

Fault and warning alarms alert you to potential problems with the operation of the gauge. The fault and warning alarms are:

- System fault
- CAL cycle aborted
- Sensor under range
- Sensor over range
- Current output maximum or minimum reached

Mode alarms provide information about the status of the gauge:

- STD mode
- CAL mode
- Hold(s) are active
- Output(s) on alt meas. (Current output(s) set to alternate mode)
- Alternate time constant (in use)
- Keypad is in use
- Power has been off

Assign "Relays" to Fault, Warning & Mode Alarms

"Relays" (or any of the alarm indicators) can be assigned to fault and warning alarms or to mode alarms using the "Assign relays to warning alarms & fault alarms" and the "Assign relays to mode alarms" menu items, respectively.

"Assign Relays to Warning & Fault Alarms" Menu	
Display	**Comments**
Assign "relays" to warning alarms & fault alarms→ **NEXT↓**	Menu subgroup heading. Press → to access menu items, press ↓ to scroll to next "Alarms" menu subgroup. For each of the following menu items, press → to scroll through and select the desired alarm indicator.
System fault alarm indicated by (Nothing) **NEXT↓ CHANGE→**	Press → to select the desired alarm indicator for the "system fault" alarm.
CAL cycle aborted alarm indicated by (Nothing) **NEXT↓ CHANGE→**	Press → to select the desired alarm indicator for the "CAL cycle aborted" alarm.
Sensor under range alarm indicated by (Nothing) **NEXT↓ CHANGE→**	Press → to select the desired alarm indicator for the "sensor under range" alarm. The "sensor under range" alarm will occur during a standardization measurement if the radiation level is less than the background level.
Sensor over range alarm indicated by (Nothing) **NEXT↓ CHANGE→**	Press → to select the desired alarm indicator for the "sensor over range" alarm.
Current max or min alarm indicated by (Nothing) **NEXT↓ CHANGE→**	Press → to select the desired alarm indicator for the "current max or min" alarm. Alarm indicated when the current output has reaches the max or min value.
←Exit from: Assign "relays" to warning alarms and fault alarms NEXT↓	Press ← to exit from this menu subgroup.

"Assign Relays to Mode Alarms" Menu	
Display	**Comments**
Assign "relays" to mode alarms→ **NEXT↓**	Menu subgroup heading. Press → to access menu items, press ↓ to scroll to next "Alarms" menu subgroup. For each of the following menu items, press → to scroll through and select the desired alarm indicator.
STD mode alarm indicated by (Nothing) **NEXT↓ CHANGE→**	Select alarm indicator for the "STD mode" alarm.
CAL mode alarm indicated by (Nothing) **NEXT↓ CHANGE→**	Select alarm indicator for the "CAL mode" alarm.
Hold(s) are active alarm indicated by (Nothing) **NEXT↓ CHANGE→**	One or more "holds" are active. See page 7-4.
Output on alt meas alarm indicated by (Nothing) **NEXT↓ CHANGE→**	The current output has switched to the alternate measurement. See "Modify or Reassign Current Output" on page 6-1.
Alternate time const alarm indicated by (Nothing) **NEXT↓ CHANGE→**	Select alarm indicator for the "alternate time constant" alarm.
Keypad is in use alarm indicated by (Nothing) **NEXT↓ CHANGE→**	The transmitter keypad or a serial port is being used to access the gauge's setup menus. See "Security" on page 9-1.
Power has been off alarm indicated by (Nothing) **NEXT↓ CHANGE→**	The gauge power has been off. Generally not a concern unless there was an unexpected interruption in power. Once saved, the gauge's setup parameters are preserved even when power is disconnected.
←Exit from: Assign "relays" to mode alarms **NEXT↓**	Press ← to exit from this menu subgroup.

Do/Do Not Show Relay Status

In addition to the four "Set up Fault Alarms…" submenus, there is a menu item that allows you to display the status of the relays (if relays are installed) on the fourth line of the measurement display. If you select "Do show relay status," a message similar to

21 RELAY# ON

is displayed, indicating that both relays number 1 and number 2 are currently on. Only the numbers of the relays that are currently "turned on" are shown in the status message.

Set Up & Control Totalizers

Use the "Set up & control totalizers" menu to set up the gauge's four totalizers. This top-level menu is only displayed if the flow input has been setup (see page 5-11) and a flow-related measurement has been assigned as an additional measurement readout (see page 4-3).

Assign & Set Up Totalizer # Menu

A totalizer is simply a counter that can be set up for volume flow, mass flow, and time measurements. Separate "Assign & Set Up…" menu groups are displayed for each totalizer (1-4). You can set up the totalizers in any order. Totalizer values are stored to non-volatile memory once per minute. The last stored value is used following a power outage.

If your gauge has relays installed, each totalizer can close a relay (for an external counter, etc.) at user-specified count intervals. The totalizers can also close relays when particular counts are reached (for batch or sample control).

"Assign & Set Up Totalizer #" Menu	
Display	**Comments**
Assign & set up Totalizer 1 (inactive)→ NEXT↓	Press → to set up Totalizer #1. Press ↓ to move to the "Assign & set up Totalizer 2" menu.
Totalizer 1 will totalize measurement gal/m carrier Continue↓ CHANGE→	Select the measurement to totalize. For example, if you selected "gallons/minute carrier" as a measurement, you can totalize the number of gallons of carrier that pass the flow sensor.
One totalizer count = 10.00 gal	Select the number of units you want each count to represent. For example, if your measurement is in gallons and you want to count tens of gallons, enter 10.0.
Tot 1 gal Do display. Change to "Do not"→ Continue as is.↓	Select whether to display the totalizer count. For example, you might not need or want to display the count if you are using it to control a relay output.
Position of decimal in readout 00000000. {Tot #1} Next↓ ←CHANGE→	Position the "decimal" if you are counting tenths, hundredths, etc. For example, if you are counting tenths of gallons, you can position the decimal one place to the right (0000000.0).
Totalizer 1 output relay 1 Continue↓ CHANGE→	If your gauge has relays installed, select a relay to assign to the totalizer.
Totalizer 1 relay close every 00000010 counts NEXT↓	Displayed if a relay is assigned to the totalizer. Enter the number of counts between relay closures. For example, you can have the relay close every 10 counts.

"Assign & Set Up Totalizer #" Menu (cont.)	
Display	**Comments**
Totalizer 1 Commands {clear, inhibit enable}→ NEXT↓	Press → to enter the "Totalizer 1 Commands" submenu. See "Totalizer # Commands" table below for details.
Batch control setup→ NEXT↓	Press → to enter the "Batch control setup" submenu. See table below for details.
Sampler control setup→ NEXT↓	Press → to enter the "Sampler control setup" submenu. See table below for details.
←Exit from: Assign & set up Totalizer 1 gal NEXT↓	Press → to exit the "Assign & set up Totalizer 1" submenu. See table below for details.

Totalizer # Commands Menu

"Totalizer # Commands" Menu	
Display	**Comments**
Zero Totalizer 1 ←Exit this menu. NEXT↓ EXECUTE CMD→	Set the totalizer count to zero.
Inhibit Totalizer 1 ←Exit this menu. NEXT↓ EXECUTE CMD→	Stop the totalizer count.
Enable Totalizer 1 ←Exit this menu. NEXT↓ EXECUTE CMD→	Start or restart the totalizer count.
Totalizer 1 stops when rate below 0.000 gal/m carrier NEXT↓	Totalizer will stop if volume (or mass) flow rate falls below the specified value.
Totalizer 1 stops when rate above 0.000 gal/m carrier NEXT↓	Totalizer will stop if volume (or mass) flow rate exceeds the specified value.

Batch Control Setup Menu

"Batch Control Setup" Menu	
Display	**Comments**
Totalizer 1 **stop feed** **relay 1** **Continue↓ Change→**	Select a relay to close when the batch "stop" count (entered in the next menu item) is reached. The totalizer holds the counted value when the "stop" relay closes. You must zero the totalizer before starting a new batch. You must specify a relay number in this menu item before the rest of the "batch control" menu items are displayed.
Totalizer 1 stop at **00000000 counts** **for batch control** **NEXT→**	Enter the count at which you want the batch "stop" relay closed.
Totalizer 1 **slow feed** **relay 2** **Continue↓ Change→**	Select a relay to close when the batch "slow" count (entered in the next menu item) is reached. The totalizer will continue counting. This can be used to slow the "feed rate" before reaching the "stop count" specified above.
Totalizer 1 slow at **00000000 counts** **for batch control** **NEXT→**	Enter the count at which you want the batch "slow" relay closed. The "slow count" should be less than the "stop count."

Sampler Control Setup Menu

"Sampler Control Setup" Menu	
Display	**Comments**
Totalizer 1 sampler **relay turns on for** **10 1/4 sec periods** **0 = sampler disabled**	Set the time period (value entered * 0.25 sec) for the sampler relay to remain closed. When the relay closes, the totalizer is automatically reset (counter starts over from zero). Enter a non-zero value to enable the rest of the "sampler control" menu items.
Totalizer 1 sampler **controls** **relay {none}** **Continue↓ Change→**	Select relay number to be used for "sampler control."
Tot 1 samples at **00000000 counts** **NEXT→**	Enter the number of counts between "samples" – the relay is closed each time the totalizer reaches the value entered. (Totalizer is then zeroed and starts counting again.)

Totalizer Action Items Menu

"Totalizer Action Items" Menu	
Display	**Comments**
Clear batch relays & totalizers ←Exit this menu. NEXT↓ EXECUTE CMD→	Zeros all totalizers and clears all batch relays.
Inhibit all totalizers ←Exit this menu. NEXT↓ EXECUTE CMD→	Stops all totalizers from counting.
Enable all totalizers ←Exit this menu. NEXT↓ EXECUTE CMD→	Start all totalizers counting.
Clear all totalizers, but do not enable ←Exit this menu. NEXT↓ EXECUTE CMD→	Zeros all totalizers, but does not restart them. Use "Enable all totalizers" to start counting again.

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Chapter 7 Action Items

The "Action items" top level menu consists of four menu subgroups as shown in the table below. When you execute a command, a message appears telling you that the command is being executed.

"Common Action Items" Menu	
Display	**Comments**
Common action items (clear memory, etc)→ **NEXT↓**	Use this menu to restart the system, erase all entries, clear all holds, change mode, and zero relays
Alarm action items (view, clear, etc)→ **NEXT↓**	Various alarm action items including clear, acknowledge, disable, erase, show history, and end delays for all alarms.
"Hold" action items (Hold reading, etc)→ **NEXT↓**	Use this menu to clear, hold current output, set hold mode value, scale, and set holds for distance, and density.
Serial port related action item→ **NEXT↓**	Use this menu to update, set up, and enable the serial ports.
Totalizer action items (clear all, etc)→ **NEXT↓**	Only displayed if totalizer menus are active, i.e., if a flow input has been set up and a volume- or mass-flow related measurement has been assigned to one of the additional measurements.

Each of these menu subgroups is described in the following sections of this chapter.

Common Action Items

"Common Action Items" Menu	
Display	**Comments**
System restart. Does not affect user data ←Exit this menu. NEXT↓ EXECUTE CMD→	Restarts system (performs a "warm boot"). Temporary memory is erased, but user-entered setup data is not affected.
Erase all entries!!! (except COMM setup) ←Exit this menu. NEXT↓ EXECUTE CMD→	Erase previously entered set up data. All settings except for the serial communication settings are reset to factory defaults. Gauge will behave just like the first time power was applied.
Clear batch relays & totalizers ←Exit this menu. NEXT↓ EXECUTE CMD→	Only displayed if totalizer menus are active (flow input has been set up.) Clear (reset) all batch relays and totalizers. See Chapter 6 for more information on totalizers.
Clear all holds (some now in effect) ←Exit this menu. NEXT↓ EXECUTE CMD→	[CMD 9] Command to clear all holds, if any are in effect. See page 7-4.
Note: If more than three measurements are set up, the readouts 4-6 are displayed in "alternate mode." The display toggles between "normal" and "alternate" modes. Items 4-6 hold the display in alternate or normal modes. Execute a "Clear all holds" command to resume toggling between normal and alternate modes.	
Switch display to alternate mode ←Exit this menu. NEXT↓ EXECUTE CMD→	Displayed when more measurements are set up than can be displayed at one time. Execute command to stop display alternation, showing only the higher-numbered readouts. Execute "Clear all holds" command to resume display alternation.
Switch display to normal mode ←Exit this menu. NEXT↓ EXECUTE CMD→	Similar to "Switch …to alternate" item above. Stops display alternation, showing only the lower-numbered readouts. Execute "Clear all holds" command to resume display alternation.
Switch current out to alternate mode ←Exit this menu. NEXT↓ EXECUTE CMD→	[CMD 132] Displayed when different measurements are assigned to the current output in normal and alternate modes, see page 6-1. Command toggles between "Switch to alternate" and "Switch to normal" current output mode.
Dec LCD ←Exit this menu. NEXT↓ EXECUTE CMD→	Command used to decrease the display contrast on the explosion-proof transmitter, which doesn't have a keypad. Contrast controls are located on the keypad for the standard (NEMA 4X) transmitter.
Inc LCD ←Exit this menu. NEXT↓ EXECUTE CMD→	Command used to increase the display contrast on the explosion-proof transmitter, which doesn't have a keypad. Contrast controls are located on the keypad for the standard (NEMA 4X) transmitter.

Alarm Action Items

"Alarm Action Items" Menu	
Display	**Comments**
`View alarm status→` `NEXT↓`	Press → to review all alarms currently in effect. Includes process, warning, fault, and mode alarms
`View alarm history→` `NEXT↓`	Press → to review history of all alarms that have occurred since the last "clear all alarms" command. Includes process, warning, fault, and mode alarms.

`Clear all alarms`
 	
`←Exit this menu.`
`NEXT↓ EXECUTE CMD→`
	Acknowledge, then clear and reset all alarms. All alarm actions are cleared, but the setup of the alarms is not affected. Alarm actions are re-established when the alarm is again activated.

`Acknowledge`
`all alarms`
`←Exit this menu.`
`NEXT↓ EXECUTE CMD→`
	Acknowledge, but do not clear or reset alarms. All alarm actions (relay, etc.) are cleared, but the actual alarm remains activated. The alarm action is not re-established until the alarm is cleared (by command or change in process), and the alarm is again activated.

`Disable all alarms`
 	
`←Exit this menu.`
`NEXT↓ EXECUTE CMD→`
	Turns off all alarms until manually turned on. This command causes the system to ignore alarms. After executing this command, the display will read "Enable all alarms." Executing the command a second time reinstates all alarms.

`Erase all alarm action`
`assignments`
`←Exit this menu.`
`NEXT↓ EXECUTE CMD→`
	Erases entries for alarm assignments to relays, command execution, display flash, and zeroing current output. Executing this command returns all alarm assignments to their defaults.

Note: The next two menu items are only displayed if "alarm delay times" have been enabled in the "Special Functions" menu (page 8-10) and a delay time for alarm activation or alarm clear has been entered for one or more alarms.	

`End alarm`
`delay command`
`←Exit this menu.`
`NEXT↓ EXECUTE CMD→`
	If an alarm condition is true but alarm activation is being delayed because the alarm delay time has been set, this command cancels the delay time and the alarm will be activated.

`End un-alarm`
`delay command`
`←Exit this menu.`
`NEXT↓ EXECUTE CMD→`
	If an alarm clear condition is true but the alarm clear is being delayed because the alarm clear (un-alarm) delay time has been set, this command cancels the delay time and the alarm will be cleared.

Hold Action Items

"Hold Action Items" Menu	
Display	**Comments**
Clear all holds **(none now in effect)** **←Exit this menu.** **NEXT↓ EXECUTE CMD→**	Execute this command to clear all holds (if any holds are in effect).
Hold current outputs **at max (20.00 mA)** **←Exit this menu.** **NEXT↓ EXECUTE CMD→**	Hold all current outputs at the value entered for the maximum current output.
Hold current outputs **at min (4.000 mA)** **←Exit this menu.** **NEXT↓ EXECUTE CMD→**	Hold all current outputs at the value entered for the minimum current output.
Hold current outputs **at FAULT LOW** **←Exit this menu.** **NEXT↓ EXECUTE CMD→**	Hold all current outputs at the FAULT LOW level, 3.6 mA or less.
Hold current outputs **at FAULT HIGH** **←Exit this menu.** **NEXT↓ EXECUTE CMD→**	Hold all current outputs at the FAULT HIGH level, 20.8 mA or greater.
Current output **hold mode value** **50.00% of scale** **NEXT↓**	Enter value in percent for the mid-range current output hold value. Default value is 50.00%.
Hold current output **at 50.00% of scale** **←Exit this menu.** **NEXT↓ EXECUTE CMD→**	Press → to execute command to hold current output at the mid-range value specified in the previous menu item.
Density hold mode **0.000 g/ml** **NEXT↓**	Enter the hold value for the primary measurement (density).
Hold Density at **0.000 g/ml** **←Exit this menu.** **NEXT↓ EXECUTE CMD→**	Press → to hold primary measurement value at the hold value specified in the previous menu item. After executing command, "Execute CMD→" changes to "Clear holds→." Press → to clear the hold density command.
Flow hold mode **value 0.000 gal/m** **NEXT↓**	Enter the hold value for the flow-related measurement. This item is only displayed if a flow-related measurement has been defined.
Hold flow at **0.000 gal/m** **←Exit this menu.** **NEXT↓ EXECUTE CMD→**	Press → to hold flow measurement value at the hold value specified in the previous menu item. After executing command, "Execute CMD→" changes to "Clear holds→." Press → to clear the hold density command.

Serial Port Related Action Items

"Serial Port Related Action Items" Menu	
Display	**Comments**
Serial port related action items→ **NEXT↓**	Press → to enter the "Hold action items" menu. Press ↓ to return to main heading for the "Action items…" menu group
Update data output to port 1, RS-232 **←Exit this menu.** **NEXT↓ EXECUTE CMD→**	Sends a data set (as defined by serial transmit setup or default) to RS-232 port.
Update data output to port 2, RS-485 **←Exit this menu.** **NEXT↓ EXECUTE CMD→**	Sends a data set (as defined by serial transmit setup or default to RS-485 port.

Totalizer Action Items Menu

The "Totalizer action items" menu is only displayed if totalizer menus are active, i.e., if a flow input has been set up and a volume- or mass-flow related measurement has been assigned to one of the additional measurements. This menu is also available under the "Set up and control totalizers" menu (see Chapter 6).

"Totalizer Action Items" Menu	
Display	**Comments**
Clear batch relays & totalizers **←Exit this menu.** **NEXT↓ EXECUTE CMD→**	Zeros all totalizers. Clears all batch relays and slow or stop counters.
Inhibit all totalizers **←Exit this menu.** **NEXT↓ EXECUTE CMD→**	Stops all totalizers from counting.
Enable all totalizers **←Exit this menu.** **NEXT↓ EXECUTE CMD→**	Starts all totalizers counting.
Clear all totalizers, but do not enable **←Exit this menu.** **NEXT↓ EXECUTE CMD→**	Zeros all totalizers, but does not restart them. Use "Enable all totalizers" to start counting again.

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Chapter 8 Serial Ports, Contact Inputs, Special Fcts

The "Set up serial ports…" menu consists of seven submenu headings as shown in the table below.

- The first four submenus allow you to configure the RS-232 (port 1) and RS-485 (port 2) serial port communication parameters and to set up the "data streaming" parameters.
- The next two submenus allow commands to be assigned to the two contact closure inputs. These commands are then executed when the contact closure inputs are opened or closed.
- The last submenu, "Special functions" includes a variety of specialized menu items for controlling the operation of relays, specifying what is shown on the measurement displays, enabling the "service only" menu items, etc.

"Set Up Serial Ports, Contact Input, or Special Functions" Menu	
Display	**Comments**
Modify port 1 RS-232 configuration→ (baud rate, parity) NEXT↓	Configure RS-232 port, baud rate, parity, word length, etc. Default parameters are 9600, 7-E-1. See "RS-232 and RS-485 Configuration Menus" on page 8-3.
Modify port 2 RS-485 configuration→ (baud rate, parity) NEXT↓	Configure RS-485 port, baud rate, parity, word length, etc. Default parameters are 9600, 7-E-1. Assign unit number for party-line communications. See "RS-232 and RS-485 Configuration Menus" on page 8-3.
Set up port 1 RS-232 data xmit→ (data streaming) NEXT↓	Set up parameters to control the selection, formatting, and transmission of measurement readouts to the terminal over the RS-232 port.
Set up port 2 RS-485 data xmit→ (data streaming) NEXT↓	Set up parameters to control the selection, formatting, and transmission of measurement readouts to the terminal over the RS-485 port. This menu also includes parameters for setting up party-line communications.
Set up serial INPUT: carrier and solids gravity → NEXT↓	Allows carrier or solids gravity (for slurries) to be input to the gauge via a serial port, either RS-232 or RS-485.
Assign commands to execute on contact open/close 1 → NEXT↓	Assign commands to be executed based on user-supplied open/close signal to contact closure #1. This menu is repeated for each of the contact closure switches.
special functions→ NEXT↓	Various specialized menu items that enable/disable relay delay times, relay latching, service only items, etc.

Serial Ports

The gauge offers both an RS-232 single-drop (port 1) and an RS-485 multi-drop (port 2) serial interface. Each port provides independent access to the gauge's measurement and software functions. Both ports can be connected to the gauge simultaneously; however, the setup menus can only be accessed by one port at a time.

You communicate with the gauge using a remote ANSI terminal, a PC with terminal emulation software, or a Hand-Held Terminal (HHT). You can connect the RS-232 port of the gauge directly to the RS-232 Com port on a PC. To connect the RS-485 port of the gauge to the Com port on a PC requires an RS-232 to RS-485 adapter. Alternately, you can connect a Thermo Scientific HHT directly to the RS-485 port on the gauge.

The RS-485 port supports multi-unit "party-line" communications. A maximum of 32 units can be connected to the party-line. A unit assigned the default unit number of zero will behave as if it is the only unit in use.

Note: Party-line Communications – Initial Setup!

To communicate with multiple gauges via an RS-485 party-line, each unit must be assigned a unique unit number to allow each unit to be addressed individually. All gauges are assigned Unit # 0 by default.

To assign a unique unit number to each gauge, you must be able to communicate with each gauge individually. This can be achieved by disconnecting each gauge from the party-line in turn and then communicating with the disconnected gauge directly. Alternately, remove power from all gauges except one, assign a unit number to the powered gauge, and repeat the process for each gauge.

Thermo Fisher offers TMTComm software for your PC that emulates a Thermo Scientific HHT and also allows you to set up and monitor multiple gauges over an RS-485 party-line. In addition, the TMTComm software allows you to download gauge setup parameters to a PC file and to later upload a saved setup file back to the gauge.

Serial Port Related Menus

There are four menu subgroups used to set up and control the serial ports, two for the RS-232 port and two for the RS-485 port. When you make entries for the parameters, the actual port operation will not change until you save the entries by exiting the menus.

The serial port communication settings are configured using the "Modify port 1 (RS-232) configuration" and the "Modify port 2 (RS-485) configuration" menus. The "Set up port 1 (RS-232) data transmission" and "Set up port 2 (RS-485) data transmission" menus control the selection, formatting, and transmission of measurement readouts to the terminal.

RS-232 and RS-485 Configuration Menus

Use this menu to set up the baud rate and other communication parameters for each port. The RS-232 and RS-485 configuration menus are very similar. The table below shows the RS-485 submenu. Most menu items apply to both ports and are identical except for the reference to "port 1 RS-232" or "port 2 RS-485." Items with the comment "*Port 2 RS-485 only*" are related to party-line communications setup and will not appear in the RS-232 menu.

"Modify Port 2 RS-485 (Port 1 RS-232) Configuration" Menu	
Display	**Comments**
Modify port 2 RS-485 configuration→ (baud rate, parity) NEXT↓	Press → key to access the "Modify port configuration" setting menus.
Do not disable port 2 RS-485 Change to "Do"→ Continue as is.↓	Turns port on or off. Change to "Do" if you need to temporarily disable the port. **Note: If you disable the RS-485 (RS-232) port, you must communicate with the gauge via the other port RS-232 (RS-485) or via the keypad to re-enable the port.**
Unit number of this gauge (0 to 32) 0 (Should be 0 if not party-line.) NEXT↓	*Port 2 RS-485 only.* Default value is "0" for single unit operations. Assign unit i.d. number (1-32) for party-line communications. Master gauge (unit) is normally assigned to be unit 1 for party-line comm's.
interface RS-485 with ANCI terminal (or PC emulation) Continue↓ Change→	Interface RS-485 with the following serial devices: - ANSI terminal (or PC emulation) - Handheld terminal - "Blind" mode (no key echo, menu or words)
Port 2 RS-485 9600 baud Continue↓ Change→	Select baud rate. Valid choices are 1200, 2400, 4800, or 9600 bps.
Port 2 RS-485 uses 7 bit word Change to "8"→ Continue as is.↓	Select word length – 7- or 8-bit words.
Port 2 RS-485 uses even parity Change to "none"→ Continue as is.↓	Select parity - even parity or none.
Do send LineFeed with CR for NewLine Change to "Do not"→ ←Exit port 1 setup.	Specify "Do" or "Do not" send a LineFeed (ASCII char 10) after a Carriage Return (ASCII char 13) for a NewLine.

Terminal Types

The menus allow you to configure the RS-232 (port 1) and RS-485 (port 2) ports to communicate with the following devices.

- *ANSI terminal*: The gauge sends ANSI escape sequences for screen and cursor control which are supported by ANSI terminals and by most PC-based communication packages. This setup allows full access to the gauge menu system from the terminal.
- *Hand–Held terminal*: This configuration supports the Thermo Scientific HHT or the TMTComm software emulation of the HHT.
- *Blind mode*: This is a special mode that supports access to the gauge via a user-written program or script. The menu system is not available, rather the hexadecimal version of the direct entry keyboard codes must be used to enter parameters. The gauge unit will echo a ">" character (ASCII code 62) if the code is understood, otherwise it sends a "<" character (ASCII code 60). This mode supports user-written scripts from within a terminal emulation communications package to automate a setup or a data monitoring procedure.

Note: Do not attempt to use "Blind mode" with the Hand-Held Terminal. The HHT does not support the hexadecimal direct entry codes required for the blind mode.

Data Transmission (data streaming) Setup

Note: Data streaming should only be used when communicating with a remote terminal or with a PC running terminal emulation software. Due to display limitations (4 line x 20 character), the Hand-Held Terminal does not support data streaming.

This menu controls the selection, formatting, and transmission of real-time measurement data to a serial device via the RS-232 or RS-485 ports. When a port is set up for data streaming (continuous transmission of readings), the system sends a readout update on a regular basis. This update interval can be varied from 1 second to 9999 seconds between updates. The update data can include the readouts from any or all of the measurements that have been set up (measurements 1 through 8).

Data streaming on a party-line (RS-485 multiple units) is automatically suspended when you send the "SLEEP" command, and is normally suspended when you "CONNECT" to any unit on the party line. You can tell a unit to "output while in connect" using the "Set up Port…" menus (described below) so the unit will continue to data stream, except while you are in the menu system. A unit with a unit number of zero will automatically "output while in connect."

A reading is a measurement such as density. A data set is all of the readings being sent by a particular unit. By default, a NEWLINE is sent after each reading. A HOME and a CLEAR are sent after each set. This causes the data to update at the same place on the screen.

"Set up Port 2 RS-485 Data Xmit" Menu	
Display	**Comments**
Set up port 2 RS-485 data transmission→ (data streaming) NEXT↓	Press → key to access the "Set up port…" menus to configure data transmission (data streaming).
Do not inhibit RS-485 data streaming. Change to "Do"→ Continue as is.↓	Turns data streaming on or off. If you inhibit data streaming (select "Do"), data transmission stops until you again select "Do not."
The following menu item is repeated for all measurements (1-8) which have been set up.	
Do not send meas 1 g/ml density to RS-485 port. NEXT↓ CHANGE→	Similar menu item is displayed for each measurement number you have set up. You can enable or disable the transmission of the data for each measurement individually.
Do not data stream in "connect" mode Change to "Do"→ Continue as is.↓	*Applies to RS-485 only.* Select "Do" to have the gauge continue data streaming while the gauge is in "connect" mode. See page 8-6.
This is a slave unit (xmit control). Change to "master"→ Continue as is.↓	*Applies to RS-485 only.* Specify whether this gauge is a slave or the master for party-line communications. See page 8-6.
Set up data format.→ NEXT↓	Press → to access data format menu items. See page 8-8.
Set up header, form feed, message, etc {RS-232}→ NEXT↓	Menu subgroup header. Only displayed if non-packet data transmission has been selected. See page 8-9 for a description of menu options.
Highest unit number in group 8 NEXT↓	*Applies to RS-485 only.* Only appears in setup for Master unit. Enter the highest unit number assigned to any gauge on the party-line. Maximum number of units is 32.
Port 2 RS-485 update time 0 sec NEXT↓	*For RS-485 party-line operations:* The update time for the master unit, must be set to the minimum time indicated or greater. See page 8-6. *For RS-232*: Set the time (seconds) between updates.

Party–Line Communications

This section describes various aspects of setting up and using party-line communications for multiple gauges.

Setting Up a Party-Line

To set up party-line communications from the local keypad and display of each gauge on the party-line, use the following procedure.

1. Wire all units to the RS-485 common lines as per the wiring instructions in the installation guide provided with your gauge.
2. For each unit, ensure the "Modify port…" menu communication settings is the same (baud rate, parity, and handshake). Assign each gauge a unique non–zero unit number. See page 8-3.
4. In the "Set up port…data transmission" menu (page 8-4), set up the desired RS-485 measurement selections, data formats, user messages, etc., for each unit.
5. Using the "Set up port…data transmission" menu, configure the "master" unit as follows. (The master unit is usually assigned the lowest unit number, typically unit #1.)
   - Specify that this unit is the master unit.
   - Specify an appropriate RS-485 update time (see the next section, "Master Update Time."
6. Using the "Set up port…data transmission" menu, configure each of the "slave" units as follows:
   - Specify that the unit is a slave.
   - Specify that the RS-485 update time is zero (0).

Party–Line Modes

The party line has three distinct modes of operation, Unconnected, Connected, and Sleep. Normally, the party line operates in the Unconnected mode.

A unit in Unconnected mode only responds to:

- a connect ESCAPE sequence with the proper unit–number suffix
- a command code with the proper unit–number suffix
- an all units SLEEP command
- an all units WAKEUP command
- a data streaming sync character

When a unit is in "Connect" mode, the unit's setup menus can be accessed (if not in Blind or Printer mode) and the unit will continue to send updates if "Do data stream in connect mode" has been enabled. Connect mode is exited when a valid DISCONNECT command is received.

A unit in Sleep mode will not respond to anything except a valid WAKEUP Command.

Party-Line Commands

Some useful escape codes are:

ESC [Z# #	CONNECT command. (## = unit number, e.g., 01 or 25).
ESC O Q	DISCONNECT command
ESC X C	SLEEP command (ANSI)
ESC X D	WAKEUP command
ESC X 1	CONNECT acknowledge (gauge sends this to acknowledge the CONNECT command)
ESC X 2	Acknowledge DISCONNECT command
ESC O V	ID REQUEST command
ESC X 4	ID REQUEST TERMINATED command
ESC [Yuu;cc;vvdd	POLLING command, where uu = unit number (in hex) on party line cc = command (in hex) vv = unit number + 3 (in hex) dd = command number +3 (in hex)

Presently, only three "cc" command values are supported:

86 – Single data stream update on RS-485
8B – Download NVRAM contents to PC on RS-485
8D – Upload NVRAM contents to gauge

Example: ESC [Y01;86;0489 sends the "Single Update" command to Unit 1.

Party-Line Limitations

The RS-485 party-line uses half-duplex communications. That is, only one system can send information at any given time. For instance, if you are entering data during the time window for a gauge to send its output, garbled characters may result. This occurs mainly when the gauge's menu system is being accessed in Connect mode. In this circumstance, you should verify that the gauge received the correct setup information before continuing.

The party-line also behaves erratically when more than one device issues synch characters. This can happen if there is more than one master on the link, or if synch characters are sent from a terminal or PC.

Data streaming has to be explicitly turned off in the "Set up port 2 RS-485 data transmission" menu. Deselecting all measurements from data streaming will not inhibit data streaming. Rather, the gauge will send a default update with all measurements, escape string positioning, and the "For setup..." message. This default update is intended to appear after a complete NVRAM erasure (i.e., performing a CMD 74), when data streaming has not yet been configured. Also, the data formatting and update time menus will not be available until at least one measurement is selected.

Set Up Data Format Menu

The “Set up data format” menu items establish the formatting used for text transmission (for example, labeling, tabulation, and pagination) for measurements sent to a terminal or printer. In the following menu items, a “reading” refers to a particular measurement such as density. A data set refers to all the readings being transmitted by a particular unit (gauge). By default, a NEWLINE is sent after each reading. A HOME and a CLEAR are sent after each data set. This causes the data to update at the same place on the screen.

The “Set up data format” menus for non-packet data are identical for the RS-232 and the RS-485 ports except for the references to the port number. The table below shows the menu items as they appear for the RS-232 port.

“Set Up Data Format” Menu	
Display	**Comments**
Set up data format→ **NEXT↓**	The following menu items allow you to setup the format of the data stream sent over the serial port. The menu items are identical for the RS-232 and RS-485 ports.
Do not put meas num before each reading. Change to “Do”→ Continue as is.↓	Select “Do” to put the measurement number (1 to 8) before each reading.
Do send NEWLINE after each reading. Change to “Do not”→ Continue as is.↓	“Do” sends a logical NEWLINE after each reading. “Do not” suppresses the NEWLINE.
Do send units with each reading. Change to “Do not”→ Continue as is.↓	“Do” sends the measurements unit string. “Do not” suppresses the units string.
Do not put unit num before each reading. Change to “Do”→ Continue as is.↓	*Applies to RS-485 party line communications only*. Sends the gauge unit number with each reading.
Do not put TAB after each reading. Change to “Do”→ Continue as is.↓	Change to “Do” to append a TAB (ASCII char 9) after each reading. Useful for sending columnar data to a printer.
Do CLEAR & HOME before each data set. Change to “Do not”→ Continue as is.↓	Sends an ANSI clear/home escape string after data set.
Do not send NEWLINE after each data set. Change to “Do”→ Continue as is.↓	Change to “Do” to send logical NEWLINE after transmission of a gauge’s data set.

"Set Up Data Format" Menu (cont.)	
Display	**Comments**
Do not send user msg before each data set. Change to "Do"→ Continue as is.↓	Change to "Do" to send a custom (user-defined) message before each data set.
Do not put unit num before each data set. Change to "Do"→ Continue as is.↓	*Applies to RS-485 party line communications only*. Change to "Do" to send the gauge unit number before transmission of each gauge's data set.
Set up custom data set messages {RS-232}→ NEXT↓	Displayed if "Do send usr msg" was selected above. Menu is similar to "Custom Units Messages," see page 8-12, and uses the same message data base.
Port 1 (RS-232) start readout at screen row 0 NEXT↓	Sends ANSI command to position readout start at a specified row number. Not available in blind, printer, or hand-held terminal modes.
Port 1 (RS-232) start readout at screen column 0 NEXT↓	Sends ANSI command to position readout start at a specified column number. Not available in blind, or hand-held terminal modes.

Contact Inputs

You can assign commands to be executed based on a user-provided contact input open or close. The following menu items are available for each contact closure input installed on your gauge.

Note: If you do not have a current I/O board installed, you will not see the "Contact closure inputs" options.

"Assign Commands to Execute on Contact Open/Close" Menu	
Display	**Comments**
Do nothing command executed by closing switch 1. Use↓ Chg→	Press → to scroll through the list of commands until the one you want is displayed. Commands include, hold current output at max/min, clear all alarms, clear all holds, etc.
Do nothing command executed by opening switch 1. Use↓ Chg→	Press → to scroll through the list of commands until the one you want is displayed. Typically, select a command to reverse the effect of the contact close command.
Note: These menu items are repeated for contact closure input number 2.	

Special Functions

"Special Functions" Menu	
Display	**Comments**
Do not enable alarm related selections Change to "Do"→ Continue as is.↓	Only displayed if relays are *not* installed. Change to "Do" to enable the alarm-related menu selections throughout the setup menus.
Do not enable alarm relay delay times. Change to "Do"→ Continue as is.↓	Only displayed if relays are installed. Change to "Do" to enable relay alarm delay time entries in menus that set up process limit alarms.
Do not make relay latching available Change to "Do"→ Continue as is.↓	Only displayed if relays are installed. Change to "Do" to enable relay latch mode entries in menus that set up process limit alarms.
Do not disable "For setup", etc. display Change to "Do"→ Continue as is.↓	Change to "Do" to suppress the message on line 4 (warnings and setup direction) of the normal readout. This allows all four lines to be used for measurement readouts.
Do not show relay status on readout. Change to "Do"→ Continue as is.↓	Change to "Do" to display relay status on measurement display. The numbers of the relays currently turned on are displayed along with the normal measurement readouts.
Do not disable dynamic tracking Change to "Do"→ Continue as is.↓	Leave this item set to "Do not" so that dynamic tracking remains enabled.
Do not enable service only items. Change to "Do"→ Continue as is.↓	Causes additional "service only" setup items to show up in several areas. Default condition is "Do not."
Do not enable multiple setups Change to "Do"→ Continue as is.↓	Change to "Do" to allow the gauge calibration data to be stored in one of eight data sets (1 - 8). When enabled the "Store/retrieve multiple setups" menu chain will be displayed under the "Set up density" menu.
Do enable serial dump items. Change to "Do not"→ Continue as is.↓	Change to "Do not" to disable commands to dump and retrieve setup data via the serial ports. See "Serial Port Related Action Items" on page 7-5.
Special span entries density→ NEXT↓	Submenu allowing the current output span for the primary measurement to be changed, overriding span defined by entries in the primary setup section.
Set up custom units messages→ NEXT↓	Submenu group to set up custom messages. See the next section for details.

Special Relay Controls

The three menu items in the table below are displayed in the "Set up alarm" menu if the corresponding relay-related options have been enabled in the "Special Functions" menu, see page 8-10. These menu items provide special controls for relays that have been assigned as an alarm indicator.

"Set Up Alarm" Menu - Relay Indicator Related Items	
Display	**Comments**
Alarm relay 1 set delay 0 seconds (0-255 s after alarm) NEXT↓	Displayed only if "alarm relay delay times" is enabled. The activate alarm condition must persist for the delay time entered before the alarm is activated.
Alarm relay 1 clear delay 0 seconds (0-255 s after alarm has cleared) NEXT↓	Displayed only if "alarm relay delay times" is enabled. The alarm clear condition must persist for the delay time entered before the alarm is cleared.
Do not use latching mode with relay 1. Change to "Do" → Continue as is.↓	Displayed only if "relay latching" is enabled. If latching is enabled, the relay remains in the alarm state when the alarm has cleared. The relay state is cleared by a "Clear alarms" command (see page 7-3), or when power is turned off.

Multiple Setups

When multiple setups are enabled under the "Special functions" menu, the "Store/ retrieve/view multiple setups" menus shown below will be available under the "Set up density…" menu.

"Store/Retreive/View Multiple Setups" Menu	
Display	**Comments**
Commands to store setup as one of nine configurations → NEXT↓	Provides commands to select the desired data set (1-8) to store calibration data and then to store the calibration data.
Commands to retrieve a stored setup → NEXT↓	Provides commands to retrieve calibration data previously stored in a data set (1-8).
View data in stored setups → NEXT↓	Allows you to view the calibration values in previously stored data sets.

When a stored data set has been retrieved for use, the number of the data set is displayed next to the "For setup, press →" message on the fourth line of the display. For example, "2 For setup, press →" indicates that stored data set 2 is currently in use.

Custom Units Messages

User entered messages can be used to redefine units and to provide headers for serial data. The system supports up to eight custom (user defined) messages strings of up to ten characters each. Custom message menus are found in the “Special functions” menu described in the previous section, as well as in the “Set up data format” submenu of the “Set up port…data transmission” menu (see page 8-8). This menu option is also displayed when you enable display scaling (see page 4-8).

In each case, you can select any of the custom messages that have been entered. You can also modify an existing message or add a new message.

You enter message characters by using the right and left arrow keys to scroll through the available character selections or by using the ASCII codes for the characters given in the table below. The entry screen for each character shows the rest of the ten-character message to provide context for your selection.

Note: Enter a value of 0 (zero) for the first character to reset the message to the null string, the default value.

32	SP(ace)	51	3	70	F	89	Y	108	l
33	!	52	4	71	G	90	Z	109	m
34	"	53	5	72	H	91	[	110	n
35	#	54	6	73	I	92	¥	111	o
36	$	55	7	74	J	93	]	112	p
37	%	56	8	75	K	94	^	113	q
38	&	57	9	76	L	95	_	114	r
39	’	58	:	77	M	96	`	115	s
40	(	59	;	78	N	97	a	116	t
41	)	60	<	79	O	98	b	117	u
42	*	61	=	80	P	99	c	118	v
43	+	62	>	81	Q	100	d	119	w
44	,	63	?	82	R	101	e	120	x
45	-	64	@	83	S	102	f	121	y
46	.	65	A	84	T	103	g	122	z
47	/	66	B	85	U	104	h	123	{
48	0 (zero)	67	C	86	V	105	I	124	|
49	1	68	D	87	W	106	j	125	}
50	2	69	E	88	X	107	k	126	→

"Set Up Custom Units Messages" Menu	
Display	**Comments**
Set up custom units messages→ **NEXT↓**	Press → to access the custom message setup menu items. There is a maximum of eight messages, ten characters per message. The custom units message has no effect on the measurement readout.
Character #1 of custom message #1 **0 ←→ ""** **NEXT↓**	Enter first character of the first custom message. Use the arrow keys to scroll through the available characters, or enter the ASCII character code from the table above. Enter "0" to reset to default (null) value.
Note: Press ↓ after selecting a character to move to the next character in the message. Pressing ↓ twice moves to the next message.	
Character #1 of custom message #2 **0 ←→ ""** **NEXT↓**	Enter characters for custom message 2, or press ↓ to continue to the next menu item.
Note: The next menu item is repeated for each measurement that has been set up using the "Set up additional measurements" menu.	
Meas #1 use message #0 for readout units "g/ml" **Continue↓ Change→**	Select message to use with measurement number 1. The default message (#0) is shown – "g/ml." Press → to scroll through and select one of the custom messages. Leave at #0 to use default message.

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Chapter 9 Security, Diagnostics, and Service Menus

The "Security, service and diagnostic functions" menus is divided into four primary menu subgroups.

- Security items: (Password, etc.)
- Diagnostics: system test, related items
- User service & related Items
- Factory service & related Items
  (only available if "Service only items" are enabled)

These menu groups are described in this chapter.

Security Items

This menu provides password protection to prevent unauthorized personnel from making new setup entries or changing existing entries in the Setup Menus.

"Security Items" Menu	
Display	**Comments**

`Security items:`
`Password, etc.)`
 	
`NEXT→`
	Press → to access the "Security items" menus.

`Password ********`
`(Lock out setup)`
 	
`NEXT↓ HELP→`
	A password can be any combination of numbers up to eight digits long. Once a password is entered, the first item in SETUP will ask for the password. To disable the password function, enter "0" here.

`Entries have been`
`changed 14 times`
`(read only)`
`NEXT↓ HELP→`
	Whenever entries are changed and saved (save is automatic when leaving SETUP), this count is increased by one. This feature can be used to verify that the system has not been changed.

`Keypad is in use`
`alarm indicated by`
`(Nothing)`
`NEXT↓ CHANGE→`
	This alarm indicates that the system setup menus are being accessed either via the keypad or serial port. Use the → key to scroll through the available alarm indicators.

The password is a numeric entry that can be from 1-8 digits in length and include any combination of the digits 0-9. For example, "056," "4321," and "12345678" are all valid passwords. Leading 0's are part of the password and must be entered.

Caution: Do not forget your password! Once a password is established, you cannot change entries or do fine tuning without the password.

Contact Thermo Fisher for assistance in case of a lost password.

Once a password has been set, you must enter this password whenever you use the set up menus. Once you enter the password and access the setup menus, you will be able to reenter the menus without entering the password for a period of ~5 minutes. To disable the password, enter "0" for the password value.

The "Entries have been changed xx times" item can be used to check for unauthorized entries. The value in this entry is updated each time a setup entry is changed and saved. After you complete the setup of your gauge, note this value and then periodically check this item to see if the number has changed. If the number has changed, it indicates that one or more menu setup items have been changed and saved.

The "Keypad is in use" item can also help you detect unauthorized changes by activating an alarm when the system is accessed by either the keypad or the serial port.

Diagnostics: System Test, Related Items

The gauge is highly fault tolerant. If you do encounter a problem, this menu offers several helpful tools. Should you need to contact Thermo Fisher about a problem, note the "version number" item to determine the software revision installed in your system. The actual date and time of the software build is also listed here if the "Service only items" are enabled.

Execute the "Run self test" command to perform the system diagnostic check. The system performs an automatic test and verification function every ten minutes. All user-entered data is double stored and periodically cross-checked. Errors are automatically corrected and an alarm is activated when an error is detected.

"Diagnostics: System Test, Related Items" Menu	
Display	**Comments**
Diagnostics: system test, related items→ **NEXT↓**	Press → to access the "Diagnostic…" menu items.
Run self test **←Exit this menu.** **NEXT↓ EXECUTE CMD→**	Execute the self-test command to test the various types of memory and data integrity.
View alarm status→ **NEXT↓**	View any alarms resulting from self-test as well as other alarms presently in effect, including process, warning, fault, and mode alarms.
View alarm history→ **NEXT↓**	Review all alarms that have occurred since the last clear alarms command, including process, warning, fault, and mode alarms.
Serial port error logs→ **NEXT↓**	**[Service only item]** Submenu containing error logs for RS-232 and RS-485 serial ports.

"Diagnostics: System test, related items" Menu (cont.)	
Display	**Comments**
Relay history logs→ **NEXT↓**	Only displayed if relays are installed. Submenu containing logs of relay activity including cumulative on time and number of times activated. See "Relay History Logs" table below.
Program rev # **5.01** **10-May-2001** **15:34:51 NEXT↓**	Software version number. Note this number when contacting Thermo Fisher with questions. Software build date and time stamp is only displayed when "Service only" items are enabled.
Snapshot MENU→ **NEXT↓**	**[Service only item]** Show instantaneous value of various dynamic internal parameters. See the "Snapshot" menu table below.
View internal constants→ **NEXT↓**	**[Service only item]** Submenu to display values of various internal constants that are computed based on user entries.
Last STD cycle was: **full of carrier**** **NEXT↓**	Read only item indicating standard configuration during the last STD cycle.
STD mode @ CAL cycle **full of carrier **** **NEXT↓**	Read only item indicating the standard configuration during the last CAL cycle.

Relay History Logs

"Relay History Logs" Menu	
Display	**Comments**
Relay 1 on time **142.1 hours** **(non-volatile save** **once per hour) NEXT↓**	Cumulative total of "on" time (need not be continuous) for relay 1. This menu item is repeated for each relay installed. Only displayed of relay has been active.
Relay 1 has been **on 20 times.** **(non-volatile save** **once per hour) NEXT↓**	Cumulative number of times relay 1 has been turned on (since last time memory was cleared). This menu item is repeated for each relay installed.

Snapshot Menu

This item (in the "Diagnostics" menu) displays the current (instantaneous) value of various dynamic internal parameters. This item only shows up if you enable "Service only items" in the "Special functions" menu.

"Snapshot" Menu [Service only item]	
Display	**Comments**
Snapshot MENU→ **NEXT↓**	**[Service only item]** Press → to view instantaneous value of various dynamic internal parameters.
Note: The fourth line of several snapshot menu items reads: "←CONT UPDATE→ NEXT↓" Press → to UPDATE the snapshot) value. Press ← to switch to CONTinuous update mode. Display will then show ←FREEZE. Press ← again to return to the "FREEZE" or snapshot mode.	
Readout from measurement 1 **3.785 g/ml** **←CONT UPDATE→ NEXT↓**	Display snapshot of measurement 1readout.
Readout from measurement 2 **20.00 lit/m** **←CONT UPDATE→**	Displays the present reading from measurement 2, if measurement 2 has been set up.
Note: The above menu item is repeated for each measurement that has been setup using the "Set up additional measurements" menu.	
Counter chip register status **NEXT↓**	Submenu that displays the values of scintillation detector counter chip registers. Values are frozen when you access this item. Used for service diagnostic purposes only.
Effective path length 8.364 cm **NEXT↓**	Effective path length used in the calculation of the density based on the detector signal. Gauge computes this value based on the "pipe ID."
Temperature readout 6.037 deg C **NEXT↓**	Current temperature readout. Displayed if process temperature compensation has been set up.
Flow **350.3 ml/sec** **NEXT↓**	Current value of the flow input in ml/sec. Displayed if flow has been setup.
Internal value of flow signal **0.000 ml/sec** **NEXT↓**	

"Snapshot" Menu (cont.) [Service only item]	
Display	**Comments**
Internal value of sensor signal 2568 cps ←CONT UPDATE→ NEXT↓	Filtered value of radiation level (counts per second) measured by scintillation detector after background level has been subtracted.
Internal value of sensor to CAL ratio 0.3565 ←CONT UPDATE→ NEXT↓	Ratio of: (measured radiation counts – background counts) to (standardization counts – background counts)
Internal value of IOUT1 % 60.80 % ←CONT UPDATE→ NEXT↓	Internal value of current output - percent of range.
Internal value of IOUT1 (fp) 5429 (7998=max) ←CONT UPDATE→ NEXT↓	Internal value of current output relative to range of 0–8000 (floating point).
Internal value of IOUT1 (fixed pt) 5430 (7998=max) UPDATE→ NEXT↓	Internal value of current output relative to range of 0–8000 (floating point).
HV ctl 1.209E-2 ←CONT UPDATE→ NEXT↓	Current high voltage control (internal software) value. [Only displayed if using a scintillator detector.]
HV delta 1.912E-2 NEXT↓	Current high voltage control adjustment (internal software) value. [Only displayed if using a scintillator detector.]
HV ctl chg 1.0 NEXT↓	Current high voltage control adjustment (internal software) weighting factor. Value ranges between 1.0 and 255.0. [Only displayed if using a scintillator detector.]

User Service & Related Items

The "User service…" menu contains commands that you can execute from the menu.

"User Service & Related Items" Menu	
Display	**Comments**
System restart. Does not affect user data ←Exit this menu NEXT↓ EXECUTE CMD→	Re-initializes system. Erases temporary memory, but does not affect user-entered setup data.
Erase all entries!!! (except COMM setup) ←Exit this menu NEXT↓ EXECUTE CMD→	Erase all previously entered set up data. All settings except for serial communication settings are reset to factory defaults. Gauge will behave just like the first time power was applied.
Clear all holds (none now in effect) ←Exit this menu. NEXT↓ EXECUTE CMD→	Execute this command to clear all holds (if any) that are in effect.
Hold current outputs at max (20.00 mA) ←Exit this menu. NEXT↓ EXECUTE CMD→	Press → to hold the current output(s) at the value entered for the maximum current output.
Hold current outputs at min (4.000 mA) ←Exit this menu. NEXT↓ EXECUTE CMD→	Press → to hold the current output(s) at the value entered for the minimum current output.
Hold current outputs at FAULT LOW ←Exit this menu. NEXT↓ EXECUTE CMD→	Holds all current output at the Fault Low level (3.6 mA).
Hold current outputs at FAULT HIGH ←Exit this menu. NEXT↓ EXECUTE CMD→	Holds all current output at the Fault High level (20.8 mA).
Current output hold mode value 50.00% of scale NEXT↓	Enter value in percent for the mid-range current output hold value. Default value is 50.00%.
Hold current outputs at 50.00% of scale ←Exit this menu. NEXT↓ EXECUTE CMD→	Press → to execute command to hold current output(s) at the value specified in the previous menu item.
Density hold mode 0.000 g/ml NEXT↓	Enter the hold value for the primary measurement (density).

"User Service & Related Items" Menu	
Display	**Comments**
Hold density at 0.000 g/ml ←Exit this menu. NEXT↓ EXECUTE CMD→	Press → to hold primary measurement value at the hold value specified in the previous menu item. After executing command, "Execute CMD→" changes to "Clear holds→." Press → to clear the hold density command.
Flow hold mode value 0.000 gal/m NEXT↓	Enter the hold value for the flow-related measurement. This item is only displayed if a flow-related measurement has been defined.
Hold flow at 0.000 gal/m ←Exit this menu. NEXT↓ EXECUTE CMD→	Press → to hold flow measurement value at the hold value specified in the previous menu item. After executing command, "Execute CMD→" changes to "Clear holds→." Press → to clear the hold density command.
Review measurement assignments 1-8→ NEXT↓	Press → to view current measurements.
Do not enable service only items. Change to "Do"→ Continue as is.↓	Change to "Do" to enable the "Service only items." This will enable a variety of additional menu items throughout the setup menus. This also enables the "Factory service" menu items shown in the next table.

Factory Service & Related Items

The following menu is only displayed if "Do enable service only items" is selected in the "Special functions" menu.

Factory Service & Related Items" Menu [Service only item]	
Display	**Comments**
Program rev # 5.01 10-May-2001 15:34:51 NEXT↓	The program revision number and the date/time of the software build.
Stack statistics Avail: 1847 bytes Used: 112 bytes NEXT↓	Statistics regarding memory usage – for service diagnostic purposes only.
Hardware diagnostics→ NEXT↓	Menu subgroup header. Menu items summarize the hardware configuration – number and type of boards installed, number of relays installed, detector-type jumper setting, etc.
View error status: bad NV writes, etc.→ NEXT↓	Menu subgroup displays various memory related status messages below – for service diagnostic purposes only.

Factory Service & Related Items" Menu [Service only item] (cont.)	
Display	**Comments**
Test relays→ **NEXT↓**	Menu subgroup header. This menu item is not displayed if relays are not installed. See "Test relays" menu table below.
Do not enable RS-232 test mode Change to "Do"→ Continue as is.↓	Enable the RS-232 test mode – for factory service diagnostic purposes only.
Do not enable RS-485 test mode Change to "Do"→ Continue as is.↓	Enable the RS-485 test mode – for factory service diagnostic purposes only.
Do not disable bad entry testing Change to "Do"→ Continue as is.↓	Change to "Do" to disable testing for invalid entries. Normally, this item should be set to "Do not" except for diagnostic purposes.
Signal diagnostics→ **NEXT↓**	Menu subgroup header. See "Signal diagnostics" menu table below.
View menu, special measurement, alarm & command codes→ **NEXT↓**	Allows you to scroll through a list of the codes for commands, special measurement code base numbers, and alarms.

Test Relays (factory service submenu)

Note: This submenu is only displayed if relays are installed.

"Test Relays" (factory service submenu) [service only item]	
Display	**Comments**
Commands 88, 89, 153 **relay to test = #1** **NEXT↓**	Enter relay number to test-set and/or test-clear in the next two menu items.
Test-set relay #1 **←Exit this menu.** **NEXT↓ EXECUTE CMD→**	Press → to test "setting" (turn on) the relay specified in the above menu item.
Test-clr relay #1 **←Exit this menu.** **NEXT↓ EXECUTE CMD→**	Press → to test "clearing" (turn off) the relay specified in the above.
Test all relays on **←Exit this menu.** **NEXT↓ EXECUTE CMD→**	Press → to test all relays on.
Test all relays off **←Exit this menu.** **NEXT↓ EXECUTE CMD→**	Press → to test clearing (turning off) all relays.
Clear all holds **(none now in effect)** **←Exit this menu.** **NEXT↓ EXECUTE CMD→**	Press → to clear any holds in effect.
Test step relay #1 **←Exit this menu.** **NEXT↓ EXECUTE CMD→**	Press → to test closing each relay in sequence, beginning with relay number entered in first item of this menu.

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Chapter 10 Contact Information

The local representative is your first contact for support and is well equipped to answer questions and provide application assistance. You can also obtain support by contacting Thermo Fisher directly.

In the United States:

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Sugar Land, TX 77478

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Fax: 713-272-2272

In Canada:

Thermo Fisher Scientific

14 Gormley Industrial Avenue

Gormley, Ontario

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Phone: 905-888-8808

Fax: 905-888-8828

On the Web:

www.thermofisher.com

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Appendix A Solution Characterization

For most solutions (unlike slurries), the relationship between density and concentration is not linear. The gauge uses a polynomial to characterize a solution's concentration (in grams per milliliter) as a function of differential density (the difference between the solution density and the solvent density).

The "Solution" section on page 3-6 explains how to select a predefined polynomial if your solution is in the list of built-in types. This appendix explains how set up a custom user-defined characterization. You can use one of two methods:

- Enter coefficients to define the solution polynomial. You can call Thermo Fisher for help finding coefficients, or use mathematical curve-fitting techniques to find them yourself.
- Set up a characterization table consisting of several break points (data points) on the curve of the solution's concentration-to-density function.

Thermo Fisher can help you define a solution characterization if you have trouble using either of these methods.

Defining a Solution Polynomial

It is likely that you know or can find your process material's density-to-concentration relationship. To define a solution characterization polynomial, you need to express this relationship as a suitable fourth-order polynomial and enter its coefficients in the "Set up density…" menu.

To be suitable, the polynomial must meet the following criteria:

- It must track the solution's density-to-concentration relationship over a broad range, not just the range of interest.
- It must be well-behaved (continuous) over the entire range of possible densities.
- Its slope must be non-zero and have the same sign (either positive or negative) over the entire range of possible densities.

These requirements ensure that the gauge's iterative calculations can *converge* (produce a definite result) for every possible density. If the calculation cannot converge at a given concentration, the gauge produces an error when you try to measure material of the corresponding density.

The solution characterization polynomial takes the following form:

$$\text{Concentration} = Ad_c + Bd_c^2 + Cd_c^3 + Dd_c^4$$

where:

Concentration is grams of solute per milliliter of solution (not % solute).

d_c is the density change from pure solvent (solution density minus solvent density).

A, B, C, and D are the polynomial coefficients to be entered.

For most applications it is sufficient to specify only the A and B coefficients and leave C and D set to zero. This usually ensures a reasonably well-behaved polynomial.

You can use computer curve-fitting software or matrix computation to find the coefficients you need. Select several data points on your solution's density-to-concentration curve. Remember to use the change from pure carrier density. For example, at zero concentration the density change is also zero. Then use computer curve-fitting software or matrix computation (plug in up to four data points and solve for the coefficients) to find coefficients for a second, third, or fourth order polynomial. Graph the resulting equation to make sure it meets the criteria described earlier in this section.

To enter the coefficients, select "user defined" in the "Soln. polynomial…" item of the "Set up density…" menu, then enter the coefficients in the subsequent items. Enter zero (0) for coefficients you do not need to use.

Built-In Polynomial Coefficients

The following table list the coefficients are used for the built-in solution polynomials.

Solution	Concentration	Coefficients			
		A	B	C	D
SUCROSE	**0 TO 100%**	2.598	1.775E-1	3.503E-1	0.0
D-FRUCTOSE	**0 TO 60%**	2.559	4.315E-1	0.0	0.0
D-GLUCOSE	**0 TO 10%**	2.639	–9.384E-2	0.0	0.0
NaCl	**0 TO 50%**	1.408	1.050	-1.346	0.0
NaOH	**0 to 50%**	8.871E-1	1.138	–1.151	1.981
KCl	**0 to 24%**	1.571	1.082	–1.786	0.0
KOH	**0 to 52%**	1.098	8.855E-1	–3.265E-1	0.0
HCl	**0 to 40%**	2.035	2.411	–12.50	48.56
H_3PO_4	**0 TO 40%**	1.866	1.288	-8.047	18.07
A-LACTOSE	**0 TO 18%**	2.518	1.053	-6.338	0.0
H-LACTOSE	**0 TO 18%**	2.656	8.647E-1	-4.504	0.0

Appendix B Attenuation Coefficients

To find the attenuation coefficient for a given process component, multiply the coefficient for each element in the material by the element's mass fraction (the number of grams found in one gram of the component material); then add these weighted values together.

For example, suppose a gram of solids contains 0.3 g of iron, 0.6 g of oxygen, and 0.1 g of silicon. From the table below, we find the attenuation coefficients for iron (0.073), oxygen (0.078), and silicon (0.078). Then the attenuation coefficient is computed as:

$$0.073 \times 0.3 \text{ (iron)} + 0.078 \times 0.6 \text{ (oxygen)} + 0.078 \times 0.1 \text{ (silicon)}$$

$$= \quad 0.0219 + 0.0468 + 0.0078 = 0.0765$$

Note: Be sure to select coefficients from the correct column for your source (Cs-137 or Co-60).

Element			Atomic Weight	Cs-137 Coef.	Co-60 Coef.
1	H	Hydrogen	1.0080	.1537	.1144
2	He	Helium	4.0026	.0775	.0575
3	Li	Lithium	6.9390	.0670	.0498
4	Be	Beryllium	9.0122	.0687	.0511
5	B	Boron	10.811	.0717	.0533
6	C	Carbon	12.011	.0775	.0576
7	N	Nitrogen	14.007	.0775	.0576
8	a	Oxygen	15.999	.0775	.0577
9	F	Fluorine	18.998	.0734	.0546
10	Ne	Neon	20.183	.0768	.0572
11	Na	Sodium	22.990	.0741	.0552
12	Mg	Magnesium	24.312	.0766	.0570
13	AL	Aluminum	26.982	.0749	.0557
14	Si	Silicon	28.066	.0776	.0576
15	P	Phosphorus	30.974	.0755	.0559
16	S	Sulfur	32.064	.0778	.0577
17	Cl	Chlorine	35.453	.0749	.0554
18	Ar	Argon	39.948	.0704	.0521
19	K	Potassium	39.102	.0760	.0562
20	Ca	Calcium	40.080	.0782	.0578
21	Sc	Scandium	44.956	.0730	.0539
22	Ti	Titanium	47.900	.0722	.0533
23	V	Vanadium	50.942	.0711	.0524

Element			Atomic Weight	Cs-137 Coef.	Co-60 Coef.
24	Cr	Chromium	51.996	.0728	.0535
25	Mn	Manganese	54.938	.0719	.0528
26	Fe	Iron (Steel)	55.847	.0738	.0542
27	Co	Cobalt	58.933	.0727	.0535
28	Ni	Nickel	58.710	.0759	.0556
29	Cu	Copper	63.546	.0729	.0533
30	Zn	Zinc	65.370	.0734	.0537
31	Ga	Gallium	69.720	.0713	.0521
32	Ge	Germanium	72.590	.0711	.0517
33	As	Arsenic	74.922	.0713	.0518
34	Se	Selenium	78.960	.0701	.0507
35	Br	Bromine	79.904	.0715	.0516
36	Kr	Krypton	83.800	.0708	.0508
37	Rb	Rubidium	85.470	.0712	.0513
38	Sr	Strontium	87.620	.0716	.0515
39	Y	Yttrium	88.905	.0725	.0521
40	Zr	Zirconium	91.220	.0733	.0523
41	Nb	Niobium	92.906	.0745	.0528
42	Mo	Molybdenum	95.940	.0741	.0526
43	Tc	Technetium	97.000	.0739	.0523
44	Ru	Ruthenium	101.07	.0741	.0522
45	Rh	Rhodium	102.91	.0754	.0529
46	Pd	Palladium	106.40	.0749	.0523
47	Ag	Silver	107.87	.0763	.0531
48	Cd	Cadmium	112.40	.0753	.0521
49	In	Indium	114.82	.0760	.0524
50	Sn	Tin	118.69	.0756	.0518
51	Sb	Antimony	121.75	.0761	.0518
52	Te	Tellurium	127.60	.0747	.0506
53	1	Iodine	126.90	.0772	.0521
54	Xe	Xenon	131.30	.0768	.0515
55	Cs	Cesium	132.91	.0780	.0521
56	Ba	Barium	137.34	.0777	.0516
57	La	Lanthanum	138.91	.0791	.0522
58	Ce	Cerium	140.12	.0805	.0530
59	Pr	Praseodymium	140.91	.0825	.0538
60	Nd	Neodymium	144.24	.0829	.0538
61	Pm	Promethium	145.00	.0837	.0540

Element			Atomic Weight	Cs-137 Coef.	Co-60 Coef.
62	Sm	Samarium	150.35	.0842	.0539
63	Eu	Europium	151.96	.0857	.0546
64	Gd	Gadolinium	157.25	.0854	.0541
65	Tb	Terbium	158.92	.0867	.0545
66	Dy	Dysprosium	162.50	.0873	.0545
67	Ho	Holmium	164.93	.0886	.0549
68	Er	Erbium	167.26	.0899	.0554
69	Tm	Thulium	168.93	.0913	.0559
70	Yb	Ytterbium	173.04	.0921	.0561
71	Lu	Lutetium	174.97	.0934	.0566
72	Hf	Hafnium	178.49	.0943	.0567
73	Ta	Tantalum	180.94	.0960	.0572
74	W	Tungsten	183.85	.0976	.0576
75	Re	Rhenium	186.20	.0986	.0580
76	Os	Osmium	190.20	.1011	.0582
77	Ir	Iridium	192.20	.1011	.0586
78	Pt	Plutonium	195.09	.1029	.0593
79	Au	Gold	196.97	.1054	.0600
80	Hg	Mercury	200.59	.1063	.0603
81	Tl	Thallium	204.37	.1072	.0606
82	Pb	Lead	207.19	.1090	.0611
83	Bi	Bismuth	208.98	.1115	.0620
84	Po	Polonium	209.00	.1142	.0631
85	At	Astatine	210.00	.1176	.0643
86	Rn	Radon	222.00	.1148	.0624
87	Fr	Francium	223.00	.1182	.0636
88	Ra	Radium	226.00	.1200	.0642
89	Ac	Actinium	227.00	.1234	.0654
90	Th	Thorium	232.00	.1242	.0655
91	Pa	Protactinium	231.00	.1286	.0673
92	U	Uranium	238.00	.1285	.0668
93	Np	Neptunium	237.00	.1338	.0687
94	Pu	Plutonium	244.00	.1357	.0701
95	Am	Americium	243.00	.1384	.0708
96	Cm	Curium	247.00	.1418	.0722
97	Bk	Berkelium	247.00	.1459	.0736
98	Cf	Californium	251.00	.1476	.0738
99	Es	Einsteinium	254.00	.1486	.0742

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Appendix C Toxic & Hazardous Substances Tables*

*English and Chinese versions.

Note that there is one set of tables for the scintillation detector and one set for the ion chamber detector.

Toxic & Hazardous Substances Table – DensityPRO+ Scintillation Detector

For Chinese Regulation: Administrative Measure on the Control of Pollution Caused by Electronic Information Products

Names and Content of Toxic and Hazardous Substances or Elements

Parts Name	Toxic and Hazardous Substances or Elements (DensityPRO+ Scintillation Detector)					
	Pb	Hg	Cd	Cr6+	PBB	PBDE
Housing	o	o	o	o	o	o
Detector Interface Board	x	o	o	o	o	o
Power Board	x	o	o	o	o	o
Scintillator Adapter Board	x	o	o	o	o	o
Temperature Compensation Board	x	o	o	o	o	o
Scintillation Tube	o	o	o	o	o	o
M-Transmitter	x	o	x	o	o	o
Cabling	x	o	o	o	o	o

○: Indicates that this toxic or hazardous substance contained in all of the homogeneous materials for this part is below the limit requirement in **SJ/T11363-2006**

X: Indicates that this toxic or hazardous substance contained in at least one of the homogeneous materials used for this part is above the limit requirement in **SJ/T11363-2006**

有毒有害物质名称及含量的标识格式

部件名称	有毒有害物质或元素 (DensityPRO+ Scintillation Detector)					
	铅 (Pb)	汞 (Hg)	镉 (Cd)	六价铬 (Cr6+)	多溴联苯 (PBB)	多溴二苯醚 (PBDE)
外壳	o	o	o	o	o	o
检测器接口电路板	x	o	o	o	o	o
电源板	x	o	o	o	o	o
闪烁器适配电路板	x	o	o	o	o	o
温度补偿电路板	x	o	o	o	o	o
闪烁器管	o	o	o	o	o	o
M-发射机	x	o	x	o	o	o
缆线连接	x	o	o	o	o	o

○：表示该有毒有害物质在该部件所有均质材料中的含量均在**SJ/T 11363-2006**标准规定的限量要求以下

x: 表示该有毒有害物质至少在该部件的某一均质材料中的含量超出**SJ/T 11363-2006**标准规定的限量要求

Toxic & Hazardous Substances Table – DensityPRO+

For Chinese Regulation: Administrative Measure on the Control of Pollution Caused by Electronic Information Products

Names and Content of Toxic and Hazardous Substances or Elements

Parts Name	Toxic and Hazardous Substances or Elements (DensityPRO+)					
	Pb	Hg	Cd	Cr6+	PBB	PBDE
Housing	o	o	o	o	o	o
Ion Chamber Board	x	o	o	o	o	o
IP Power Board	x	o	o	o	o	o
Pre-Amp Board	x	o	o	o	o	o
Temperature Compensation Board	x	o	o	o	o	o
Ion Chamber	x	o	x	o	o	o
Cabling	o	o	o	o	o	o

○: Indicates that this toxic or hazardous substance contained in all of the homogeneous materials for this part is below the limit requirement in **SJ/T11363-2006**

X: Indicates that this toxic or hazardous substance contained in at least one of the homogeneous materials used for this part is above the limit requirement in **SJ/T11363-2006**

有毒有害物质名称及含量的标识格式

部件名称	有毒有害物质或元素 (DensityPRO+)					
	铅 (Pb)	汞 (Hg)	镉 (Cd)	六价铬 (Cr6+)	多溴联苯 (PBB)	多溴二苯醚 (PBDE)
外壳	o	o	o	o	o	o
离子腔电路板	x	o	o	o	o	o
IP 电源电路板	x	o	o	o	o	o
前置放大器电路板	x	o	o	o	o	o
温度补偿电路板	x	o	o	o	o	o
离子腔	x	o	x	o	o	o
缆线连接	o	o	o	o	o	o

○：表示该有毒有害物质在该部件所有均质材料中的含量均在**SJ/T 11363-2006**标准规定的限量要求以下

x: 表示该有毒有害物质至少在该部件的某一均质材料中的含量超出**SJ/T 11363-2006**标准规定的限量要求

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