DensityPRO

Gamma Density System
User Guide
P/N 717784

Revision E

Part of Thermo Fisher Scientific

Thermo
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DensityPRO

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User Guide
P/N 717784

Revision E

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Revision History

Revision Level	Date	Comments
1.0	06-2000	Initial release.
2.0	07-2001	Released.
A	03-2005	Name change.
B	09-2007	Per ECO 5987.
C	03-2008	Per ECO 6210.
D	04-2011	Per ECO 7714.
E	07-2011	Per ECO 7778.

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Contents

Safety Information & Guidelines

This section contains information that must be read and understood by all persons installing, using, or maintaining this equipment.

Safety Considerations

Failure to follow appropriate safety procedures or inappropriate use of the equipment described in this manual can lead to equipment damage or injury to personnel.

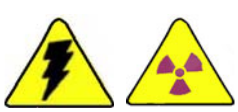
Any person working with or on the equipment described in this manual is required to evaluate all functions and operations for potential safety hazards before commencing work. Appropriate precautions must be taken as necessary to prevent potential damage to equipment or injury to personnel.

The information in this manual is designed to aid personnel to correctly and safely install, operate, and/or maintain the system described; however, personnel are still responsible for considering all actions and procedures for potential hazards or conditions that may not have been anticipated in the written procedures. **If a procedure cannot be performed safely, it must not be performed until appropriate actions can be taken to ensure the safety of the equipment and personnel.** The procedures in this manual are not designed to replace or supersede required or common sense safety practices. All safety warnings listed in any documentation applicable to equipment and parts used in or with the system described in this manual must be read and understood prior to working on or with any part of the system.

Failure to correctly perform the instructions and procedures in this manual or other documents pertaining to this system can result in equipment malfunction, equipment damage, and/or injury to personnel.

Warnings, Cautions, & Notes

The following admonitions are used throughout this manual to alert users to potential hazards or important information. **Failure to heed the warnings and cautions in this manual can lead to injury or equipment damage.**



Warning Warnings notify users of procedures, practices, conditions, etc. which may result in injury or death if not carefully observed or followed. The triangular icon displayed with a warning may contain a lightning bolt or the radiation symbol, depending on the type of hazard. ▲

Caution Cautions notify users of operating procedures, practices, conditions, etc. which may result in equipment damage if not carefully observed or followed. ▲

Note Notes emphasize important or essential information or a statement of company policy regarding an operating procedure, practice, condition, etc. ▲

Chapter 1
Product Overview

Introduction

The Thermo Scientific DensityPRO gamma density system 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, it can calculate mass flow.

The system consists of the source head, which contains the radioisotope source, and the integrated detector-transmitter, which contains the scintillator detector and electronics. 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 amount of radiation arriving at the detector, which varies with the density of the process material.

Note The gamma radiation used by the gauge **cannot** make the vessel, process or structure radioactive. ▲

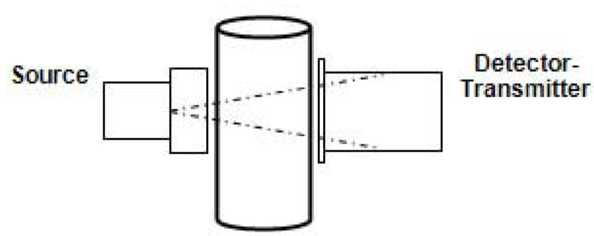


Figure 1–1.

The 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. Refer to the Gamma Radiation Safety Guide (p/n 717904).

The Integrated Detector-Transmitter

The DensityPRO system uses a scintillator-type detector to measure the radiation reaching the detector from the source. The detector consists of a special plastic scintillator material and a photomultiplier tube with the associated electronics. When radiation strikes the plastic scintillator material, small flashes of light are emitted. As the density of the process material increases, more gamma radiation is attenuated by the process material and fewer light pulses are generated by the scintillator material. The photomultiplier tube and associated detector electronics convert the light pulses into electrical pulses that are processed to determine the process material density and related measurement values.

Functional Description

Measurement Calculation

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

By inputting flow data, the DensityPRO gauge can generate mass flow measurements. A 4–20 mA current output from a magnetic flow sensor or from a fixed or portable flow meter can be input to the gauge.

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

Communications & Measurement Display

Communication with the gauge can be via the RS485 or the RS232 serial ports using a Thermo Scientific Model 9734 handheld terminal (HHT), a PC with the Thermo Scientific TMT Comm communication software or other terminal emulation software installed, or a standard ANSI or VT-100 terminal.

The HART® communication protocol is supported over the 4–20 mA current output with an optional daughter board. Communication with the gauge is through the 275, 375, 475, or later field communicator from Emerson Electric Co. Refer to the DensityPRO gauge with HART operation guide (p/n 717817) for instructions.

With the FOUNDATION™ fieldbus communication option, the DensityPRO system provides users with access to control or program parameters via a host system.

Once the gauge has been set up, the primary (density) measurement is displayed on the external display, if present, and on the remote terminal or HHT.

Inputs & Outputs

The characteristics of the input and output options for the DensityPRO system are summarized in the table below.

Table 1–1.

Type	Characteristics	Comments
Current output	Three configurations available for the 4–20 mA current output: - Isolated, loop-powered (default) - Non-isolated, self-powered - Isolated, self-powered output (requires optional daughter board p/n 886595)	Default range is 4–20 mA DC. One current output is provided on the CPU board.
Serial communications	RS485 half duplex RS232 full duplex	Half duplex communication to PC or HHT. Full duplex communication with remote terminal or PC.
HART communications	HART protocol supported over the 4–20 mA current output.	Optional daughter board required.
FOUNDATION fieldbus communications	The Device Description is a DD4 that is interpreted by a host implementing DD Services 4.x or higher.	The DD is available from the Fieldbus Foundation website.
Optional relays	Two relays optionally available on the AC power/ relay board. Form C relays, SPDT, isolated 8 A @ 220 Vac.	Process alarms and system fault or warning alarms can be assigned to control (open/close) relays.

Type	Characteristics	Comments
Inputs	Flow meter: 4–20 mA linear Dry contact closure Temperature compensation circuitry with 100-ohm Platinum RTD, 2 or 3 wire	Execute system commands based on a user-provided contact switch opening or closing input.
Optional Thermo Scientific Model 9723 display	Backlit LCD for measurement readouts. 2-line x 16-character.	Up to four measurement readouts can be displayed at a time.

Other Features

In addition to the functionality discussed above, the DensityPRO system has the following features.

Dynamic Menu System

The setup menus enable you to quickly configure the gauge by requiring you to enter all of the basic parameters. Additional menu groups contain fields in which you can enter specialized parameters and commands, allowing you to customize the gauge for a wide variety of applications.

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

Instantaneous Response

Thermo Fisher Scientific's Dynamic Process Tracking (DPT) ensures there is no lag time in the system response to significant changes in process level. When changes occur, the DPT feature reduces the normal averaging time constant by a factor of eight, ensuring a rapid, 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 level 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.

Process Alarms

Define up to 16 process alarms in addition to the built-in system fault alarms and warning alarms.

Totalizers and Batch Control

Four independent totalizers may be configured to “count” elapsed time or cumulative mass / volume when a flow input signal is provided and a mass / volume-flow measurement has bee defined. Totalizers can be assigned to drive relays. Relays can be set to open or close at specified “slow” or “stop” counts for batch or sample control.

Output Signals

Any measurement can be assigned to the 4–20 mA current output, or the measurement values can be sent to a remote terminal or host computer as serial data. The two contact closure inputs can be used to activate any system command based on a user-provided switch input (open or close). Two relay outputs are available on the optional AC power / relay board.

Associated Documentation

Along with this guide, the following documents must be read and understood by all persons installing, using, or maintaining this equipment:

- DensityPRO gauge installation guide, p/n 717774
- Gamma radiation safety guide, p/n 717904
- DensityPRO gauge with FOUNDATION™ Fieldbus Application Guide, p/n 717917 (if FOUNDATION fieldbus installed)
- DensityPRO / DensityPRO+ gaugewith HART operation manual, p/n 717816 (if using HART® protocol)
- Model 9734 handheld terminal operation manual, p/n 717797 (if using the Thermo Scientific handheld terminal)

Chapter 2
Getting Started

Warning In the United States, you may uncrate and mount the source housing, but you may not remove the shipping bolt unless you are licensed to commission the gauge. In Canada, you must have a license condition permitting mounting / dismounting, and without this condition, users may not remove the source from the shipping crate. ▲

Warning The DensityPRO system is a nuclear device regulated by federal and / or state authorities. You are responsible for knowing and following the pertinent safety and regulatory requirements. Refer to the Gamma Radiation Safety Guide (p/n 717904). ▲

Communications Setup

This section assumes that the system has been properly installed and all required connections have been made (reference the DensityPRO gauge installation guide, p/n 717774).

Serial Communications

The gauge provides one RS232 single-drop and on RS485 multi-drop serial interface. An RJ-11 connector (phone jack) is also provided for the RS485 port.

The serial port on a personal computer (COM1, COM2, etc.) can be connected directly to the gauge's RS232 port. An RS485/RS232 adapter is required to connect a PC to the gauge's RS485 port. You can then communicate with the gauge from a PC running TMT Comm software or other terminal emulation software, such as HyperTerminal.

In non-hazardous locations the Thermo Scientific Model 9734 HHT can be connected directly to the RJ-11 connector.

Note The HHT requires an 8 Vdc power source. The RJ-11 connector (6 wide, 4 conductor) for the RS485 port uses two wires (+Data, -Data) for RS485 communications and two wires (+8 Vdc, common) for the 8 V supply. ▲

The default communication settings for the gauge RS232 and RS485 ports and for the HHT are:

- 7 data bits
- even parity
- 1 stop bit
- 9600 baud data rate

For additional information on setting up serial communications, refer to "Serial Ports" (Chapter 8).

HART Communication Protocol

The HART communication protocol is supported over the 4–20 mA current output and requires an optional daughter board. Communication with the gauge is via the 275, 375, 475, or later field communicator from Emerson Electric Co. As practical, the HART menu structure mirrors the menu structure as described in this guide. Additional information can be found in the DensityPRO / DensityPRO+ gauge with HART operation guide (p/n 717816).

Once the optional HART board is installed, the instrument enters a special mode of operation. In this mode, all user-entered RS232 selections are overridden and the RS232 setup functions are disabled. The HART interface provides access to basic setup functions, including primary measurement setup, process alarms, additional measurements, current output settings, gauge fine tuning, and action items.

Note Do not use the HART communication system for technical troubleshooting. You must use either the Model 9734 or a computer with RS232/RS485 converter and the TMT Comm software to access the technical troubleshooting capabilities of the DensityPRO system. ▲

Gauge Operation

The first time you apply power to the instrument (after establishing communication with the gauge), the message below is displayed. If the display is blank, refer to Chapter 11 for troubleshooting procedures.

```
 Unit has not
 been set up!

For setup, press →
```

Figure 2–1.

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

```
  3.10 g/ml


For setup, press →
```

Figure 2–2.

The measurement display is continuously updated 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" prompt or alarm / warning messages when they occur. Up to six measurements can be displayed (three at a time). Up to eight measurements can be displayed (four at a time) by disabling the "For setup" prompt. See "Special Functions" (Chapter 8) for instructions.

Entering Data

The keys used to operate the instrument are described in the table below.

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. ▲

Table 2–1.

Key	Action
Right arrow	Press to enter the setup menus and to step through the top-level menu headings. Also use to scroll through the list of menu options.
Up arrow	Return to the previous menu item or scroll through menu items in the reverse direction.
Left arrow	Press to return to the previous option.
Down arrow	Press to select an option and continue to the next menu item.
Decimal	Press once to enter a decimal. Press twice to enter the decimal in scientific notation. For example, to enter 4.567E6, press **4.567.6** If you are entering data from a terminal keyboard, you can press **E** or **e** before entering the exponent value rather than pressing the decimal key twice.
Number keys	Press to enter data values. Press the down arrow to indicate the end of the number entry.
Minus sign	Press to indicate a negative number.

The Setup Menus

The setup menus take you through the steps for entering the data required for instrument operation. In each menu item, data values that can be entered or changed are 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.

To exit the setup menus, press the EXIT key on the HHT or press **x** on the terminal keypad. This will save any changes you made and return you to the measurement display.

Note When accessing the setup menus, the display times out and returns to the measurement display if no entries are made for five minutes. Changes or entries made up to that point are saved and used by the instrument. ▲

Note The appearance of many menu items varies dynamically with context and depends on the parameter values and selections entered during setup. Thus, the appearance of the menu items as described in this manual may vary slightly from what is actually displayed on the gauge. ▲

Reset to Factory Defaults

If the display shown in Figure 2–1 is not displayed upon power-up, the instrument has been at least partially set up. If you do not want the instrument to use these settings or if the instrument has been moved to a new location, you can restore factory defaults.

Use command DAC 82 (Erase All Entries Except COMM Setup) to reset all user entries except communication settings to factory defaults. Use command DAC 74 (Erase All Entries) to reset all user entries including communication settings to factory defaults.

Service Only Menu Items

The menu structure has two "layers" of menu items, the user layer and the service layer. The 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 (Chapter 8).

The Direct Access Method

The direct access method allows users to bypass the menu structure and directly access a specific menu item. Note that most menu items display a slightly different message when accessed using this method. In order to use this method, you must know the direct access code (DAC or keypad code). Parameter DACs have six digits, and command DACs have one, two, or three digits.

To find the DAC for a particular menu item:

1. Scroll to the desired menu item.

2. If the menu item is not for a floating point number entry (an entry containing a decimal point), press the decimal key to display the DAC information screen. If the menu item is for floating point entries, press decimal followed by up arrow to display the DAC information screen.

Caution Use the direct access method with caution. When entering or changing a parameter value for one menu item, you may also need to enter or modify the value of other menu items. ▲

Locating Direct Access Codes

Following is an example of how to locate a DAC. One of the first items in the Set up Density, Den. Alarms, & Flow menu is the Sensor Uses item, shown in Figure 2–3. Press the decimal key.

```
Sensor uses
5202 source head

     NEXT↓  CHANGE→
```

Figure 2–3.

Figure 2–4 is then displayed. Note the keypad code: 005002. This is the DAC. Press the down arrow to return to the previous screen.

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

Figure 2–4.

Figures 2–5 and 2–6 illustrate how to locate a DAC for a decimal (floating point) data entry item. At the Pipe Inside Diameter item shown in Figure 2–5, press the decimal key followed by the up arrow.

```
Pipe inside diameter
4.000 in

           NEXT↓
```

Figure 2–5.

Note the keypad code (048003). Press the down arrow to return to the previous screen.

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

Figure 2–6.

Using Direct Access Codes

Use the DAC found in the previous section to view or modify the value for the pipe inside diameter:

1. From the measurement display, press **EXIT** on the HHT or **x** on the terminal keypad. Figure 2–7 is displayed.

```
Key in entry ID or
command code then ↓

Press ↑ to exit.
```

Figure 2–7.

2. Enter the DAC (**048003**) and press the down arrow.

3. If the value shown is correct, press **EXIT** to keep the value and return to the measurement display. To modify the value, press the down arrow and enter the new number. Press **EXIT**. The new value is stored and used by the instrument.

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Chapter 3

Set up Density, Den. Alarms, & Flow

Overview

The Set up Density, Den. Alarms, & Flow menu takes you through the steps required for basic system setup:

- Specify the source head model.
- Select the material type that best defines your process material.
- Set up temperature compensation (if required).
- Select the primary measurement and units.
- Enter the values of the primary measurement that correspond to the maximum and minimum values of the current output.
- Set the decimal point position for the primary measurement readout.
- Set up a process alarm for the primary measurement.
- Select the flow input settings (if any) to be used. (The flow input source must be defined before a flow related measurement readout can be configured.)
- Perform a standardization measurement that provides the gauge with a standard configuration reference point.
- Perform calibration measurement(s), if necessary, to fine tune the gauge for the process material.

Density Measurement Setup

The Set up Density, Den. Alarms, & Flow menu contains the items necessary for a basic system setup.

1. From the measurement display, press the right arrow to move to the Set up Density, Den. Alarms, & Flow menu heading. Press the down arrow to enter the menu. Note that the software will detect whether output relays are installed. If relays are not installed, the menu heading will be “Set up Density and Flow.”

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

Figure 3–1.

2. Help screens are provided throughout the menus to assist you with the setup process. Press the down arrow to continue to the first setup item.

```
General HELP text.→
{Information on how
to set up this
gauge}        NEXT→
```

Figure 3–2.

3. The gauge tunes its response using a “geometry factor” associated with the gauge head model selected. Press the right arrow to scroll through the list of source head models, and when the correct model is displayed, press the down arrow to accept the selection and move to the next menu item.

```
Sensor uses
5202 source head

       NEXT↓ CHANGE→
```

Figure 3–3.

The following source head models can be selected:

- 5190
- 5191
- 5176
- 5200
- 5201

- 5202
- 5203 or 5204
- 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 will be displayed to let you enter a custom geometry factor. Contact Thermo Fisher for help in determining the geometry factor for your gauge head type. The default user's geometry factor is 0.85.

4. Press the right arrow to scroll through the list of material types: slurry, solution, single phase, or emulsion. See "Material Type" later in this chapter for detailed discussion. When the correct material type is displayed, press the down arrow to accept the selection and move to the next menu.

```
Material type is
slurry

   CONTINUE↓ CHANGE→
```

Figure 3–4.

5. The wording of the following menu item depends on the material type selection in the previous item. For a slurry, enter the specific gravity of the carrier liquid. For a solution, enter the solvent gravity, and so on. Press the down arrow to move to the next menu item.

```
Carrier gravity
.9982 g/cc

        NEXT↓
```

Figure 3–5.

6. The wording of the following menu item depends on the material type selection in the previous item. For a slurry, enter the specific gravity of the suspended solids. For a solution, set up the solution characterization, and so on. Press the down arrow to move to the next menu item.

```
Solids gravity
3.000 g/cc

        NEXT↓
```

Figure 3–6.

7. If the material type selected is solution or emulsion or if the material type is slurry and the solids gravity is less than 2.0, the Process Temperature Compensation Setup submenu is displayed. For certain materials, temperature compensation is required to provide accurate density measurements as the process temperature changes.

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

Note Temperature compensation should be configured prior to standardization, if the standard configuration is affected by temperature. ▲

The temperature compensation submenu is always available under the Gauge Fine Tuning menu. Refer to "Process Temperature Compensation Setup Menu" in Chapter 5 for specific instructions on setting up temperature compensation. When ready, press the down arrow to move to the next menu item.

```
Process temperature
compensation setup→

        NEXT↓
```

Figure 3–7.

8. At the next screen, select the primary Available measurements depend on the material type selected. This is discussed in "Primary Measurement Type" later in this chapter. Press the down arrow when you are ready to move to the next menu.

Note By default, the primary measurement is displayed as readout #1 and is assigned to the current output signal. The primary measurement cannot involve mass or flow. Mass or flow related measurements must be assigned as additional measurements (Chapter 4). ▲

```
Primary measurement:
density
  To change, press→
        NEXT↓
```

Figure 3–8.

9. Select the units system using the right arrow. Options are: ALL, English, or Metric. Press the down arrow to move to the next menu item.

```
Allow display of All
units.  Change to:
 Metric or English→
        NEXT↓
```

Figure 3–9.

10. Press the right arrow to scroll through and select the desired units for the primary measurement.

```
Density
units = g/ml
To change, press→
        NEXT↓
```

Figure 3–10.

The complete list of units available for the density measurement is provided in the following table. After making the desired selection, press the down arrow to move to the next menu item.

Table 3–1. Units for the density measurement

Abbreviation	Unit
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 (2,000 lb) per cubic yard
lton/cu yd	long tons (2,240 lb) 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

11. Press the right arrow to scroll through and select the units that will be used to specify the pipe inside diameter. The available units depend on the selection made earlier in the Allow Display of menu item. Press the down arrow to continue to the next menu item.

```
Size units = in
To change to ft, yd,
M, cm, or mm  press→
        NEXT↓
```

Figure 3–11.

12. Enter the value for the pipe inside diameter in the units selected in the previous menu item. Press the down arrow to continue.

```
Pipe inside diameter
4.000 in

        NEXT↓
```

Figure 3–12.

13. Set the measurement range for the current output.

    Meas #1 is associated with the density measurement, and the current output value is associated with Meas #1 by default.

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. ▲

Enter the density value at which the current output will be at maximum. The default maximum current output value is 20 mA. Then press the down arrow.

```
Meas #1 reading for
20.00 mA output:
3.000 g/ml
         NEXT↓
```

Figure 3–13.

Enter the density value at which the current output will be at minimum. The default minimum current output value is 4 mA.

```
Meas #1 reading for
4.000 mA output:
2.000 g/ml
          NEXT↓
```

Figure 3–14.

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 to 20 mA. The Fault Low and Fault High current output levels are 3.6 mA or lower and 20.8 mA or greater, respectively. See "Modify or Reassign Current Output" (Chapter 6) for details on modifying the current output range.

Display Scaling

Specifying a value greater than 9,999 for the maximum current output reading enables the Display Scaling menu items. For example, values in the range from 0 to 100,000 can be scaled by a factor of 100 to a range of 0 to 1,000 so that the displayed values do not exceed the limits of the four-digit numerical display. See "Display Scaling" (Chapter 4).

14. Use the right or left arrow to adjust the position of the decimal point for the Meas #1 readout. A maximum of three decimal places can be displayed. Note that 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. When the decimal position is set, press the down arrow to move to the next menu item.

```
Position of decimal
in readout 1   000.0
{g/ml}
    NEXT↓   ←CHANGE→
```

Figure 3–15.

15. Press the right arrow to enter the Set up Alarm 1 submenu and specify process alarm #1 for the primary measurement. After defining alarm #1, the submenu for alarm #2 will be displayed. Refer to “Alarm Setup” later in this chapter.

```
Set up alarm 1
(Alarm point, etc.)→

          NEXT↓
```

Figure 3–16.

16. Press the right arrow to enter the Flow Input Setup submenu. The gauge can accept a 4 –20 mA current input signal from an external flow meter. This menu prompts you for the parameters required to set up the flow input and the units for volume and mass flow measurements. This menu is also available under the Gauge Fine Tuning menu chain. See “Flow Input Setup” (Chapter 5) for detailed information.

```
Flow INPUT setup →


          NEXT↓
```

Figure 3–17.

17. After the Flow Input Setup menu, menu items related to gauge standardization and calibration are displayed. These items are discussed later in this chapter.

Material Type

Use the Material Type 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 as the material type 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 "Attenuation Coefficients" (Appendix D).

After a material type is selected, additional menu items are displayed so that required specific gravity values for that material type can be entered. These additional menu items are discussed below.

Slurry

If the material type selection is slurry, menu items will prompt you for the following values.

Carrier gravity: Enter the specific gravity of the carrier liquid in g/cc. The default value is 0.9982, correct for water at sea level and 20°C (68°F).

Solids gravity: Enter 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

If the material type selection is solution, menu items will prompt you for the following values.

Solvent gravity: Enter the specific gravity of your solvent liquid in g/cc. The default value is 0.9982, correct for water at 20°C (68°F).

Solution characterization: Solution characterization is 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 "Solution Characterization" (Appendix C) for information about entering a user-defined solution characterization polynomial or break point table.

Single Phase

If the mixture in the pipe has multiple changing variables, the process material must be treated as one product in order to give an average density. In this case, select single phase.

Emulsion

If the material type selection is emulsion, menu items will prompt you for the following values.

Fluid_1 gravity: Enter the specific gravity of your carrier liquid in g/cc. The default value is 0.9982, correct for water at 20°C (68°F).

Fluid_2 gravity: Enter 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.

Primary Measurement Type

From the Primary Measurement Type screen, 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 of the material weighs 500 grams 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, the slurry has a solids concentration of 270 g/l if one liter of slurry contains 270 grams of suspended solids.

  Carrier content/vol: The concentration, or mass of carrier in a volume of slurry. For example, the slurry has a carrier concentration of 910 g/l if 1 liter of slurry contains 910 grams of carrier liquid.

  Solids/carrier: The ratio of suspended solids mass to the volume of the carrier liquid. For example, the slurry has a solids to carrier ratio of 2 lb/gal if 2 pounds of solids are mixed with every 1 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, the slurry is 30% 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, the slurry is 80% by volume liquid if each liter of material contains 800 milliliters 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. ▲

Alarm Setup

The Set up Alarm 1 submenu appears after the density measurement items. Enter this submenu to set up an alarm.

```
Set up alarm 1
(Alarm point, etc.)→

             NEXT↓
```

Figure 3–18.

This subgroup allows you to assign and set up a process alarm for the density measurement. You can define up to 16 process alarms. It is recommended that you keep a record of each alarm set up (assigned measurement, set point, clear point, alarm action) for future reference.

By default, all process alarms are assigned to Meas #1 (the primary measurement). You can assign process alarms for any additional measurements that have been set up. The procedure is the same as the procedure detailed below.

1. From the Set up Alarm 1 screen, press the right arrow to access the menu items.

2. Enter the process density at which the alarm will activate. Note that the screen below is an example only. Alarm 1 can be set as either a high density alarm or low density alarm. Press the down arrow to continue.

```
←Exit alarm 1 setup
Alarm 1 set point
2.000 g/ml
         NEXT↓ HELP→
```

Figure 3–19.

Note A set point must be entered to activate the remaining menus in this subgroup. ▲

3. Select a clear point or dead band to clear the alarm. Press the down arrow to continue to the next screen.

```
Alarm 1 clear based
on clr point
Chng to “dead band”→
Continue as is.↓
```

Figure 3–20.

Set Point and Clear Point / Dead Band

An alarm is defined with 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 is defined at 2.5 g/ml and the dead band is set at 1.0 g/ml, the implicit clear point will 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. Use a dead band configuration if you want the alarm clear point to remain at a fixed distance relative to the set point.

4. Enter desired clear point value. The clear point is the process density where you want the alarm to stop alarming. If dead band was selected above, enter the span of the dead band relative to the set point.

```
Alarm 1 clear point
2.500 g/ml
{Makes alarm “Low”
limit}   NEXT↓ HELP→
```

Figure 3–21.

High Limit & 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 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.

5. Use the right arrow key to cycle through actions that can be used to indicate the alarm has been triggered. The default action is "Nothing". Other actions are described below. Once the desired selection is made, press the down arrow to continue to the next menu item.

```
Alarm 1: g/ml
is indicated by
controlling relay 1
       NEXT↓ CHANGE→
```

Figure 3–22.

- **Controlling relay 1** (2)**:** If relays are installed, assign relay 1 or 2 as the alarm indicator.
- **Zero output 1**: Hold current output at zero while the alarm is active.
- **Max output 1**: Hold current output at maximum value while the alarm is active.
- **Outputs to alt**: Switch current output(s) to alternate mode if alternate mode has been defined.
- **#1 act on ALM action**: Executes the command pair assigned as the #1action when the alarm is activated / cleared. This selection is only displayed if an alarm action has been assigned. The selection is repeated for #2 and #3 actions, if assigned.

6. The following menu item is displayed if **controlling relay 1** (or 2) was selected in the previous menu item. By default, relays are turned on when an alarm is activated and turned off when the alarm clears. Press the right arrow to change to **off** and reverse this behavior.

   This is the final menu item in the Set up Alarm 1 menu group. Press the left arrow to exit.

```
Relay 1 turns on
when alarm occurs.
Change to “off”→
←Exit alarm 1 setup.
```

Figure 3–23.

7. After you set up an alarm, the menu to set up the next alarm will be displayed. Press the right arrow to set up the next alarm, or press the down arrow to go on to the next menu item.

```
Set up alarm 2
(Alarm point, etc.)→

         NEXT↓
```

Figure 3–24.

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. 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.

When to Standardize

The primary benefit of periodic standardization is it adjusts the standardization point to compensate for changes in the tank or gauge head assembly. Determining 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 standardize the gauge when one or more of the following conditions listed below occur.

- Pipe wear is caused by corrosive or abrasive materials.
- There is buildup of process material in the pipe.
- Cleaning or spontaneous breakup of built-up material in the pipe has occurred.
- Repairs or changes to the pipe or gauge head mount have been made.
- The gauge head mount has shifted or realigned, 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. ▲

Procedure

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 a significant effect on your process, set up temperature compensation before standardizing with the pipe full.

To perform the standardization cycle:

1. Put the gauge head and pipe in one of the following standard configurations. Use the same standard configuration every time you standardize.
   a. 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 the process material.
   b. Pipe empty: Standardizing on an empty pipe is suitable for some applications when using small to medium pipes.
   c. Full with block: Some installations come with a density reference block to be placed in the beam path during standardization. Use the block with a pipe full of reference fluid (such as pure carrier) if so directed.
   d. Empty with block: This configuration is similar to "full with block." Use it if you have a reference block and are directed to use it with an empty pipe.

Note There is a selection called "Defer Standardization." **Do not make this selection.** ▲

2. Turn on (open) the source shutter.

3. Enter the Sensor Head Standardization menu.

```
Sensor head
Standardization→

         NEXT↓
```

Figure 3–25.

4. Verify that the Standardize On menu item is set to the correct standard configuration, as described in step 1.

```
Standardize on: pipe
full of carrier
To change, press→
         NEXT↓
```

Figure 3–26.

5. Move to the Start Standardize Cycle menu item and press the right arrow to start the cycle.

```
Start standardize
 cycle (tank empty)
←Exit this menu.
 NEXT↓ EXECUTE CMD→
```

Figure 3–27.

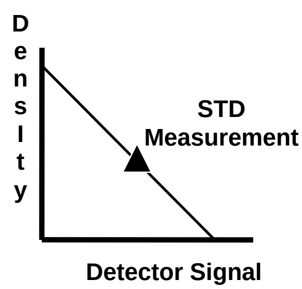
After beginning standardization, a menu item is displayed that lets you abort the standardization measurement, continue with the setup menus, or return to the measurement display where a countdown timer will display the time remaining in the standardization cycle.

Note If you perform standardization with the pipe full of carrier standard configuration, 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 using the 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 the gauge does not require calibration, it may be necessary to perform periodic standardization. ▲

Calibration

Unless standardization is performed using the pipe full of carrier / solvent / fluid_1 /ref fluid standard configuration, you must perform a calibration measurement using the Density Gauge Calibration menus under the set up menus.

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 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. ▲

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.

Calibration Procedure

Use the following procedure to perform 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. ▲

Note It is recommended that the standardization measurement be performed prior to performing the calibration measurement if possible. ▲

Note The CAL 2 measurement and density value are 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. ▲

Note The procedure for the second calibration point is essentially the same as for a one-point calibration. Go through the procedure below for the first CAL point and repeat the procedure if a second CAL point is required. ▲

1. 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. If performing this procedure for the second calibration point, fill the pipe with process material of a different density. It can be either more or less dense than for CAL 1, but it should be as different as is practical within the range of interest.

2. Enter the Density Gauge Calibration menu.

```
Density gauge
calibration →

            NEXT↓
```

Figure 3–28.

3. Select a one or two-point calibration. If performing 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.

```
Use 1 point CAL
Change to "2" point→

Continue as is. ↓
```

Figure 3–29.

4. Specify the number of time constant periods used for the calibration measurement. The default CAL cycle is eight time constant periods. If the default time constant (128 seconds) is used, calibration lasts about 17 minutes. If you decrease 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 cycle time:
8 x time constant
{time constant is
128 sec}  NEXT↓ HELP→
```

Figure 3–30.

5. 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, and modify the value later.

```
CAL density
3.000 g/ml

NEXT↓ HELP→
```

Figure 3–31.

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).

Note If the CAL density value is changed after the command to use the CAL value has been executed (see below), you must execute a CMD 6 (Process and Store) before the gauge will use the new CAL density value. ▲

6. If you have configured temperature compensation, the following menu items will appear.

   a. Process Temperature Learned: This 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 the first CAL point when you execute the Use Latest CAL Value command.

   b. CAL #1 Temperature: This item displays the process temperature that is in use for the first calibration point.

   c. CAL #2 Temperature: This item displays the process temperature that is in use for the second calibration point.

7. Press the right arrow to begin the calibration cycle. During the cycle, take several samples of the process material and determine the average of the sample densities.

```
Start calibration
 cycle.

NEXT↓  EXECUTE CMD→
```

Figure 3–32.

When calibration 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 menu item. Enter the actual density of the samples you took

Note that the message "CAL PT pending" will be displayed and the calibration point will not be used by the gauge until the Use Latest CAL Value command is executed.

8. The CAL/STD ratio if the ratio of the last calibration measurement to the standardization value. This menu item is displayed until the Use Latest CAL Value is executed (next menu item).

```
** CAL/STD ratio
(from latest CAL)
.7255
              NEXT↓
```

Figure 3–33.

9. From the screen shown below, press the right arrow to use the latest CAL value for CAL point 1/2.

```
Use latest CAL value
for CAL point 1.
←Exit this menu.
NEXT↓ EXECUTE CMD→
```

Figure 3–34.

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

10. The menu item below is only displayed if a one-point calibration was selected.

```
Atten. coef
of carrier
8.600E-2 sqcm/gm
              NEXT↓
```

Figure 3–35.

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 using a Co-60 source, however, you should change the coefficients to 0.065 for the carrier (water) and 0.058 for solids (minerals).

For other 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 D 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 for assistance with determining the correct attenuation coefficient for your process material.

11. The item below is only displayed if one-point calibration was selected. It is the same as previous item, but for the other component of the process material.

```
Atten. coef
of solids
7.700E-2 sqcm/gm
              NEXT↓
```

Figure 3–36.

12. For a two-point calibration, a density slope correction factor is computed based on the CAL 2 point. 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.

```
Density slope
correction factor:
1.000
              NEXT↓
```

Figure 3–37.

Caution 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. ▲

Chapter 4
Additional Measurements

Overview

Meas #1 is set up using the Set up Density, Den. Alarms, & Flow menu as discussed in Chapter 3. Up to seven additional measurements can be defined using the Set up Additional Measurements menu.

You can also assign process alarms to the additional measurements and then assign these measurements to the current output(s), depending on the needs of your application. Refer to "Modify or Reassign Current Output" (Chapter 6) for information on assigning current outputs to measurements.

Access the Set up Additional Measurements menu from the measurement display by pressing the right arrow twice. The first time you access this menu, the Assign and Set up Measurement 2 menu appears. Meas #1 is assigned to the primary density measurement by default. After setting up each measurement, you are prompted to set up the next additional measurement.

Note It is recommended that you keep a list of the measurements you set up for future reference. ▲

Setting up the Additional Measurement

1. From the measurement display, press the right arrow twice. The Set up Additional Measurements item is displayed. Press the down arrow to continue.

```
Set up additional
measurements
(readouts).↓
     Other functions→
```

Figure 4–1.

2. By default, Meas #1 is assigned to the density measurement. Press the down arrow to continue.

```
NOTE: Meas. #1 is the
primary measurement
See “density setup”
to modify.   NEXT↓
```

Figure 4–2.

3. Press the right arrow to assign a readout to Meas #2, and continue to the next section. After setup is complete, this menu item displays “Modify setup of measurement 2”.

```
Assign & set up
measurement 2→

         NEXT↓
```

Figure 4–3.

4. The next step in setting up an additional measurement is to select the measurement type. See “Select Measurement Type” later in this chapter for details. Press the down arrow to continue to the next menu item.

```
Reading represented by
measurement 2 is
bulk density
       NEXT↓ CHANGE→
```

Figure 4–4.

5. Press the right arrow to scroll through and select the units for the selected readout.

```
Bulk density
units = g/ml
  To change, press→
          NEXT↓
```

Figure 4–5.

6. The alarm setup submenu will be displayed here if an alarm has been assigned to the measurement. By default, all alarms are assigned to the primary measurement, but once an additional measurement has been set up, you can assign an alarm to it. See “Assign Alarms to Measurements” (Chapter 6). Set up an alarm for additional measurements by following the same steps detailed in “Alarm Setup” in Chapter 3.

```
Set up alarm 2
(Alarm point, etc.)→

         NEXT↓
```

Figure 4–6.

7. To disable display of the Meas #2 readout on the measurement display press the right arrow to change the selection to “Do not”. Press the down arrow to continue to the next menu item.

```
Do display mea 2
bulk density
Change to "Do not"→
           NEXT↓
```

Figure 4–7.

8. To enable the display scaling menu items, enter a value greater than 9999 for the highest expected reading value. Additional discussion of display scaling can be found later in this chapter. Press the down arrow to continue to the next menu item.

```
Highest expected
reading:
0.000 g/ml
         NEXT↓
```

Figure 4–8.

Note If the current output is assigned to Meas #2, the "Meas #2 reading for 20.00 (4.00) mA output" menu items are displayed, rather than the "highest expected reading." ▲

9. 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. When ready, press the down arrow to continue.

```
Position of decimal
in readout 2   000.0
{g/ml}             |
    NEXT↓  ←CHANGE→
```

Figure 4–9.

10. Press the left arrow to exit the "Modify setup of measurement 2" submenu.

```
←Exit from:
Modify setup of
measurement 2
liter
```

Figure 4–10.

Note After Meas #2 has been set up, you will be prompted to assign and set up Meas #3 and so on. ▲

Select Measurement Type

In addition to the usual density related measurements, you can set up any combination (up to seven) of the measurements listed below.

Note Flow related measurements are not available until the flow input has been set up (Chapter 5). Temperature readouts are only available if you have selected a temperature input in the Process Temperature Compensation Setup menu (Chapter 5). ▲

Measurement types for any material type:

- 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 degrees C (if temperature compensation is used)
- temperature (deg F), temperature in degrees F (if temperature compensation is used)

Measurement types for slurry process material:

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

Measurement types for solution process material:

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

Measurement types for single phase process material:

- 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. Rate can be computed for any measurement that has been set up (assigned to a measurement number) and can always be computed for the primary measurement.

1. Select a measurement for which to compute the rate of change. The measurement number for the rate should be greater than the number of the base measurement.

```
Rate readout will be
rate of:
g/ml/time
        NEXT↓ CHANGE→
```

Figure 4–11.

2. Set a threshold for the minimum change required before a rate value is computed. Rate will not be computed until the change in the measurement exceeds the value entered here. Rate is recomputed when the change threshold is again exceeded or when the expected time for the change threshold to be exceeded has elapsed. This allows the estimated rate to settle back towards zero if the change in the process measurement stops.

```
Smallest change for
rate compute
0.000 g/ml
1.563E-2 assumed NEXT↓
```

Figure 4–12.

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

```
Rate smoothing
 factor 1.000
{0.01=smoothest}
{0.01 to 1.0}   NEXT↓
```

Figure 4–13.

4. Select the time interval associated with the rate measurement. Options are seconds (s), minutes (m), hours (h), and days (d).

```
Rate time code
g/ml/s

    Continue↓ Change→
```

Figure 4–14

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 and are displayed if service only items have been enabled in the Special Functions menu (Chapter 8).

```
Special code for
measurement 2 1048
see manual
                NEXT↓
```

Figure 4–15.

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 greater than 9,999 is entered as the highest expected reading.

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.

If you expect the maximum measurement readout to exceed four digits (value greater than 9,999), enter an estimate of the maximum measurement value as the highest expected reading.

```
Highest expected
reading:
4.000E4 gal/d
         NEXT↓
```

Figure 4–16.

If you set a highest expected reading value of 10,000 or greater (more than four digits), three additional menu items will be displayed that allow you to set up display scaling so the gauge's display is meaningful throughout the expected range.

The value for the highest expected reading is not critical; pick a convenient number with the correct order of magnitude. If the actual measurement exceeds the range you expect, the readout still displays the correct, scaled measurement value as long as the scaled value can be displayed in four digits. In the example where 40,000 gallons is scaled by a factor of 1000 to read 40.00 on the display, if the gauge measures 43,875 gallons, the displayed value is 43.88. Any value up to 99990 can be displayed correctly (divided by 1,000 and displayed as 99.99).

The Lowest Expected Reading menu item is displayed if you set a highest expected reading value greater than 9,999 for a measurement.

```
Lowest expected
reading:
0.000 gal/d
         NEXT↓
```

Figure 4–17.

To scale the displayed value by a constant factor, leave this parameter and the Scale Actual to Low End Readout parameter set to zero. If you scale both the highest expected and lowest expected readings, 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 to high end and scale to low end readout values.

Enter the value to be displayed when the measurement value equals the highest expected reading value. For example, to scale a highest expected reading value of 40,000 to a display value of 40.00, enter 40.00.

```
Scale actual 4.000E4
{ gal/d }
to high end readout
of 40.00  NEXT↓ HELP→
```

Figure 4–18.

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.

```
Scale actual 0.000
{ gal/d }
to low end readout
of 0.00         NEXT↓
```

Figure 4–19.

By default, the original units are displayed for the scaled value on the measurement display. This menu item allows you to set up a user-defined units message up to 10 characters long. For example, if the flow measurement with units of gallons/day is scaled by a factor of 1,000, the displayed value has units of kilogallons/day. In this case, you can set up a custom units message to read “kgal/d”. You can set eight custom messages using any combination of ASCII characters. Refer to “Custom Units Messages” (Chapter 8) for instructions.

Press the right arrow and follow the menu instructions to set up a custom units message for the scaled display.

```
Set up custom units
messages→

        NEXT↓
```

Figure 4–20.

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Chapter 5
Gauge Fine Tuning

Overview

After completing the basic setup, you can use the Gauge Fine Tuning menu to access the following menus:

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

```
Gauge fine tuning
{Time constant,
STD, CAL, etc.} ↓
      Other functions→
```

Figure 5–1.

Press the down arrow to access the related menu items.

Time Constant Setup

The Time Constant Setup menu is the first item in the Gauge Fine Tuning menu group. From this item, you can modify the instrument time constant and related items.

1. Press the right arrow key to access the related menu items.

```
Time constant
setup→

        NEXT↓
```

Figure 5–2.

2. Enter the time constant. The default setting for the time constant is 128 seconds. Press the down arrow to move to the next menu item.

```
Density signal
time constant
128 sec
         NEXT↓ HELP→
```

Figure 5–3.

A certain amount of noise or fluctuation is inherent in any radiation-based measurement. The effectiveness of the instrument's filtering to reduce the effect of statistical variations in the radiation measurement depends on the primary time constant.

If you decrease the time constant, you can increase the responsiveness of the gauge, but measurement stability will suffer, since there will be an increase in measurement fluctuations.

If you increase the time constant, you can increase precision (stability), but the precision changes only with the square root of the time increase. For example, to increase precision by a factor of three (reduce error to one-third of its previous range), multiply the time constant by nine. This can significantly reduce responsiveness of the gauge.

The time constant also affects the cycle time for standardization and calibration.

3. Do not disable dynamic tracking during normal operation. This is a service only item. Press the down arrow to continue.

```
Do not disable
dynamic tracking
Change to "Do"→
Continue as is.↓
```

Figure 5–4.

4. The Source Half-Life menu item is displayed if service only items are enabled in the Special Functions menu (Chapter 8). The gauge uses this value to adjust the standardization value for source decay. 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.

```
Source half life
30.00 yr

         NEXT↓
```

Figure 5–5.

5. The alternate time constant is typically set to a much shorter time than the primary time constant. The default is 8 seconds. During periods when the process is known to be changing, switching from the primary time constant to the shorter, alternate time constant makes measurements more responsive but less stable. Switch to the longer time constant when the process has stabilized to increase the measurement stability.

```
Density signal
time constant
(alternate) 8 sec
         NEXT↓ HELP→
```

Figure 5–6.

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. ▲

6. The alternate time constant is not used for any instrument function until you enable it by selecting it in this menu item or entering command DAC 53 (command DAC 54 switches to the normal time constant).

```
Switch to alternate
time constant: 8s
←Exit this menu.
 NEXT↓  EXECUTE CMD→
```

Figure 5–7.

7. This is the final item in the Time Constant Setup group. Press the left arrow to exit.

```
←Exit from:
Time constant
setup
               NEXT↓
```

Figure 5–8.

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, Den. Alarms, & Flow menu (Chapter 3). Since the Process Temperature Compensation Setup menu is always available under the Gauge Fine Tuning menu, it is described in detail here.

```
Process temperature
compensation setup→

       NEXT↓
```

Figure 5–9.

Temperature Input Source

Use the Temperature Input Source menu item to select the source of the temperature input signal. Selections are listed below.

- Not used: Temperature compensation will not be performed. If this option is selected, the remaining temperature compensation menu items will not be displayed.
- 100-ohm American RTD: Select this option if the optional 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 RS485 or RS232 serial port. Specify which serial port to use and the parameter number to interpret as the temperature input. If the RS485 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" (Chapter 8).

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, Den. Alarms, & Flow menu (Chapter 3).

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

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

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

- Solvent polynomial: Specify the density change of the solvent as the process temperature changes.
- Solution polynomial: Specify 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: Specify 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: Specify 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 a 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. User-defined temperature polynomials are discussed later in this chapter.

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 during the density measurement setup are used as the reference densities. For example, the carrier gravity and the solids gravity values are used when the material type is slurry.

Note If you use temperature compensation, the material density values you enter during the density measurement setup must be correct at the reference temperature. For example, the density of water is 0.9982 at a temperature of 20°C. If you change the reference temperature to 4°C, you should change the carrier gravity to 1.00. ▲

The reference temperature must be outside the expected range of process temperatures. For example, if the process temperature varies 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.

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:

Δ d = The change in density due to the change in temperature relative to the reference temperature.

Δ T = The difference between the process temperature and the reference temperature.

A = The slope of the density change (Δd) versus 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 = Higher order coefficients that can be defined if a linear approximation to the density change (Δd) versus temperature change (ΔT) response curve is not adequate.

In many cases, a linear approximation to the density change (Δd) versus 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 the process material’s temperature density response formula is non-linear (higher order coefficient B and C are non-zero), you must calculate new coefficients if you ever change the reference temperature. ▲

If the 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 defining 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 slurry) that is assumed to correspond to the standardization. To correct for this, 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. 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

Standardization was introduced in Chapter 3, as you can initiate a standardization measurement from the Set up Density, Den. Alarms, & Flow menu.

If you access the Sensor Head Standardization menu item from the Gauge Fine Tuning group after performing standardization, you gain access to additional parameters related to the standardization as well as commands for performing a standardization measurement under special conditions.

```
Sensor head
Standardization→

          NEXT↓
```

Figure 5–10.

Press the right arrow to access the menus items described below.

1. If the standardization has not been performed, select the standard configuration for the standardization measurement. Options are: pipe full of carrier (solvent, fluid_1, or ref fluid), pipe empty, pipe full with block, or pipe empty with block. To preserve any calibration measurement(s) that have been made, the same standard configuration must be used as when the gauge was first standardized. For additional discussion on the standard configuration, refer to step 1 of the standardization procedure (Chapter 3). When ready, press the down arrow.

```
Standardize on: pipe
full of carrier
To change, press→
          NEXT↓
```

Figure 5–11.

2. If the standardization has been performed, the menu item shown below will be displayed instead of the menu item shown above. It is a read-only item that indicates status of the last standardization cycle. Press the down arrow to continue.

```
Last STD cycle was:
 full of carrier**

          NEXT↓
```

Figure 5–12.

3. 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 or by changing the number of time constant periods used.

```
STD cycle time:
8 X time constant
{time constant is
128 sec} NEXT↓ HELP→
```

Figure 5–13.

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.

4. The following 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 this item is not particularly important if a Cs-137 source (30-year half-life) is used and standardization is performed periodically. If a Co-60 source is used, 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.

```
Time since last
Standardization:
3.456 weeks
         NEXT↓
```

Figure 5–14.

5. 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 per day and seven days per 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 gauge.

```
Gauge is ON
7 days per week

         NEXT↓
```

Figure 5–15.

6. Use the menu item shown below to start a normal standardization using the settings described in the previous sections. The standardization procedure is described in Chapter 3.

```
Start standardize
 cycle (tank empty)
←Exit this menu.
 NEXT↓ EXECUTE CMD→
```

Figure 5–16.

Service Only Items

The following items are displayed in the Sensor Head Standardization menu if service only items have been enabled from the Special Functions menu (Chapter 8).

1. Specify the maximum allowable difference between the standardization value measured during a "qualify" standardization cycle (next menu item) and the standardization value currently in use. Press the down arrow.

```
Max. allowable STD
value difference:
.5000 %
         NEXT↓
```

Figure 5–17.

2. At the screen below, press the right arrow. A qualify standardization cycle performs a standardization measurement, but the new value is not used if it differs from the current value by more than the allowable difference specified in the previous menu item.

```
Start standardize
 cycle {Qualify val}
←Exit this menu.
 NEXT↓  EXECUTE CMD→
```

Figure 5–18.

3. A hold standardization cycle performs a standardization measurement, but the measured value is held, rather than used to replace the current value. To apply the "held" standardization value, execute the "Use latest STD value" command shown in step 6.

```
Start standardize
 cycle {Hold value}
←Exit this menu.
 NEXT↓ EXECUTE CMD→
```

Figure 5–19.

4. The item shown below displays the detector signal value from the most recent standardization cycle. A large change in the standardization value may indicate a problem with the instrument or an anomalous condition, such as extraneous radiation sources, during the standardization measurement.

```
STD value from latest
cycle:
**4.550E4
         NEXT↓
```

Figure 5–20.

5. The item shown below is read-only and displays the standardization value currently in use. This value will differ from the latest value if several weeks have passed since the last standardization.

```
STD value in use:
4.550E4
(read only)
         NEXT↓
```

Figure 5–21.

6. Executing the "Use latest STD value" command copies the standardization value from the latest cycle to replace the value in use. This is done automatically if you use the normal standardize command.

```
Use latest STD
value.
←Exit this menu.
 NEXT↓ EXECUTE CMD→
```

Figure 5–22.

7. The Data/Ref value affects the control of the high voltage (gain) applied to the photomultiplier tube in the detector. **Do not change this value unless instructed to do so by Thermo Fisher.** Enter 0.0 to use the default value (6.000).

```
Data/ref cnt ratio
0.000
(6.000 in use)
         NEXT↓
```

Figure 5–23.

Density Gauge Calibration

Calibration is discussed earlier in Chapter 3.

Flow Input Setup

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

Once the flow input has been set up, flow related measurements can be defined using the Set up Additional Measurements menus (Chapter 4), and once a flow related measurement has been configured, the Set up and Control Totalizers menu will be displayed in the top-level menus.

1. Press the right arrow to set up the flow input.

```
Flow INPUT setup→

             NEXT↓
```

Figure 5–24.

2. Press the right arrow to select source for the flow input. Select **current input** if you have connected a flow sensor with a 4–20 mA current output to the flow input terminals of the gauge.

```
Flow INPUT from:
none
  To change, press →
          NEXT↓
```

Figure 5–25.

3. Press the right arrow to select the volume units for the flow measurement (flow = volume/time).

```
Flow volume units:
liter

     NEXT↓ CHANGE→
```

Figure 5–26.

The available volume units are listed in the table below.

Table 5–1. Units for the flow measurement

Unit	Comment
ml (cu cm)	milliliters or cubic centimeters
cubic Meter	1 cubic meter = 1,000 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 = 1,000 milliliters
acre foot	43,560 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	1,000 US liquid gallons
UK quart	1,137 ml, 1/4 UK gallon

Unit	Comment
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

4. Press the right arrow to select the time units for the flow measurement (flow = volume/time). Available units are: s (seconds), m (minutes), h (hours), d (days), w (weeks), M (months), and y (years).

```
Volume flow time
units: minutes
{liter/m}
     NEXT↓ CHANGE→
```

Figure 5–27.

5. Press the right arrow to select the mass units for the flow measurement (flow = volume/time).

```
Mass flow
units: Kgram

     NEXT↓ CHANGE→
```

Figure 5–28.

Units for mass flow measurement are listed in the following table.

Table 5–2. Units for the mass flow measurement

Unit	Comment
gram	
kgram	kilograms (kg)
pound	
metric ton	1,000 kg
short ton	2,000 pounds
long ton	2,240 pounds
oz	avoirdupois ounces

6. Press the right arrow to select the time units for the flow measurement (flow = volume/time). Available units are: s (seconds), m (minutes), h (hours), d (days), w (weeks), M (months), and y (years).

```
Mass flow time
units: minutes
{Kgram/m}
     NEXT↓ CHANGE→
```

Figure 5–29.

7. Enter the flow signal time constant, which determines the amount of averaging applied to the flow signal input. The default of 4.0 seconds is usually adequate.

```
Flow signal
time constant
4 sec
          NEXT↓
```

Figure 5–30.

8. Specify the minimum value for the range of the flow current input signal. The default value is 4.0 mA.

```
Minimum flow input:
4.000 mA
          NEXT↓
```

Figure 5–31.

9. Specify the maximum value for the range of the flow current input signal. The default value is 20.0 mA.

```
Maximum flow input:
20.00 mA
          NEXT↓
```

Figure 5–32.

10. 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
4.000 mA:
20.00 lit/m
          NEXT↓
```

Figure 5–33.

11. 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 at
20.00 mA:
30.00 lit/m
          NEXT↓
```

Figure 5–34.

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Chapter 6
Current Output, Alarms, & Totalizers

Overview

This chapter describes the menu items under the Modify or Reassign Current Output menu, the Set up Fault Alarms or Change Process Alarm Assignments menu, and the Set up and Control Totalizers menu.

Modify or Reassign Current Output

Use the Modify or Reassign Current Output menu to perform the following tasks:

- Specify the measurement that should drive the current output in normal mode.
- Specify the measurement that should drive the current output in alternate mode.
- Implement correction factors on each current output.
- Set a current output hold value other than the default (50% of scale).

The primary measurement is assigned to the current output in both normal and alternate modes by default. To assign a measurement other than the primary measurement to a current output, follow these steps.

1. Define one or more additional measurement according to "Additional Measurements" (Chapter 4).

2. Use the Modify or Reassign Current Output menu to assign the current output (in normal mode, alternate mode, or both) to the desired measurement.

3. Return to the Set up Additional Measurements menu, enter the Modify Setup menu for the desired measurement, and specify the measurement range for the maximum and minimum current output values.

The current output can be set to switch from normal mode to alternate mode when an alarm is triggered. You can also directly enter a command to force a switch between normal and alternate modes. For example, if you are 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:

1. Set up Meas #1 as density and assign it to drive the current output in normal mode with a density range of 2.0–3.0 g/ml.

2. Set up Meas #2 as density and assign it 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 (Chapter 4).

The Menu Items

1. Press the down arrow to access the menu items.

```
Modify or re-assign
current output↓

     Other functions→
```

Figure 6–1.

2. The maximum current output value can be between 4.0 mA and 20.0 mA. The default value is 20.0 mA. Enter the value, and press the down arrow to continue.

```
Maximum current
output 20.00 mA
(4.000 to 20.00)
               NEXT↓
```

Figure 6–2.

3. The minimum current output value can be between .0001 mA and 20.0 mA. The default value is 4.0 mA.

```
Minimum current
output 4.00 mA
(.0001 to 20.00)
               NEXT↓
```

Figure 6–3.

Note Entering a value of exactly 0.0 sets the minimum current output to the default value of 4.0 mA. It is recommended that this value be set to 3.5 mA or greater. ▲

4. The two menu items below are only displayed if you have more than one measurement set up.

   Assign a measurement to the current output in normal mode. Select from the primary measurement and any additional measurements you have set up.

```
Mea 1: g/ml
is sent to current
out 1 in normal
mode. NEXT↓ CHANGE→
```

Figure 6–4.

   Assign a measurement to the current output in alternate mode. Select from the primary measurement and any additional measurements you have set up.

```
Mea 1: g/ml
is sent to current
out 1 in alternate
mode.  NEXT↓ CHANGE→
```

Figure 6–5.

5. Fine tune the maximum current output value to correct for any variation among systems. The maximum current output value is scaled by the value entered here.

```
Correction factor
for current output 1
at maximum: 1.000
        NEXT→
```

Figure 6–6.

6. Fine tune the minimum current output value to correct for any variation among systems. The minimum current output value is scaled by the value entered here.

```
Correction factor
for current output 1
at minimum: 1.000
        NEXT→
```

Figure 6–7.

7. Enter the value for midrange hold value for the current output. The value is entered as a percentage of the maximum current output value. The default is 50%.

```
Current output
hold mode value
50.00 % of scale
         NEXT↓
```

Figure 6–8.

Set up Fault Alarms or Change Process Alarm Assignments

The Set up Fault Alarms or Change Process Alarm Assignments menu allows you to perform the following tasks:

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

Note If relays are not installed, the Set up Fault Alarms or Change Process Alarm Assignments menu will not be displayed. To enable alarm related functions, such as a non-relay display alarm, go to the Special Functions menu (Chapter 8). ▲

Set up Alarms to Execute Commands

The first submenu in the Set up Fault Alarms or Change Process Alarm Assignments menu allows you 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 is defined, the alarm action is added to the list of alarm indicators and can be assigned as an alarm indicator for a specific alarm.

Note To assign a command action to a fault, warning, or mode alarm, use the menu items described in "Assign Relays to Warning and Fault Alarms" and "Assign Relays to Mode Alarms" later in this chapter. ▲

Note Due to limited display space, the "alarm indicated by" selection cannot display the full command name. The alarm action pairs are referred to as "#1 act on ALM action," etc. It is recommended that you write down each command action pair you assign for future reference. ▲

1. From the Set up Fault Alarms or Change Process Alarm Assignments menu, press the down arrow.

```
Set up fault alarms or
change process alarm
assignments.↓
   Other functions→
```

Figure 6–9.

2. From the Set up for Alarms to Execute Commands menu item, press the right arrow to continue.

```
Set up for alarms to
execute commands→

           NEXT↓
```

Figure 6–10.

3. Press the right arrow to scroll through and select the command to be executed when an alarm is set. The default is “Do nothing”. The available actions are listed in “Alarm Commands” later in this chapter. After making the desired selection, press the down arrow.

```
#1 act on ALM SET is
“Do nothing” command

    Continue↓ Change→
```

Figure 6–11.

4. Press the right arrow to scroll through and 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. The available actions are listed in “Alarm Commands” later in this chapter. After making the desired selection, press the down arrow.

```
#1 act on ALM CLR is
“Do nothing” command

    Continue↓ Change→
```

Figure 6–12.

5. The menu items shown in steps 3 and 4 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 20.0 mA)
- Hold current output(s) at minimum (normally 4.0 mA)
- Clear all holds
- Hold current output(s) at FAULT HIGH (20.8 mA or greater)
- Clear batch relays & totalizers
- Stop data stream on port 1 (RS232)
- Restart data stream on port 1 (RS232)
- Stop data stream on port 2 (RS485)
- Restart data stream on port 2 (RS485)
- 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 (3.6 mA or less)
- Enable totalizer 1 (2 / 3 / 4)
- Zero totalizer 1 (2 / 3 / 4)
- Save relay log data to NVRAM
- Update data output to port 1, RS232
- Update data output to port 2, RS485
- 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 totalizer
- 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 at least one measurement in addition to the primary measurement.

1. Press the right arrow to access menu items.

```
Assign alarms to
measurements→

         NEXT↓
```

Figure 6–13.

2. Press the right arrow to scroll through and select the desired measurement. The message on third line indicates the measurement type corresponding to the measurement number.

```
#1 alarm monitors
measurement 1
g/ml
  Continue↓ Change→
```

Figure 6–14.

Note By default, all 16 process alarms are assigned to measurement 1 (the primary measurement). The previous menu item is repeated for alarms 2 through 16. ▲

Assign Relays to Warning & Fault Alarms

Fault and warning alarms alert you to potential problems with gauge operation. Access the Assign Relays to Warning Alarms and Fault Alarms menu group to assign actions to indicate a system fault alarm, a warning alarm, or a signal loss alarm.

```
Assign “relays” to
warning alarms and
fault alarms→
         NEXT↓
```

Figure 6–15.

From the above menu item, press the right arrow. Select the desired alarm indicator for the fault and warning alarms, which are listed below.

- System fault
- CAL cycle aborted
- Sensor under range (occurs during standardization measurement if the radiation level is less than the background level)
- Sensor over range
- Current output maximum or minimum reached

Assign Relays to Mode Alarms

Mode alarms provide information about the status of the gauge. Access this menu group to assign actions to mode alarms.

```
Assign “relays” to
mode alarms→

         NEXT↓
```

Figure 6–16.

Mode alarms are listed below.

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

Show Relay Status

You can choose to display status of relays if they are installed by accessing the Do/Do Not Show Relay Status menu item. If enabled, relay status appears on the fourth line of the measurement display. Only the numbers of the relays currently turned on are displayed. For example, if relays 1 and 2 are currently on, a message similar to the one below will appear:

```
21 RELAY# ON
```

Set up and Control Totalizers

Use the Set up and Control Totalizers menu to set up the gauge's four totalizers. A totalizer is a counter that can be set up for volume flow, mass flow, and time measurements. If the 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).

Totalizer Setup Menus Items

1. This top-level menu is only displayed if the flow input has been set up (Chapter 5) and if a flow related measurement has been assigned as an additional measurement readout (Chapter 4). Press the down arrow to enter the menu.

```
Set up and control
totalizers.↓

   Other functions→
```

Figure 6–17.

2. To set up totalizer #1, press the right arrow. To set up another totalizer, press the down arrow until the desired one is displayed.

```
Assign & set up
totalizer 1
(inactive)→
          NEXT↓
```

Figure 6–18.

3. 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. When the correct one has been selected, press the down arrow.

```
Totalizer 1 will
totalize measurement
gal/m carrier
   Continue↓ CHANGE→
```

Figure 6–19.

4. 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.

```
One totalizer count
= 10.00 gal

   Continue↓ CHANGE→
```

Figure 6–20.

5. Select whether to display the totalizer count. For example, you might not need or want to display the count if you using it to control a relay output.

```
Tot 1 gal
Do display.
Change to "Do not"→
Continue as is.↓
```

Figure 6–21.

6. Position the "decimal" if you counting tenths, hundredths, etc. For example, if you are counting tenths of gallons, you can position the decimals one place to the right (0000000.0).

```
Position of decimal in
readout 00000000.
{Tot #1}
   Next↓  ←CHANGE→
```

Figure 6–22.

7. If your gauge has relays installed, select a relay to assign to the totalizer.

```
Totalizer 1 output
relay 1

Continue↓ CHANGE→
```

Figure 6–23.

8. The menu item below is 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.

```
Totalizer 1 relay close
every
00000010 counts
        NEXT↓
```

Figure 6–24.

9. Press the right arrow to enter the Totalizer Commands submenu.

```
Totalizer 1 Commands
 {clear, inhibit
  enable}→
        NEXT↓
```

Figure 6–25.

Totalizer commands are listed below:

- Zero totalizer 1 (2 / 3 / 4): Sets totalizer count to zero.
- Inhibit totalizer 1 (2 / 3 / 4): Stops the totalizer count.
- Enable totalizer 1 (2 / 3 / 4): Starts or restarts the totalizer count.
- Totalizer 1 (2 / 3 / 4) stops when rate below 0.000 gal/min carrier: Totalizer will stop if volume (or mass) flow rate falls below the specified value.
- Totalizer 1 (2 / 3 / 4) stops when rate above 0.000 gal/m carrier: Totalizer will stop if volume (or mass) flow rate exceeds the specified value.

10. Press the right arrow to enter the Batch Control Setup submenu. This submenu is discussed in "Batch Control Setup" later in this chapter.

```
Batch control
setup→

        NEXT↓
```

Figure 6–26.

11. Press the right arrow to enter the Sampler Control Setup submenu. This submenu is discussed in "Sampler Control Setup" later in this chapter.

```
Sampler control
setup→

        NEXT↓
```

Figure 6–27.

12. Press the right arrow to exit the Assign & Set up Totalizer menu.

```
←Exit from:
Assign & set up
totalizer 1
gal       NEXT↓
```

Figure 6–28.

Batch Control Setup

The items contained within the Batch Control Setup submenu are described below.

1. 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. Specify a relay number in this menu item before the rest of the menu items are displayed.

```
Totalizer 1
stop feed
relay  1
  Continue↓ Change→
```

Figure 6–29.

2. Enter the count at which you want the batch "stop" relay closed.

```
Totalizer 1 stop at
00000000 counts
for batch control
         NEXT→
```

Figure 6–30.

3. 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 feed
relay  2
  Continue↓ Change→
```

Figure 6–31.

4. Enter the count at which you want the batch "slow" relay closed. The "slow count" should be less than the "stop count."

```
Totalizer 1 slow at
00000000 counts
for batch control
         NEXT→
```

Figure 6–32.

Sampler Control Setup

The items contained within the Sampler Control Setup submenu are described below.

1. Set the timer period 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 menu items.

```
Totalizer 1 sampler
relay turns on for
10  1/4 sec periods
0 = sampler disabled
```

Figure 6–33.

2. Select relay number to be used for sampler control.

```
Totalizer 1 sampler
controls
relay  {none}
  Continue↓ Change→
```

Figure 6–34.

3. Enter the number of counts between samples – the relay is closed each time the totalizer reaches the value entered. The totalizer is then zeroed and begins counting again.

```
Tot 1 samples at
00000000 counts

         NEXT→
```

Figure 6–35.

Totalizer Action Items

The Totalizer Action Items are discussed in Chapter 7.

Chapter 7
Action Items

The Action Items menus provide access to frequently used commands. These commands are grouped by function:

- Common action items
- Alarm action items
- Hold action items
- Serial port related action items
- Totalizer action items

Common Action Items

The Common Action Items group allows you to restart the system, erase all entries, clear alarms, and access other useful system commands.

1. Press the right arrow to enter the menu.

```
Common action items
(clear memory, etc)→

             NEXT↓
```

Figure 7–1.

2. Press the right arrow to perform a warm boot. This command restarts the system, erasing temporary memory, but user-entered setup data is not affected.

```
System restart. Does
not affect user data
←Exit this menu.
  NEXT↓ EXECUTE CMD→
```

Figure 7–2.

3. The Erase All Entries (Except Comm Setup) command erases previously entered set up data. All settings except for the serial communication settings are reset to factory defaults.

```
Erase all entries!!!
(except COMM setup)
←Exit this menu.
  NEXT↓ EXECUTE CMD→
```

Figure 7–3.

4. The Clear Batch Relays and Totalizers command is only displayed if totalizer menus are active. Executing this command clears (resets) all totalizers.

```
Clear batch relays
& totalizers
←Exit this menu.
  NEXT↓ EXECUTE CMD→
```

Figure 7–4.

5. The Clear All Holds command clears all holds that are in effect.

```
Clear all holds
(some now in effect)
←Exit this menu.
  NEXT↓ EXECUTE CMD→
```

Figure 7–5.

6. Switching to alternate mode is only an option when the number of measurements set up is greater than the number of measurements that can be displayed at one time. By default, the system assigns the extra readouts to show up in alternate mode, and the display toggles between normal and alternate modes. Execute the Switch Display to Alternate Mode command to stop the display from alternating. Only the higher-numbered readouts will be displayed. Resume display alternation by executing the Clear All Holds command.

```
Switch display to
alternate mode
←Exit this menu.
  NEXT↓ EXECUTE CMD→
```

Figure 7–6.

7. This item is similar to the one above, except it causes the lower-numbered readouts to be displayed. Resume display alternation by executing the Clear All Holds command or by switching the display to normal mode.

```
Switch display to
normal mode
←Exit this menu.
  NEXT↓ EXECUTE CMD→
```

Figure 7–7.

8. Switching the current output to alternate mode is only an option if different measurements are assigned to the current output in normal and alternate modes. The command toggles between switching to alternate and switching to normal modes.

```
Switch current out
to alternate mode
←Exit this menu.
  NEXT↓ EXECUTE CMD→
```

Figure 7–8.

Alarm Action Items

The Alarm Action Items menu group enables you to view alarm status and history, acknowledge or clear alarms, and disable or erase all alarm action assignments.

1. Press the right arrow to enter the menu.

```
Alarm action items
(view, clear, etc)→

             NEXT↓
```

Figure 7–9.

2. The menu item below allows you to review all alarms currently in effect. Process, warning, fault, and mode alarms are included.

```


View alarm status→
           NEXT↓
```

Figure 7–10.

3. The menu item below allows you to review the history of all alarms that have occurred since the last Clear All Alarms command. Process, warning, fault, and mode alarms are included.

```


View alarm history→
           NEXT↓
```

Figure 7–11.

4. Executing the Clear All Alarms command acknowledges, clears, and resets all alarms. Alarm actions are cleared, but the setups are not affected. Alarm actions are re-established when the alarms activates again.

```
Clear all alarms

←Exit this menu.
  NEXT↓ EXECUTE CMD→
```

Figure 7–12.

5. The Acknowledge All Alarms command acknowledges but does not clear or reset alarms. The alarm actions are cleared, but the actual alarm remains activated. Alarm actions are not re-established until the alarm is cleared by command or there is a change in process and the alarm is again activated.

```
Acknowledge
all alarms
←Exit this menu.
  NEXT↓ EXECUTE CMD→
```

Figure 7–13.

6. The Disable All Alarms command turns all alarms off until they are manually turned on, essentially causing the system to ignore alarms. After execution, the display reads "Enable all alarms," allowing you to reinstate the alarms.

```
Disable all alarms

←Exit this menu.
  NEXT↓ EXECUTE CMD→
```

Figure 7–14.

7. The Erase All Alarm Action Assignments command erases entries for alarm assignments to relays, command execution, display flash, and zeroing current output. All alarm assignments will return to their defaults.

```
Erase all alarm action
assignments
←Exit this menu.
  NEXT↓ EXECUTE CMD→
```

Figure 7–15.

8. The End Alarm Delay and End Un-Alarm Delay commands are displayed only if alarm delay times have been enabled in the Special Functions menu (Chapter 8) and a delay time for alarm activation or alarm clear has been entered. If an alarm condition is true but alarm activation is being delayed because the alarm delay time has been set, the End Alarm Delay command cancels the delay time and the alarm will be activated. 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, the End Un-Alarm command cancels the delay time and the alarm will be cleared.

```
End alarm
delay command
←Exit this menu.
  NEXT↓ EXECUTE CMD→
```

Figure 7–16.

```
End un-alarm
delay command
←Exit this menu.
  NEXT↓ EXECUTE CMD→
```

Figure 7–17.

Hold Action Items

Access the Hold Action Items menu to clear holds, set hold mode value, and to set holds for the density measurement.

1. Press the right arrow to enter the menu.

```
"Hold" action items
(Hold reading, etc)→

             NEXT↓
```

Figure 7–18.

2. Execute the Clear All Holds command to clear any holds currently in effect. Press the right arrow to execute the command or the down arrow to continue to the next menu item.

```
Clear all holds
(none now in effect)
←Exit this menu.
  NEXT↓  EXECUTE CMD→
```

Figure 7–19.

3. The Hold Current Output at Max command allows you to hold the current output at the maximum output value. Press the right arrow to execute the command or the down arrow to continue to the next menu item.

```
Hold current outputs
at max (20.00 mA)
←Exit this menu.
  NEXT↓  EXECUTE CMD→
```

Figure 7–20.

4. The Hold Current Output at Min command allows you to hold the current output at the minimum output value. Press the right arrow to execute the command or the down arrow to continue to the next menu item.

```
Hold current outputs
at min (4.000 mA)
←Exit this menu.
  NEXT↓  EXECUTE CMD→
```

Figure 7–21.

5. The Hold Current Output at FAULT LOW command allows you to hold the current output at the FAULT LOW level (3.6 mA or less). Press the right arrow to execute the command or the down arrow to continue to the next menu item.

```
Hold current outputs
at FAULT LOW
←Exit this menu.
  NEXT↓  EXECUTE CMD→
```

Figure 7–22.

6. The Hold Current Output at FAULT HIGH command allows you to hold the current output at the FAULT HIGH level (20.8 mA or greater). Press the right arrow to execute the command or the down arrow to continue to the next menu item.

```
Hold current outputs
FAULT HIGH
←Exit this menu.
  NEXT↓  EXECUTE CMD→
```

Figure 7–23.

7. Enter the value (in percentage) of the midrange current output hold value. The default value is 50.00%. Press the down arrow to move to the next menu item.

```
Current output
hold mode value
50.00% of scale
        NEXT↓
```

Figure 7–24

8. Press the right arrow to execute the Hold Current Output command to hold the current output at the midrange value you specified in the previous step. Press the down arrow to continue to the next menu item.

```
Hold current output
at 50.00% of scale
←Exit this menu.
  NEXT↓  EXECUTE CMD→
```

Figure 7–25.

9. Enter the hold value for the density measurement. Press the down arrow.

```
Density hold mode
0.000 g/ml

         NEXT↓
```

Figure 7–26.

10. At the next screen, press the right arrow to hold the density measurement value at the hold value specified in the previous menu item. Press the down arrow to continue to the next menu item.

```
Hold Density at
0.000 g/ml
←Exit this menu.
  NEXT↓  EXECUTE CMD→
```

Figure 7–27.

11. Enter the hold value for the flow related measurement. This item is only displayed if a flow related measurement has been defined. Press the down arrow.

```
Flow hold mode
value 0.000 gal/m

         NEXT↓
```

Figure 7–28.

12. At the next screen, press the right arrow to hold the flow measurement value at the hold value specified in the previous menu item.

```
Hold flow at
0.000 gal/m
←Exit this menu.
  NEXT↓  EXECUTE CMD→
```

Figure 7–29.

Serial Port Action Items

Access the Serial Port Related Action Items menu to update, set up, and enable the serial ports.

1. Press the right arrow to access this menu group.

```
Serial port related
action item→

             NEXT↓
```

Figure 7–30.

2. Press the right arrow to send a data set (as defined by serial transmit setup or default) to the RS232 port. Press the down to continue to the next menu item.

```
Update data output
to port 1, RS232
←Exit this menu.
  NEXT↓  EXECUTE CMD→
```

Figure 7–31.

3. Press the right arrow to send a data set (as defined by serial transmit setup or default) to the RS485 port.

```
Update data output
to port 2, RS485
←Exit this menu.
  NEXT↓  EXECUTE CMD→
```

Figure 7–32.

Totalizer Action Items

The Totalizer Action Items menu is displayed if a flow input has been set up and a volume or mass flow related measurement has been assigned to an additional measurement.

1. Press the right arrow to access this menu group.

```
Totalizer
action items
(clear all, etc)→
                NEXT↓
```

Figure 7–33.

2. Press the right arrow to zero all totalizers, clear all batch relays, and slow or stop counters. Press the down arrow to continue to the next menu item.

```
Clear batch relays
& totalizers
←Exit this menu.
 NEXT↓  EXECUTE CMD→
```

Figure 7–34.

3. Press the right arrow to stop all totalizers from counting. Press the down arrow to continue to the next menu item.

```
Inhibit all
totalizers
←Exit this menu.
 NEXT↓  EXECUTE CMD→
```

Figure 7–35.

4. Press the right arrow to start the totalizers counting. Press the down arrow to continue to the next menu item.

```
Enable all
totalizers
←Exit this menu.
 NEXT↓  EXECUTE CMD→
```

Figure 7–36.

5. Press the right arrow to reset the totalizers to zero. This command does not restart the totalizers. Use the Enable All Totalizers command (previous step) to start the counting.

```
Clear all totalizers,
but do not enable
←Exit this menu.
 NEXT↓  EXECUTE CMD→
```

Figure 7–37.

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Chapter 8
Serial Ports, Contact Inputs, & Special Functions

From the Set up Serial Ports, Contact Inputs, or Special Functions menu you can perform the following tasks:

- Configure the RS232 (port 1) and RS485 (port 2) serial port communication parameters and set up data streaming parameters.
- Assign commands to the contact closure inputs.
- Customize the measurement displays and enable Service Only menu items.

Serial Ports

The instrument offers one RS232 single-drop (port 1) and one RS485 multi-drop (port 2) serial interface. Both provide independent access to the gauge's measurement and software functions. They can be connected to the gauge simultaneously; however, the setup menus can only be accessed by one port at a time.

Communication with the gauge can be established via remote terminal, a PC with terminal emulation software, or the Model 9734 HHT. The RS232 port of the gauge may be connected directly to the RS232 com port on a PC. Connecting the RS485 port of the gauge to the PC requires an RS485/RS232 adapter. Alternately, you can connect the Model 9734 HHT directly to the RS485 port on the gauge.

The RS485 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.

Terminal Types

The serial port related menu items allow you to configure the RS232 and RS485 ports to communicate with the devices listed below.

- ANSI terminal: The gauge sends ANSI escape sequences for screen and cursor control that are supported by ANSI terminals and by most PC-based communication packages. This setup allows full access to the instrument menu system from the terminal.
- Handheld terminal: This configuration supports the Model 9734 HHT or the TMT Comm software emulation of the HHT.
- Blind mode: Available if service only items have been enabled from the Special Functions menu (Chapter 8). Blind mode is a special mode that supports access to the gauge via a user-written program or script. The menu system is not available; the hexadecimal version of the direct entry keyboard codes must be used to enter parameters. The instrument echoes a “>” character (ASCII code 62) if the code is understood and a “<” character (ASCII code 60) if the code is not understood. This mode supports user-written scripts from within a terminal emulation communications package to automate a setup or data monitoring procedure.

Caution Do not use blind mode with the HHT. The HHT does not support the hexadecimal direct entry codes required for blind mode. ▲

Party-Line Communications

This section describes various aspects of party-line communications. Related menu items are discussed in “Data Transmission Setup” later in this chapter.

Setup

Note To communicate with multiple gauges via an RS485 party-line, each unit must be assigned a unique unit identification number so it can be addressed individually. All gauges are assigned as unit #0 by default. To assign a unique number to each gauge, you must be able to communicate with each gauge individually. This can be accomplished by disconnecting a gauge from the party-line in turn and then communicating with that gauge directly. Alternatively, you can remove power from all gauges except the one you want to communicate with. ▲

Follow the procedure below to set up a party-line.

1. Wire all units to the RS485 common lines according to the wiring instructions provided in the DensityPRO gauge installation guide (p/n 717774).

2. Ensure the port settings (baud rate, parity, and handshake) are the same for each unit (Modify Port Configuration menu). Assign each gauge a unique non-zero unit number.

3. Access the Data Transmission Setup menu to perform the following tasks:

   a. Set the desired RS485 measurements selections, data formats, user messages, etc. for each unit.

   b. Configure a Master unit (usually assigned the lowest unit number, typically unit #1).

   c. Specify an appropriate RS485 update time.

   d. Configure each slave unit.

   e. Set the RS485 update time as zero (0).

Modes

The party-line has three distinct modes of operation: unconnected, connect, and sleep. The party-line normally operates in the unconnected mode.

A unit in unconnected mode will only respond to the following:

- 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 unit 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 you have enabled streaming in connect mode. The unit exits connect mode 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

Several useful escape codes are provided in the table below.

Table 8–1. Escape codes

Code	Description
ESC [Z# #	CONNECT command. ## = unit number, i.e. 01 or 24.
ESC 0 Q	DISCONNECT command.
ESC X C	SLEEP command (ANSI).
ESC X D	WAKEUP command.
ESC X 1	CONNECT acknowledge. The gauge sends this to acknowledge the CONNECT command.
ESC X 2	DISCONNECT acknowledge.
ESC 0 V	ID REQUEST command.
ESC X 4	ID REQUEST TERMINATED command.
ESC [Yuu;cc;vvdd	POLLING command. uu = unit number (in hex) on party-line cc = command (in hex)* vv = unit number + 3 (in hex) dd = command number + 3 (in hex)

*Currently, only three cc command values are supported:

- 86: Single data stream update on RS485
- 8B: Download NVRAM contents to PC on RS485
- 8D: Upload NVRAM contents to gauge

Example: ESC [Y01;86;0489 will send the single data stream update command to unit 1.

Party-Line Limitations

The RS485 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 situation, you should verify that the gauge received the correct setup information.

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

Data streaming has to be explicitly turned off in the Data Transmission Setup 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 (command DAC 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.

Modify Port Configuration

The Modify Port menus allow you to set the baud rate and other communication parameters for the RS232 and RS485 ports. The configuration menus for both ports are similar, and unless stated otherwise, the following steps apply to RS232 and RS485 configuration.

1. Enter the Modify Port menu to set up the baud rate and other communication parameters for each port.

```
Modify port 2 RS485
configuration→
(baud rate, parity)
         NEXT↓
```

Figure 8–1.

2. Press the right arrow to enable or disable the port. Note that if you disable the RS485 or RS232 port, you must communicate with the gauge via the other port to re-enable the port.

```
Do not disable
port 2 RS485
Change to “Do”→
Continue as is.↓
```

Figure 8–2.

3. **RS485 port only:** Assign a unit ID between 1 and 32 for party-line communications. The Master unit is normally assigned as unit 1. For single unit operations, the default ID is 0. Press the down arrow to move to the next menu item.

```
Unit number of this
gauge (0 to 32) 0
(Should be 0 if not
party line.)  NEXT↓
```

Figure 8–3.

4. Press the right arrow to scroll through and select the serial device the port will interface with. Options are ANSI terminal (or PC emulation), HHT, and blind mode. See "Terminal Types" earlier in this section for descriptions of these options. Press the down arrow to move to the next menu item.

```
Interface RS485 with
ANSI terminal
(or PC emulation)
   Continue↓ Change→
```

Figure 8–4.

5. Press the right arrow to scroll through and select the baud rate (1200, 2400, 4800, or 9600 bps). Press the down arrow to move to the next menu item.

```
Port 2 RS485
9600 baud

    Continue↓ Change→
```

Figure 8–5.

6. Press the right arrow to scroll through and select the word length (7 or 8 bit). Press the down arrow to move to the next menu item.

```
Port 2 RS485 uses
7 bit word
Change to "8"→
Continue as is.↓
```

Figure 8–6.

7. Press the right arrow to scroll through and select the parity (even or none). Press the down arrow to move to the next menu item.

```
Port 2 RS485 uses
even parity
Change to "none"→
Continue as is.↓
```

Figure 8–7.

8. Specify whether to send a LINEFEED (ASCII character 10) after a carriage return (ASCII character 13) for a NEWLINE. Press the down arrow to move to the next menu item.

```
Do send LineFeed
with CR for NewLine
Change to "Do not"→
←Exit port 1 setup.
```

Figure 8–8.

Data Transmission 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, the Thermo Scientific HHT does not support data streaming. ▲

The Set Up Port for Data Xmit menu items provide control for the selection, formatting, and transmission of real-time measurement data to a serial device via the RS232 or RS485 ports. When a port is set up for data streaming (continual transmission of readings), the system sends a readout update on a regular basis. This update interval can be varied from 1 second to 9,999 seconds. The update data can include the readouts from any or all of the measurements that have been set up.

Data streaming on a party-line is automatically suspended when you send the SLEEP command and is normally suspended when you send a CONNECT to any unit on the party-line. You can set the unit to "output while in connect," causing it to continue to data stream, except while you are in the menu system. A unit assigned as unit #0 will automatically do this.

A reading is a measurement such as density or flow. 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 data set. This causes the data to update at the same place on the screen.

The steps for setting up data streaming for both ports are similar, and unless stated otherwise, the following steps apply to RS232 and RS485 configuration.

1. Press the right arrow to enter the menu.

```
Set up port 2 RS485
data xmit→
(data streaming)
         NEXT↓
```

Figure 8–9.

2. Press the right arrow to turn data streaming on or off. Press the down arrow to continue to the next menu item.

```
Do not inhibit RS485
data streaming.
Change to “Do”→
Continue as is.↓
```

Figure 8–10.

3. The menu item shown below is repeated for each measurement that has been set up. Enable or disable data transmission the measurement shown on the screen. Press the down arrow to continue to the next menu item.

```
Do not send meas 1
g/ml to
RS485 port.
        NEXT↓ CHANGE→
```

Figure 8–11.

4. **RS485 port only**: Select Do to allow the gauge to continue data streaming while in connect mode. Press the down arrow to continue to next menu item.

```
Do not data stream
in “connect” mode
Change to “Do”→
Continue as is.↓
```

Figure 8–12.

5. **RS485 port only**: Specify whether this gauge is a slave or the master for party-line communications. Press the down arrow to continue to the next menu item.

```
This is a slave
unit (xmit control).
Change to “master”→
Continue as is.↓
```

Figure 8–13.

6. The item shown below is a menu subgroup heading. The individual menu items are discussed in “Data Format Setup” later in this chapter. Press the right arrow to enter the submenu or the down arrow to continue to the next menu item.

```
Set up data format.→


           NEXT↓
```

Figure 8–14.

7. The item shown below is another menu subgroup heading. It is displayed only if non-packet data transmission has been selected. Press right arrow to enter the submenu or the down arrow to continue to the next menu item.

```
Set up header- Form
feed, message, etc
{RS232}→
           NEXT↓
```

Figure 8–15.

8. **RS485 port only:** The item shown below only appears if the setup is for a master unit on an RS485 party-line. Enter the highest unit number assigned to any gauge on the party-line. Press the down arrow to continue to the next menu item.

```
Highest unit number
in group 8

           NEXT↓
```

Figure 8–16.

9. If setting up the master unit on an RS485 party-line, the update time must be set to the minimum time indicated or greater. If not setting up a party-line, set the time between updates (in seconds). Press the down arrow to continue to the next menu item.

```
Port 2 RS485 update
time 0 sec
{12 sec minimum}
           NEXT↓
```

Figure 8–17.

Data Format Setup

The Set up Data Format menu items establish the formatting used for text transmission (labeling, tabulation, pagination) for measurements sent to a terminal or printer.

The menu items are identical for the RS232 and RS485 ports except where noted.

```
 Set up data format.→


         NEXT↓
```

Figure 8–18.

Step through the screens in this menu and choose how the data sets will be formatted. You have the following options:

1. Select whether to put the measurement number before each reading. Press the down arrow to continue to the next menu item.

```
Do not put meas num
before each reading.
Change to “Do”→
Continue as is.↓
```

Figure 8–19.

2. Select whether to send a logical NEWLINE after each reading. Press the down arrow to continue to the next menu item.

```
Do send NEWLINE
after each reading.
Change to “Do not”→
Continue as is.↓
```

Figure 8–20.

3. Select whether to send the measurement's unit string after each reading. Press the down arrow to continue to the next menu item.

```
Do send units
 with each reading.
Change to “Do not”→
Continue as is.↓
```

Figure 8–21.

4. **RS485 port only:** For units on an RS485 party-line, select whether to send the unit number with each reading. Press the down arrow to continue to the next menu item.

```
Do not put unit num
before each reading.
Change to “Do”→
Continue as is.↓
```

Figure 8–22.

5. Select whether to send a TAB (ASCII character 9) after each reading. This setting is useful for sending columnar data to a printer. Press the down arrow to continue to the next menu item.

```
Do not put TAB
after each reading.
Change to “Do”→
Continue as is.↓
```

Figure 8–23.

6. Select whether to send an ANSI clear/home escape string after a data set. Press the down arrow to continue to the next menu item.

```
Do CLEAR & HOME
before each data set.
Change to “Do not”→
Continue as is.↓
```

Figure 8–24.

7. Select whether to send a logical NEWLINE after transmission of the data set. Press the down arrow to continue to the next menu item.

```
Do not send NEWLINE
after each data set.
Change to “Do”→
Continue as is.↓
```

Figure 8–25.

8. Select whether to send a custom (user-defined) message before each data set. Press the down arrow to continue to the next menu item.

```
Do not send user msg
before each data set.
Change to “Do”→
Continue as is.↓
```

Figure 8–26.

9. **RS485 port only:** Select whether to send the gauge unit number before transmission of each gauge’s data set for units on an RS485 party-line only). Press the down arrow to continue to the next menu item.

```
Do not put unit num
before each data set.
Change to “Do”→
Continue as is.↓
```

Figure 8–27.

10. If you chose to send a user message before each data set (step 8), select whether to send a custom data set message. Press the down arrow to continue to the next menu item.

```
Set up custom
data set messages
{RS232}→
         NEXT↓
```

Figure 8–28.

11. Send an ANSI command to position the readout start on the specified row number (not available in blind, printer, or HHT terminal modes). Press the down arrow to continue to the next menu item.

```
port 1 (RS232) start
readout at screen
row 0
         NEXT↓
```

Figure 8–29.

12. Send an ANSI command to position the readout start in a specified column number (not available in blind, printer, or HHT terminal modes). Press the down arrow to continue to the next menu item.

```
Port 1 (RS232) start
readout at screen
column 0
         NEXT↓
```

Figure 8–30.

Contact Inputs

You can assign commands to be executed based on a user-provided contact input open or close. These menu items shown below are for contact closure #1. They are repeated for contact closure #2 if it is installed.

1. Press the right arrow to enter the menu.

```
Assign commands to
execute on contact
open/close 1→
         NEXT↓
```

Figure 8–31.

2. Press the right arrow to scroll through the list of commands until the one you want to execute with the switch closure is displayed. Press the down arrow to continue to the next menu item.

```
Do nothing command

executed by closing
switch 1. Use↓ Chg→
```

Figure 8–32.

3. Press the right arrow to scroll through the list of commands until the one you want to execute with the switch opening is displayed. This command will usually be the reverse of the contact close command.

```
Do nothing command

executed by opening
switch 1. Use↓ Chg→
```

Figure 8–33.

Special Functions

The Special Functions menu group contains specialized menu items that enable / disable relay delay times, relay latching, custom messages, etc.

1. Press the right arrow to enter the menu.

```
Special functions→


         NEXT↓
```

Figure 8–34.

2. If relays *are not* installed, the menu item below is displayed. Press the right arrow to change to "Do" to enable the alarm-related menu selections throughout the setup menus.

```
Do not enable alarm
related selections
Change to "Do"→
Continue as is.↓
```

Figure 8–35.

3. If relays are installed, the menu item below is shown. Press the right arrow to change to "Do" to enable relay alarm delay time entries in the menus which set up process limit alarms. If enabled, refer to "Special Relay Controls" later in this chapter. Press the down arrow to continue to the next menu item.

```
Do not enable alarm
relay delay times.
Change to "Do"→
Continue as is.↓
```

Figure 8–36.

4. If relays are installed, the menu item below is shown. Press the right arrow to change to "Do" to enable relay latch mode entries in the menus which set up process limit alarms. If enabled, refer to "Special Relay Controls" later in this chapter. Press the down arrow to continue to the next menu item.

```
Do not make relay
latching available
Change to "Do"→
Continue as is.↓
```

Figure 8–37.

5. Press the right arrow to change to "Do" to suppress the message on line 4 of the normal readout. This will allow all four lines to be used for measurement readouts. Press the down arrow to continue to the next menu item.

```
Do not disable "For
setup", etc. display
Change to "Do"→
Continue as is.↓
```

Figure 8–38

6. Press the right arrow to change to "Do" to display relay status on the measurement display. The numbers of the relays currently turned on will be displayed along with the normal measurement readouts. Press the down arrow to continue to the next menu item.

```
Do not show relay
status on readout.
Change to "Do"→
Continue as is.↓
```

Figure 8–39

7. Leave dynamic tracking enabled. Press the down arrow to continue to the next menu item.

```
Do not disable
dynamic tracking
Change to "Do"→
Continue as is.↓
```

Figure 8–40.

8. Press the right arrow to change to "Do" to cause service only setup items to appear in various menus. Press the down arrow to continue to the next menu item.

```
Do not enable
service only items.
Change to "Do"→
Continue as is.↓
```

Figure 8–41.

9. Press the right arrow to change to "Do" to enable multiple setups. This allows the instrument calibration data to be stored in one of four data sets and displays the Store/Retrieve Multiple Setups menu chain. If enabled, refer to "Multiple Setups" later in this chapter. Press the down arrow to continue to the next menu item.

```
Do not enable
multiple setups
Change to "Do"→
Continue as is.↓
```

Figure 8–42.

10. Press the right arrow to change to "Do not" to disable commands to dump and retrieve setup data via the serial ports. Press the down arrow to continue to the next menu item.

```
Do enable
serial dump items.
Change to "Do not"→
Continue as is.↓
```

Figure 8–43.

11. Press the right arrow to enter the Special Span Entries Density submenu group. This submenu allows you to change the current output span for the primary measurement (Meas #1 reading for current output maximum/minimum), overriding the span defined by entries in the primary setup section. Press the down arrow to continue to the next menu item.

```
Special span entries
density→

        NEXT↓
```

Figure 8–44.

12. Press the right arrow to enter the Set up Custom Units Messages submenu group. Custom messages are detailed in the section titled "Custom Units Messages" (later in this chapter).

```
Set up custom units
messages→

        NEXT↓
```

Figure 8–45.

Special Relay Controls

The three menu items shown below will be displayed in the alarm setup menu (Chapter 3) if the corresponding relay-related options are enabled in the Special Functions menu. These menu items provide special controls for relays that have been assigned as an alarm indicator.

1. If the alarm relay delay times function is enabled, the menu item below will be displayed. Set how the length of time in seconds that the alarm condition must persist before the alarm is activated. Press the down arrow to continue to the next menu item.

```
Alarm relay 1 set delay
0 seconds
(0-255 s after
alarm)          NEXT↓
```

Figure 8–46.

2. If the alarm relay delay times function is enabled, the menu item below will be displayed. Set how the length of time in seconds that the alarm condition must persist before the alarm is cleared. Press the down arrow to continue to the next menu item.

```
Alarm relay 1 clear
delay 0 seconds
(0-255 s after alarm
has cleared)   NEXT↓
```

Figure 8–47.

3. If relay latching is enabled, the menu item below will be displayed. With latching enabled, the relay will remain in the alarm state when the alarm has cleared. The relay state is cleared by a Clear All Alarms command (see "Alarm Actions" in Chapter 7) or when power is turned off.

```
Alarm relay 1 clear
delay 0 seconds
(0-255 s after alarm
has cleared)   NEXT↓
```

Figure 8–48.

Multiple Setups

The three menu items shown below will be displayed in the density setup menu (Chapter 3) if the multiple setups option is enabled in the Special Functions menu.

1. Press the right arrow to access commands that allow you to select the desired data set (1-8) to store calibration data and then store the calibration data. Press the down arrow to continue to the next menu item.

```
Commands to store
setup as one of nine
configurations →
        NEXT↓
```

Figure 8–49.

2. Press the right arrow to access commands to retrieve calibration data previously stored in a data set. Press the down arrow to continue to the next menu item.

```
Commands to retrieve
a stored setup →

        NEXT↓
```

Figure 8–50.

3. Press the right arrow to view the calibration values in previously stored data sets.

```
View data in stored
setups →

        NEXT↓
```

Figure 8–51.

Custom Units Messages

You can use custom messages to redefine units and to provide headers for serial data. The system supports up to eight custom message strings, each with a maximum of ten characters. You can find these menus within the Special Functions menu and the Set up Data Format submenu. This menu option is also displayed when you enable display scaling (Chapter 4). 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.

Message characters are entered 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 following table.

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

Table 8–2. Codes for custom units messages

Code	Character	Code	Character	Code	Character
32	SP(ace)	64	@	96	`
33	!	65	A	97	a
34	"	66	B	98	b
35	#	67	C	99	c
36	$	68	D	100	d
37	%	69	E	101	e
38	&	70	F	102	f
39	'	71	G	103	g
40	(	72	H	104	h
41	)	73	I	105	i
42	*	74	J	106	j
43	+	75	K	107	k
44	,	76	L	108	l

Code	Character	Code	Character	Code	Character
45	-	77	M	109	m
46	.	78	N	110	n
47	/	79	O	111	o
48	0 (zero)	80	P	112	p
49	1	81	Q	113	q
50	2	82	R	114	r
51	3	83	S	115	s
52	4	84	T	116	t
53	5	85	U	117	u
54	6	86	V	118	v
55	7	87	W	119	w
56	8	88	X	120	x
57	9	89	Y	121	y
58	:	90	Z	122	z
59	;	91	[	123	{
60	<	92	¥	124	|
61	=	93	]	125	}
62	>	94	^	126	→
63	?	95	–		

Follow the steps below to set up custom messages.

1. Press the right arrow to enter the menu.

```
Set up custom units
messages→

         NEXT↓
```

Figure 8–52.

2. Enter the 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. Press the down arrow after selecting a character to move to the next character in the message. If you press the down arrow twice, you move to the next message.

```
Character #1 of
custom message #1
0 ←→ “”
NEXT↓
```

Figure 8–53.

3. Enter the characters for the second custom message, or press the down arrow to continue to the next menu item.

```
Character #1 of
custom message #2
0 ←→ “”
NEXT↓
```

Figure 8–54.

4. Select the message to use with Meas #1. Press the right arrow to scroll through and select the message. Leave at 0 to use the default message. This menu item is repeated for each measurement that you have set up.

```
Meas #1 use message
#0 for readout units
“g/ml”
    Continue↓ Change→
```

Figure 8–55.

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Chapter 9
Security, Service, & Diagnostics

Overview

The Security, Service and Diagnostic Functions menu is divided into four groups:

- Security items
- Diagnostics
- User service and related items
- Factory service and related items

Security Items

The Security Items menu allows you to set a password and view other security-related items.

1. Press the right arrow to access the menu items.

```
Security items:
password, etc.)

        NEXT→
```

Figure 9–1.

2. Passwords are numeric entries that can be from 1 to 8 digits in length. Once you have set a password, you must enter it whenever you use the setup menus. Upon entering the correct password, you can access the menus without entering the password again for approximately five minutes. Disable this function by entering '0' (zero), but note that leading zeroes are part of the password and must be entered (0234, for example). Press the down arrow to continue to the next menu item.

```
Password ******** (Lock
out setup)

      NEXT↓ HELP→
```

Figure 9–2.

Caution Do not forget your password. Without it, you cannot change entries or fine tune the instrument. ▲

3. Whenever entries are changed and saved, the count shown in the figure below increases by one. Use this item to check for unauthorized entries. After you complete setting up the instrument, note this value and periodically check this item to see if the number has changed.

```
Entries have been
changed 14 times
(read only)
      NEXT↓ HELP→
```

Figure 9–3.

4. The Keypad in Use alarm indicates that the system setup menus are being accessed via the keypad or serial port. Press the right arrow to scroll through the available alarm indicators.

```
Keypad is in use
alarm indicated by
(Nothing)
      NEXT↓ CHANGE→
```

Figure 9–4.

Diagnostics

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 service only items are enabled in the Special Functions menu (Chapter 8).

1. Press the right arrow to access the menu items.

```
Diagnostics: System
test, related items→

          NEXT↓
```

Figure 9–5.

2. Press the right arrow to execute the Run Self Test command. This command causes the unit to test the various types of memory, the data integrity, and the signal processor. The system performs an automatic test and verification function every 10 minutes, and all user-entered data is doubly stored and periodically cross-checked. Errors are automatically corrected, and an alarm is activated when an error is detected. Press the down arrow to move to the next menu item.

```
Run self test

←Exit this menu.
  NEXT↓  EXECUTE CMD→
```

Figure 9–6.

3. Press the right arrow to review all alarms currently in effect. Press the down arrow to move to the next menu item.

```

View alarm status→
          NEXT↓
```

Figure 9–7.

4. Press the right arrow to review the history of all alarms that have occurred since the last Clear All Alarms command. Press the down arrow to move to the next menu item.

```
View alarm history→
          NEXT↓
```

Figure 9–8.

5. If service only items have been enabled in the Special Functions menu (Chapter 8), the RS232 and RS485 serial port error logs will be available for review. Press the right arrow to review the logs, or press the down arrow to move to the next menu item.

```
Serial port
 error logs→

          NEXT↓
```

Figure 9–9.

6. If relays are installed, the relay history logs will be available for review. Press the right arrow to review the logs, or press the down arrow to move to the next menu item.

```
Relay history logs→


          NEXT↓
```

Figure 9–10.

The two log items are described below.

a. The Relay On Time screen displays the total amount of time the specified relay has been on (may not be continuous). It is repeated for each relay installed. Press the down arrow to move to the next menu item.

```
Relay 1 on time
142.1 hours
(non-volatile save
once per hour)  NEXT↓
```

Figure 9–11.

b. The Relay Has Been On screen displays the cumulative number of times the specified relay has been turned on since the last time memory was cleared. It is repeated for each relay installed. Press the down arrow to move to the next menu item.

```
Relay 1 has been
on 20 times.
(non-volatile save
once per hour)  NEXT↓
```

Figure 9–12.

7. The Program Rev item displays the software version number. Have this number available when contacting Thermo Fisher with questions. The software build date and time stamp is only displayed if service only items have been enabled in the Special Functions menu (Chapter 8). Press the down arrow to move to the next menu item.

```
Program rev #
4.01
19-May-2000
18:45:48     NEXT↓
```

Figure 9–13.

8. The Snapshot Menu is shown if service only items have been enabled in the Special Functions menu (Chapter 9). Press the right arrow to enter the menu and view instantaneous values of various dynamic internal parameters. Refer to "The Snapshot Menu" later in this chapter for additional information. Press the down arrow to move to the next menu item.

```
Snapshot MENU→

            NEXT↓
```

Figure 9–14.

9. The View Internal Constants submenu is shown if service only items have been enabled in the Special Functions menu (Chapter 8). Press the right arrow to view the values of various internal constants that are computed based on user entries. Press the down arrow to move to the next menu item.

```
View internal
constants→

          NEXT↓
```

Figure 9–15.

10. The screen shown below is a read-only item that indicates the standard configuration during the last standardization cycle. Press the down arrow to move to the next menu item.

```
Last STD cycle was:
 full of carrier**

          NEXT↓
```

Figure 9–16.

11. The screen shown below is a read-only item that indicates the standard configuration during the last CAL cycle. Press the down arrow to move to the next menu item.

```
STD mode @ CAL cycle
 full of carrier **

          NEXT↓
```

Figure 9–17.

The Snapshot Menu

Access the Snapshot Menu items to view the instantaneous value of various dynamic internal parameters. This menu only appears if service only items have been enabled in the Special Functions menu (Chapter 8).

Note that the fourth line of several snapshot menu items displays:

◀CONT UPDATE▶ NEXT▼

Press the right arrow to update the snapshot value. Press the left arrow to switch to continuous update mode, and the fourth line changes to:

◀FREEZE

Press the left arrow again to return to the snapshot mode.

1. Press the right arrow to access the menu items.

```
Snapshot MENU→

          NEXT↓
```

Figure 9–18.

2. The Readout from Measurement displays the snapshot of the measurement readout. The menu item is repeated for each measurement set up. Press the down arrow to move to the next menu item.

```
Readout from
measurement 1
3.785 g/ml
←CONT UPDATE→  NEXT↓
```

Figure 9–19.

3. This is a submenu heading used for service diagnostic purposes only. It contains the values of scintillation detector counter chip registers. Values are frozen when you access this item. Press the down arrow to move to the next menu item.

```
Counter chip
register status

         NEXT↓
```

Figure 9–20.

4. The item below shows the effective path length used in the calculation of the density based on the detector signal. The gauge computes this value based on the pipe ID and the source head model. Press the down arrow to move to the next menu item.

```
Effective path
length 8.364 cm

          NEXT↓
```

Figure 9–21.

5. If temperature compensation has been set up, the current temperature readout will be shown here. Press the down arrow to move to the next menu item.

```
Temperature
readout  6.037 deg C

          NEXT↓
```

Figure 9–22.

6. If a flow measurement has been set up, the current value of the flow input will be shown here. Press the down arrow to move to the next menu item.

```
Flow
350.3 ml/sec

          NEXT↓
```

Figure 9–23.

7. View the internal value of the flow signal. Press the down arrow to move to the next menu item.

```
Internal value of
flow signal
0.000 ml/sec
          NEXT↓
```

Figure 9–24.

8. The next item displays the filtered value of radiation level (counts per second) measured by scintillation detector after background level has been subtracted. Press the down arrow to move to the next menu item.

```
Internal value of
sensor signal
2568 cps
←CONT UPDATE→ NEXT↓
```

Figure 9–25.

9. The item below displays the result of the following ratio:

   (measured radiation – background) to (standardization – background).

   Press the down arrow to move to the next menu item.

```
Internal value of
sensor to CAL ratio
0.3565
←CONT UPDATE→ NEXT↓
```

Figure 9–26.

10. The Internal Value of Iout % screen displays the internal value of the current output as a percentage of range. Press the down arrow to move to the next menu item.

```
Internal value of
IOUT1 %
60.80 %
←CONT UPDATE→ NEXT↓
```

Figure 9–27.

11. The Interval Value of IOut Flt screen displays the internal value of the current output relative to the range of 0–8000 (floating point). Press the down arrow to move to the next menu item.

```
Internal value of
IOUT1  (fp)
5429 (7998=max)
←CONT UPDATE→ NEXT↓
```

Figure 9–28.

12. The Internal Value of IOut Fix screen displays the internal value of the current output relative to the range of 0–8000 (fixed point). Press the down arrow to move to the next menu item.

```
Internal value of
IOUT1  (fixed pt)
5430 (7998=max)
UPDATE→       NEXT↓
```

Figure 9–29.

13. The following screen displays the HV Ctl, which is the current high voltage control (internal software) value. Press the down arrow to move to the next menu item.

```
HV ctl
1.209E-2

←CONT UPDATE→  NEXT↓
```

Figure 9–30.

14. The following screen displays the HV delta, which is the current high voltage control adjustment (internal software) value. Press the down arrow to move to the next menu item.

```
HV delta
1.912E-2

             NEXT↓
```

Figure 9–31.

15. The following screen displays the HV ctl chg, which is the current high voltage control adjustment (internal software) weighting factor. Value can range from 1.0 to 255.0.

```
HV ctl chg
1.0

             NEXT↓
```

Figure 9–32.

User Service & Related Items

Many of the menus within the User Service & Related Items may also be accessed from the Common Action Items and Hold Action Items menu groups (Chapter 7).

Common action items found in this group include:

- System Restart command
- Erase All Entries Except COMM Setup command
- Clear All Holds

Hold action items found in this group include:

- Hold current output at maximum command
- Hold current output at minimum command
- Hold current output at fault low command
- Hold current output at fault high command
- Current output hold mode value
- Hold current output command
- Density hold mode value
- Hold density command
- Flow hold mode value
- Hold flow command

Two additional menu items appear in the User Service menu group. They are:

1. Review Measurement Assignments 1-8: Press the right arrow to view assigned measurements.

```
Review measurement
assignments 1-8→

            NEXT↓
```

Figure 9–33.

2. Enable/Disable Service Only Items: Change to “Do” to enable the service only Items. This will enable a variety of additional menu items throughout the setup menus and the Factory Service menu items discussed in the next section.

```
Do not enable
service only items.
Change to “Do”→
Continue as is.↓
```

Figure 9–34.

Factory Service & Related Items

The Factory Service & Related Items menu is accessible if service only items have been enabled in the Special Functions menu (Chapter 8).

1. Press the right arrow to enter the menu.

```
Factory service
& related items→

          NEXT↓
```

Figure 9–35.

2. The Program Rev item displays the program revision number and the date/time of the software build. Press the down arrow to move to the next menu item.

```
Program rev #
4.01
19-May-2000
18:45:48     NEXT↓
```

Figure 9–36.

3. The following screen displays statistics regarding memory usage. It is for service diagnostic purposes only. Press the down arrow to move to the next menu item.

```
Stack statistics
Avail: 1847 bytes
Used: 112 bytes
         NEXT↓
```

Figure 9–37.

4. The following item is a menu subgroup header. Press the right arrow to access menu items that summarize the hardware configuration, such as the number and type of boards installed, number of relays installed, detector-type jumper setting, etc. Press the down arrow to move to the next menu item.

```
Hardware
diagnostics→

          NEXT↓
```

Figure 9–38.

5. The following item is a menu subgroup header. Press the right arrow to access menu items that display various memory related status messages. Press the down arrow to move to the next menu item.

```
View error status:
Bad NV writes, etc.→

          NEXT↓
```

Figure 9–39.

6. If relays are installed, the following item is a menu subgroup header. Press the right arrow to access the Test Relay submenu. Reference "Testing Relays" later in this chapter. Press the down arrow to move to the next menu item.

```
Test relays→


          NEXT↓
```

Figure 9–40.

7. RS232 test mode is for service diagnostic purposes only. Press the down arrow to move to the next menu item.

```
Do not enable
RS232 test mode
Change to "Do"→
Continue as is.↓
```

Figure 9–41.

8. RS485 test mode is for service diagnostic purposes only. Press the down arrow to move to the next menu item.

```
Do not enable
RS485 test mode
Change to “Do”→
Continue as is.↓
```

Figure 9–42.

9. Testing for invalid entries should only be enabled for diagnostic purposes. Press the down arrow to move to the next menu item.

```
Do not disable
bad entry testing
Change to “Do”→
Continue as is.↓
```

Figure 9–43.

10. The following item is a menu subgroup header. Press the right arrow to access menu items that signal diagnostics. See “Signal Diagnostics” later in this chapter. Press the down arrow to move to the next menu item.

```
Signal diagnostics→


         NEXT↓
```

Figure 9–44.

11. The following item is a menu subgroup header. Press the right arrow to scroll through a list of command codes, special measurement code base numbers, and alarms.

```
View menu, special
measurement, alarm &
command codes→
         NEXT↓
```

Figure 9–45.

Testing Relays

The items in the Test Relays menu subgroup are shown below.

1. Enter the relay number to test.

```
Commands 88, 89, 153
relay to test = #1

         NEXT↓
```

Figure 9–46.

2. Press the right arrow to test setting (turning on) the specified relay.

```
Test-set relay #1

←Exit this menu.
  NEXT↓  EXECUTE CMD→
```

Figure 9–47.

3. Press the right arrow to test clearing (turning off) the specified relay.

```
Test-clr relay #1

←Exit this menu.
  NEXT↓  EXECUTE CMD→
```

Figure 9–48.

4. Press the right arrow to turn all relays on.

```
Test all relays on

←Exit this menu.
  NEXT↓  EXECUTE CMD→
```

Figure 9–49.

5. Press the right arrow to turn all relays off.

```
Test all relays off

←Exit this menu.
  NEXT↓  EXECUTE CMD→
```

Figure 9–50.

6. Press the right arrow to clear any holds in effect.

```
Clear all holds
(none now in effect)
←Exit this menu.
  NEXT↓  EXECUTE CMD→
```

Figure 9–51.

7. Press the right arrow to test closing each relay in sequence, beginning with the relay number entered in the first item of this menu.

```
Test step relay #1

←Exit this menu.
  NEXT↓  EXECUTE CMD→
```

Figure 9–52.

Signal Diagnostics

The items in the Signal Diagnostics menu subgroup are shown below.

1. After stabilizing, the high voltage control value is saved on a daily basis. If power is removed from the gauge, the stored value is used when power is reapplied. The default is 1024. Press the down arrow to move to the next menu item.

```
Scintillator
HV control value
2647
              NEXT↓
```

Figure 9–53.

2. The item below displays the maximum value (internal software value) for the high voltage control value. The default is 8185. Press the down arrow to move to the next menu item.

```
Scintillator
HV control maximum:
8185
              NEXT↓
```

Figure 9–54.

3. Execute this command to hold the high voltage at the current saved value. Press the down arrow to move to the next menu item.

```
Hold HV at
2647
←Exit this menu.
  NEXT↓  EXECUTE CMD→
```

Figure 9–55.

4. Press the right arrow to hold the high voltage at the current value, or press the down arrow to move to the next menu item.

```
Hold HV at
present
←Exit this menu.
  NEXT↓  EXECUTE CMD→
```

Figure 9–56.

5. Selecting a measurement at the item shown below causes additional menu items to display that allow you to track the measurement's minimum and maximum values. Press the right arrow to change the values.

```
Track MIN & MAX on
measurement 0
none
      NEXT↓  CHANGE→
```

Figure 9–57.

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Chapter 10
Maintenance

Warning Remove all power from the unit before servicing. Electrocution can result if power is present. ▲

Warning In hazardous locations, ensure that power is removed from the detector before removing the housing cover. Be sure that the housing cover has been replaced and the grounds are properly connected before reapplying power. ▲

Maintenance Overview

In general, maintenance of the DensityPRO system consists of the tasks listed in the table below.

Table 10–1. Maintenance schedule

Task	Interval
Complete a shutter check.	Every 6 months.
Complete a tag and label check.	Every 6 months.
Complete a source housing check.	Every 6 months.
Check all wire connections	Every 30 days.
Complete a leak test.	Every 36 months for U.S. or every 12 months for Canadian installations.

Shutter Check

Check the shutter every six months. A shutter check consists of sliding the shutter into each position to make sure it is working properly. For source housings with an exposed shutter lever pivot, you can apply grease to the pivot if necessary to prevent corrosion and jamming.

Tag and Label Check

Check tags and labels every six months. All tags and labels attached to the source must be visible per radiation safety standards. All tags and labels must be securely attached and legible (including engraved labeling). Immediately replace any label that is damaged, illegible, or not securely attached.

Do not paint or overcoat the source housing without first masking the radiation identification tag and other labeling.

Source Housing Check

Complete a source housing check every six months. This check consists of looking for rust, corrosion, worn parts, damaged housing, missing tags, illegible tags, and worn or broken shutter(s). Also check for any debris that may have accumulated in the beam path between the source housing and the outer wall of the process vessel.

Warning Use a long handled brush to remove debris in the beam path to ensure that no part of your body, including your hands, enters the radiation beam path. ▲

Replacing System PCBs

This section provides general instructions on installing/replacing the PCBs in the DensityPRO system.

Warning Remove all power from the unit before servicing. Electrocution can result if power is present. ▲

Warning In hazardous locations, ensure that power is removed from the detector before removing the housing cover. Be sure that the housing cover has been replaced and the grounds are properly connected before reapplying power. ▲

Warning Close the shutter on the source housing before servicing the detector. ▲

To access the detector-transmitter electronics, follow the steps below.

1. Make sure all source shutters are in the “OFF” position.

2. Make sure all power to the gauge is turned off.

3. Remove the housing access cover:

    For the Model 9719A NEMA 4 housing, remove the bolts that secure the cover to the housing.

    For the Model 9720A explosion proof housing, loosen the screw on the cover retaining bracket and slide the bracket off of the housing cover. Unscrew the housing access cover (two lugs are provided on the top of the cover to aid in the removal of the cover).

4. Disconnect the plug-in screw terminals from the board connector. If the connector is tight, brace the board with your hand (but do not touch the circuit or components) and pull firmly but carefully. Lay the cables and connectors back over the edge of the housing so they will not be in the way when lifting the unit out of the housing.

5. Remove the screw that secures the unit in the housing. There will be a large plastic wire tie looped through the chassis of the detector. Pull on this loop to squeeze the triangle chassis together, allowing the detector to slide out of the housing smoothly. Slide the detector assembly up out of the housing, being careful to not snag the wiring, until it clears the housing. It is recommended that you take the detector to a clean, dry work place to change out the boards.

6. To remove a PCB from the detector, disconnect any cabling from the PCB, and then remove the retaining screws holding the PCB to the aluminum chassis.

7. Place the new PCB onto the chassis and secure it with the removed retaining screws. Connect any cabling that was disconnected from the removed PCB, and reinstall the detector in the housing.

8. Reconnect the plug-in screw terminals to the board connectors, and replace the housing access cover.

9. Apply power to the unit.

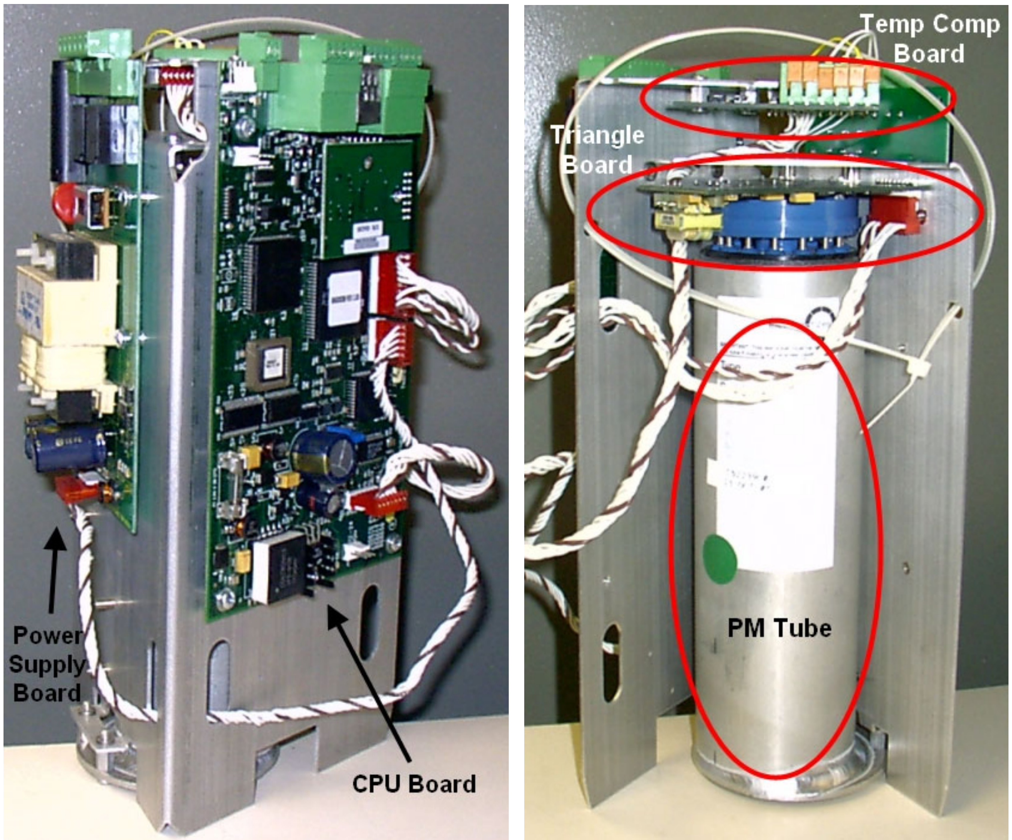
Power
Supply
Board
CPU Board
Temp Comp
Board
Triangle
Board
PM Tube

Figure 10–1.

Chapter 11
Troubleshooting & Support

Note Do not use the HART communication system for technical troubleshooting. You must use either the Thermo Scientific Model 9734 HHT or a computer with RS232/RS485 converter and the TMT Comm communication software to access the technical troubleshooting capabilities of the DensityPRO system. ▲

General Troubleshooting

1. Verify the source shutter is in the on (open) position. If the source has an internal shutter, use a radiation survey meter to verify the shutter is working properly and that the source is on.

2. Remove the detector housing lid, and connect the gauge detector to the 9734 HHT or to a PC that has TMT Comm installed.

3. While the lid is removed, verify the red LED on the CPU board is lit. This indicates that the CPU is operational.

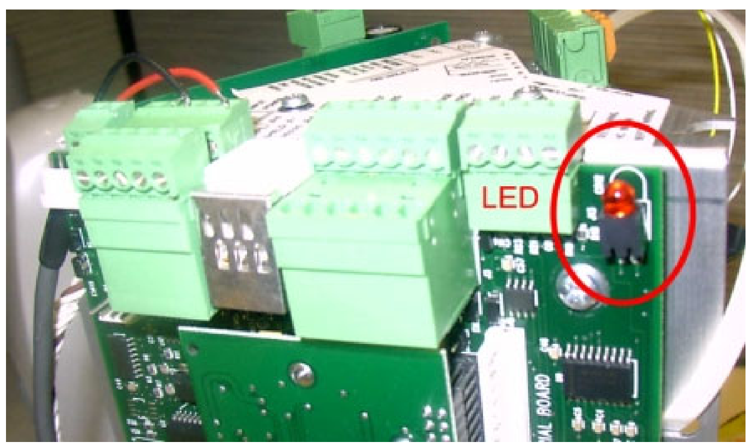

Figure 11–1. Power LED on the CPU board

4. If the gauge is AC powered and the LED is not lit, check the fuse on the power supply board (Figure 11–2).

Caution For reliable operation and to maintain safety approval, the fuse on the AC power supply board must only be replaced with an approved fuse (250V, 0.125A (1/8A), Type T (SB), Size 3AG). Also reference drawing 868578 in the DensityPRO gauge installation guide (p/n 717774). ▲

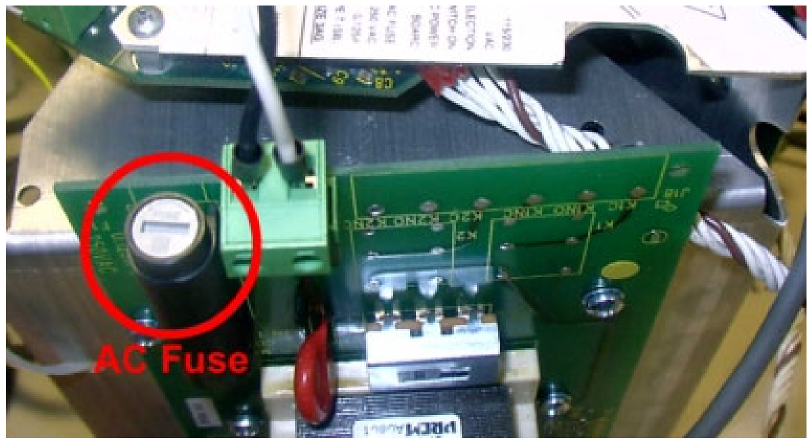

Figure 11–2. Fuse on AC power supply board

If the gauge is DC powered and the LED is not lit, check the F1 fuse on the CPU board (Figure 11–3).

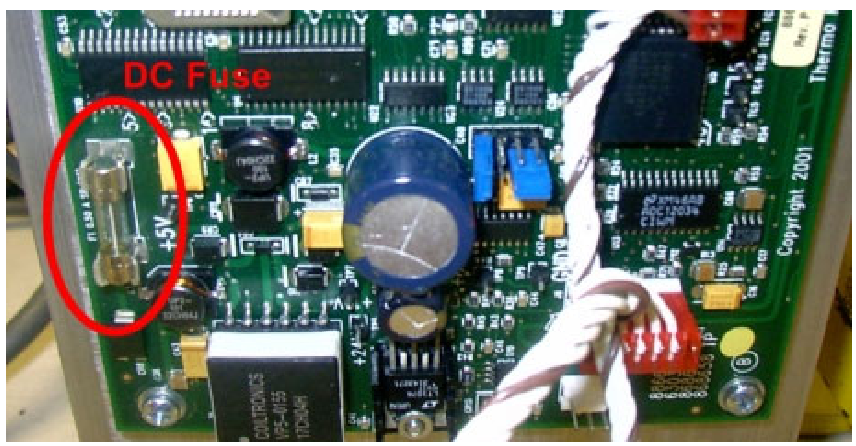

Figure 11–3. Fuse on CPU board for gauges with DC power

5. If the red LED is not lit and the fuse is not blown, use a voltmeter to measure terminals 1 and 2 of connector J12 on the CPU. If 24–28 Vdc is measured, the power supply is operating properly and supplying the correct power to the CPU. If the voltage is not there, the problem may be with the power supply or the supply voltage.

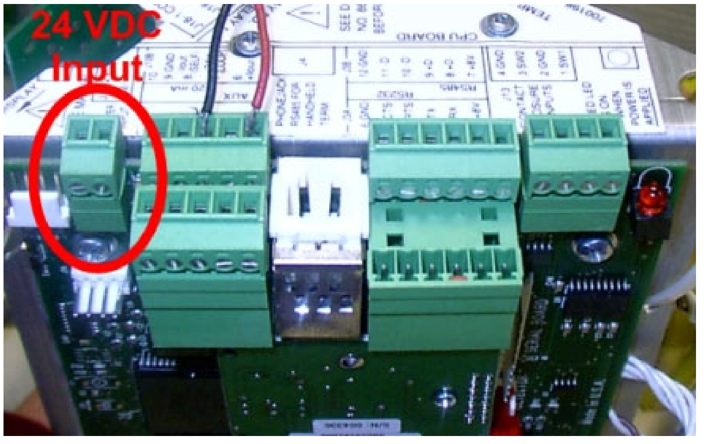

Figure 11–4. J12 connector on the CPU

The Detector-Transmitter

Note Enable the service only items in the Special Functions menu (Chapter 8) before proceeding with this section. ▲

Note Direct access codes are used in this section. For instructions on how to use direct access codes, refer to Chapter 2. ▲

If you suspect a problem with the detector-transmitter, follow the troubleshooting steps below.

1. Determine whether the detector is responding to changes in radiation. Do this by entering **112003** to view the internal value of the sensor signal.

```
Internal value of
sensor signal
2.057E4
```

Figure 11–5.

2. Note the value, and then close the source shutter. The value should decrease. Open the shutter, and the value should increase, returning to approximately the original signal value.

   If the sensor signal does not change or if it is zero when you cycle the source shutter, the signal is getting lost or corrupted between the scintillation crystal and the CPU. This may be caused by a fault with the photomultiplier tube, the detector interface board (triangle board), the cabling, or the CPU board.

3. Enter **045020** and press the right arrow once to enable the diagnostic measurements feature.

```
Do enable diag
measurements
Change to “Do”→
```

Figure 11–6.

4. With the diagnostic measurements feature enable, the display will toggle between two screens and display the density reading and five additional values. Note that there is a section later in this chapter to record these five values.

```
   .999 g/ml
>9999 VD
   2273 CTLSIG
 For setup, press →
```

Figure 11–7.

```
  0000 ERRSIG
     6 CNT-ratio
  1763 REF(cps)
 For setup, press →
```

Figure 11–8.

- ERRSIG: This value may also be seen as “HVCorr”, depending on the version of software in the instrument. It is a relative value representing the length of the control pulses for the high voltage control and should be at or near 0. If it is staying under 10, the detector is under normal control and working correctly. If it is running between 10 and 50, the detector may be damaged (possibly from being overheated for a period of time), and its indication should be suspect. If this number is running from 50 to 256 (the highest possible value), the gauge cannot control the high voltage, and the detector has probably failed.

- CTLSIG: This value may also be seen as "HVCtrl", depending on the version of software in the instrument. It is a relative value representing the amount of control time the CPU is using to control the detector. The value can be from 10 to 8000. The normal control range for a new detector is from 2000 to 5000. Every scintillation detector will have a different value; however, it should be a steady value. If it is ramping up or down, then detector is faulty and not under control.
- VD (cps): This value is the "DATA" count rate in counts per second (cps). Display the value by entering **025030** to enable the R&D test items. It should be the same as the internal value of the sensor signal, which was viewed earlier in this procedure by entering **112003**. The value will be displayed in scientific notation, and if it is above 9999, the displays will show ">9999". Note that other values will also change to scientific notation and lose their names. Only leave this feature enabled long enough to verify the value increases as the density decreases and decreases as the density increases.
- REF(cps): This value is the "Reference" count rate in counts per second. It should be 1/6 of the VD count rate. The CPU will adjust the CTLSIG until the VD is six times the REF count rate. If it is unable to reach this 6:1 ratio, the CTLSIG will ramp up to 8000, go back to 10, and ramp up again. If the REF(cps) is a low number, 5 for example, the reference counts are getting lost between the photomultiplier tube and the CPU.
- CNT-ratio: This value is the ratio of the "DATA" count rate (VD) and the "Reference" count rate (REF(cps)). This ratio should stay at 6:1. If the R&D test items are enabled (see VD (cps) above), the number will move back and forth from slightly below 6 to slightly above 6. This indicates that the CPU control is functioning properly.

5. If the problem still exists, record the values of the parameters listed below and contact Thermo Fisher for assistance.

Recorded Values for Troubleshooting

The values of the following parameters are useful to Thermo Fisher Technical Support when troubleshooting problems with the DensityPRO system.

To recall these values, press **EXIT**, enter the direct access code, and press the down arrow. Record the value shown and press **EXIT** again to return to the main screen. The first five values (ERRSIG through CNT-ratio) were accessed earlier by enabling the diagnostic measurements in step 4 of the above procedure.

Table 11–1.

Parameter Name / Direct Access Code	Description	Value
ERRSIG	Error from stable control	
CTLSIG	Control signal from CPU	
VD	Data count rate in cps	
REF(cps)	Reference count rate in cps	
CNT-ratio	VD/REF(cps) ratio	
128003	Standardization value	
112003	Snapshot of detector signal	
049003	Density slope correction	
048003	Pipe ID in inches	
031001	Software version	
007004	Time constant in seconds	
085003	Carrier gravity in g/ml	
083003	Solids gravity in g/ml	
058003	Density of CAL point 1	
148003	Density of CAL point 2	
086003	CAL/STD ratio for CAL point 1	
149003	CAL/STD ratio for CAL point 2	
019003	Carrier attenuation coefficient	
020003	Solids attenuation coefficient	
138013	20 mA output value	
115013	4 mA output value	
023003	Source half-life value	

The Current Output

If you suspect a problem with the current output, first verify that wiring and jumper setting are correct for the current output configuration. The current output configuration is marked on a label on the inside of the gauge housing lid. Refer to the current output section in the DensityPRO gauge installation guide (p/n 717774) for a description of the three possible configurations.

If the current output is correctly configured, attach an ammeter in series with the current output load and verify the current output at various levels. Use the commands from the User Service & Related Items submenu within the Security, Service, and Diagnostic Functions menu group (Chapter 9) to hold the current output at specific levels for testing.

The Relay

If you suspect a problem with a relay output, attach a continuity tester to the suspected relay output and use the Test Relays commands in the Factory Service & Related Items menu (Chapter 9) to test relay operation.

Communication Problems

If the gauge will not communicate at all, hard boot the unit.

Note This procedure will erase memory and return all parameters to the factory defaults. ▲

Warning Remove power from the gauge prior to performing this procedure. ▲

1. Locate the J11 connector on the CPU board. The blow-away jumper as set for normal operation is shown below.

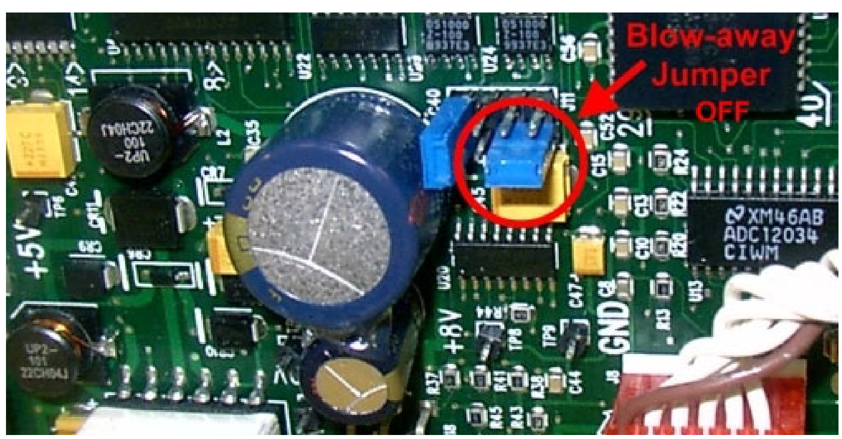

Figure 11–9. Blow-away jumper in normal operation position

2. With power removed, remove the blow-away jumper, rotate it 90° clockwise, and insert onto the pins as shown below.

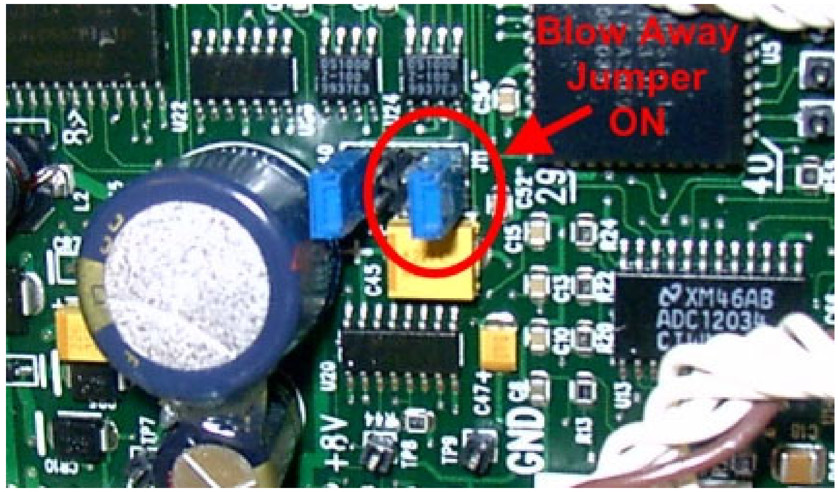

Figure 11–10.

3. Apply power to the gauge for approximately 15 seconds.

4. Remove power from the gauge, and return the jumper to its original position.

5. Apply power to the gauge. All parameters will be set to factory defaults.

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 contact Thermo Fisher directly.

Process Instruments		
1410 Gillingham Lane Sugar Land, TX 77478 USA +1 (800) 437-7979 +1 (713) 272-0404 direct +1 (713) 4573 fax	14 Gormley Industrial Avenue Gormley, Ontario L0H 1G0 CANADA +1 (905) 888-8808 +1 (905) 888-8828 fax	Unit 702-715, 7/F Tower West Yonghe Plaza No. 28 Andingmen East Street, Beijing 100007 CHINA +86 (10) 8419-3588 +86 (10) 8419-3580 fax
A-101, 1CC Trade Tower Senapati Bapat Road Pune 411 016 Maharashtra, INDIA +91 (20) 6626 7000 +91 (20) 6626 7001 fax	Ion Path, Road Three Winsford, Cheshire CW7 3GA UNITED KINGDOM +44 (0) 1606 548700 +44 (0) 1606 548711 fax	
www.thermoscientific.com		

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Appendix A
Ordering Information

Table A–1. DensityPRO gamma density system

High Performance Input Power	
1	115/230 Vac, ± 10%, 50/60 Hz
2	24 Vdc
Region Requirement	
0	ROW
C	CE-EMC (when selected, no relays or local display)
Relays	
R	Two Form C relays, SPDT isolated 8A @ 220 Vac
N	No relay contacts
4–20 mA Output	
L	Isolated, loop-powered (Namur compliant, 700 ohm load maximum)
S	Isolated, self-powered (Namur compliant, 700 ohm load maximum)
Detector Approvals	
N4	Non-hazardous model 9719A, Type 4, CSA/C-US
XP	Hazardous model 9720A, XP – Class 1 Div. 1, CSA/C-US, Type 4, ATEX IP65
Detector Enclosure	
D	Dual chain mount
B	Base plate mount (required for pipe saddle or wall mount)
W	Base plate mount, water-cooled (pipe saddles required)
Mounting Hardware	
N0	No mounting hardware
DS	Dual chain, 2” steel pipes (dual chain mount required)
DM	Dual chain, 2.5–18” steel pipes (dual chain mount required)
DL	Dual chain 20–36” steel pipes (dual chain mount required)
1.5	Pipe saddle for 1.5” or 2.0” pipes
XX	Pipe saddle for 3–16” pipes. (Available pipe sizes in inches: 3, 4, 5, 6, 8, 10, 12, 14, and 16.)

XX	Pipe saddles for 18–42” pipes. (Available pipe sizes in inches: 18, 20, 22, 24, 26, 28, 30, 36, and 42.)
Backshield Option	
B	Detector with backshield (Model 9719A only)
N	No backshield
Temperature Compensation	
N	None
T	Temperature compensation board
R	Temperature compensation with RTD
Communications	
0	No selection
A	Thermo Scientific Model 9734 HHT
E	HART communication module
F	FOUNDATION fieldbus module
Optional Accessories	
L	Lg SS tag (3.3” x 2.5”), wired
R	RJ-11 modular connector jack
D	Thermo Scientific Model 9723 backlit LCD
T	Pipe tabs (pipe saddles only)

Table A–2. Spare parts

P/N	Description
886631	Complete electronics chassis
886670-2	CPU assembly
NDMI-PWR001	AC power supply assembly without relays
NDMI-PWR002	AC power supply assembly with relays
886595-1	Kit, 4–20 mA isolated, self-powered
885882-1	Backlit display PCB assembly (circuit board only)
886609	Temperature compensation circuitry assembly
OPR0101C	Complete electronics chassis with AC power supply, no relays
OPR0101D	Complete electronics chassis with AC power supply, with relays
DPROCBLKIT	Kit, complete set of DensityPRO connection cables (excluding those required for HART communication)

Appendix B
Specifications

Results may vary under different operating conditions.

Table B–1. Performance specifications

System performance	From ± 0.0001 gm/cc depending on application

Table B–2. Gamma ray source

Source type	Cs-137 or Co-60, both stainless steel doubly encapsulated
Size	10 to 10,000 mCi Cs-137 or 1,000 to 3,000 mCi Co-60
Source housing	Carbon steel or stainless steel, lead filled, polyurethane painted. Two-position shutter, locks in OFF (closed) position.

Table B–3. Integrated detector-transmitter

System architecture	Multiprocessor based electronics provides uninterrupted output during data entry and system interrogation. Surface mount technology provides high degree of reliability. All user data doubly stored in non-volatile memory with no battery backup required.
Detection type	PVT plastic scintillator with wide dynamic range. PVT resists shock and moisture damage.
Detector stabilization	Electronic control without heater stabilization for optimum performance
Enclosure construction	Carbon steel polyurethane painted
Approvals – Model 9719A	FMRC approved dust-ignition proof in Class II, Div. 1, Groups E, F, G; suitable for Class III, Div. 1 hazardous locations, indoor and outdoor NEMA 4. CSA approved dust-ignition proof in Class II, Div. 1, Groups E, F, G; suitable for Class III, Div. 1 hazardous locations, indoor and outdoor CSA ENCL 4.

Approvals – Model 9720A	FMRC approved explosion proof in Class I, Div. 1, Groups B, C, D; dust-ignition proof in Class II, Div. 1, Groups E, F, G; suitable for Class III, Div. 1 hazardous locations, indoor and outdoor NEMA 4. CSA approved explosion proof in Class I, Div. 1, Groups B, C, D; dust-ignition proof in Class II, Div. 1, Groups E, F, G; suitable for Class III, Div. 1 hazardous locations, indoor and outdoor CSA ENCL 4. CE-ATEX II 2 G Ex d IIC T5 Gb CE-EMC compliance contingent upon installation of EMC protection kit as illustrated on drawing 880100.
Power	115/230 Vac, ± 10%, 50/60 Hz or 24 Vdc
Operating temperature	-40°C to +60°C (-40°F to +140°F) ambient
CE-EMC surge protection board junction box	CE-ATEX II 2 G Ex d IIC T6 Gc -40°C <= Ta <= 60°C **Warning: Do not open when an explosive atmosphere may be present.**

Table B–4. Inputs and outputs

Inputs	Flow meter: 4–20 mA linear Dry contact closure Temperature compensation circuitry with 100-ohm Platinum RTD, 2 or 3 wire
Current outputs	Three configurations available for the 4–20 mA current output: - Isolated, loop-powered (default) - Non-isolated, self-powered - Isolated, self-powered output (requires optional daughter board p/n 886595)
Serial outputs	RS485 half duplex RS232 full duplex Fieldbus: A Device Description (DD) for the DensityPRO gauge is available from the Fieldbus Foundation website. The DD is a DD4 that is interpreted by a host implementing DD Services 4.x or higher.
Contact closure (relay) outputs	Two optionally available Form C relays, SPDT isolated 8A @ 220 Vac.
Wiring entry	(2) 3/4 NPT female conduit ports. Use only suitably approved cable glands and blanking plugs.

Table B–5. Mounting hardware

Gamma ray source	Integral bolt-on bracket; compatible with chain or saddle mount
Integrated detector-transmitter	Dual chain universal mount, 2.5 to 36 in (63.5 to 914.4 mm) Pipe saddle mount, 2 to 42 in (50.8 to 1066.8 mm) Pipe saddle with tabs for mounting on insulated pipes Axial mount hardware for Z-pipe installations, 1 to 4 in (25.4 to 101.6 mm)

Table B–6. Optional Thermo Scientific Model 9723 display

Display	2-line x 16-character backlit LCD
Qualifications	CSA/C-US: Class I, Groups B, C, and D; Class II, Groups E, F, G; Class III; Type 4 Enclosure ATEX: II 2G Ex d IIC T6 (Tamb -40°C to +60°C) EN60079-0:2006 and EN60079-1:2007
Power	Display powered from electronics
Installation site	Maximum separation from electronics: 300 ft (91.4 m)

Table B–7. Programming options

Fieldbus host, such as National Instruments™ NI-FBUS Configurator	Provides the interface between the DensityPRO gauge and other devices on a FOUNDATION fieldbus network.
275/375/475/later field communicator from Emerson Electric Co	For gauge configuration and calibration. Communicates with any DensityPRO gauge via the current loop. BEL202FSK standard.
Thermo Scientific Model 9734 handheld terminal	For gauge configuration and calibration. Communicates with any DensityPRO gauge via RS485 connector. Provides upload / download of gauge configuration to / from PC via RS232 interface.
Comm PC interface software	For interfacing with up to 32 DensityPRO gauges over RS485.

Appendix C
Solution Characterization

Overview

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 in Chapter 3 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 density setup 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; in other words, 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 density setup menu, and then enter the coefficients in the subsequent items. Enter zero (0) for coefficients you do not need to use.

Built-In Polynomial Coefficients

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

Table C–1.

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
H3PO4	0 to 40%	1.866	1.288	-8.047	18.07
A-LACTOSE	0 to18%	2.518	1.053	-6.338	0.0
H-LACTOSE	0 to 18%	2.656	8.647E-1	-4.504	0.0

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Appendix D
Attenuation Coefficients

Overview

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 x 0.3 (iron) + 0.078 x 0.6 (oxygen) + 0.078 x 0.1 (silicon)

          =    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). ▲

Attenuation Coefficients

Attenuation coefficients are listed in the table below.

Table D–1. Attenuation coefficients

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
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

Element			Atomic Weight	Cs-137 Coef.	Co-60 Coef.
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
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

Element			Atomic Weight	Cs-137 Coef.	Co-60 Coef.
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

Element			Atomic Weight	Cs-137 Coef.	Co-60 Coef.
99	Es	Einsteinium	254.00	.1486	.0742

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Appendix E
Toxic & Hazardous Substances Tables

The English and Chinese versions of the Toxic and Hazardous Substances tables are shown below.

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
4-20 mA Output Board	x	o	o	o	o	o
CPU Board	x	o	o	o	o	o
Detector Interface Board	x	o	o	o	o	o
HART Board	x	o	o	o	o	o
Power Supply Board	x	o	o	o	o	o
Temperature Compensation Board	x	o	o	o	o	o
Cabling	x	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
4-20 mA 输出电路板	x	o	o	o	o	o
CPU 电路板	x	o	o	o	o	o
检测器接口电路板	x	o	o	o	o	o
HART 电路板	x	o	o	o	o	o
电源板	x	o	o	o	o	o
温度补偿电路板	x	o	o	o	o	o
缆线连接	x	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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Appendix F
Vapor Density Compensated Level

Introduction

This appendix explains the setup used to compensate for errors in level reading due to gas density variations.

Note In addition to this appendix, refer to the Thermo Scientific LevelPRO user guide (p/n 717778). ▲

The vapor density of a gas can roughly be estimated using the following formula:

$$D = (M \times P) / (82 \times T),$$

where:

D = gas density in g/cc

M = g of gas/mole of gas

P = gas pressure in atm

T = gas temperature in Deg Kelvin (Deg K = Deg C + 273)

Example:

Find the density of nitrogen at 20°C and a pressure of 8 atmospheres.

Nitrogen gas = N_2; therefore M = 2 * 14 = 28

P = 8

T = 20 + 273 = 293

Thus,

D = (28 * 8) / (82 * 293) = 0.00932 g/cc

When the minimum and maximum densities are known, the error in level reading due to the vapor density variation can be estimated. If the error is higher than can be allowed by operations, density compensation should be considered. The Thermo Scientific level application program can make it easier to determine this estimate.

The compensation is based on a linear model where the density gauge is placed near the top of the level gauge, measuring the attenuation of the gamma rays due solely to the changing gas density. The radiation reaching the density gauge must never be blocked by the process level. This condition would result in a completely erroneous level indication.

Finding a Compensation Formula

Where:

L_{comp} = Compensated Level reading

L_{uncomp} = Uncompensated Level reading

VDR = Signal to ref ratio measured by the density gauge (VSENS)

VLR = Signal to ref ratio measured by the level gauge (VSENS)

Assumptions:

1. The signal is linear with level.

2. At 100% level, VLR will be zero, i.e. the signal is completely attenuated when the vessel is full.

3. VLR is attenuated by the gas in the ratio measured by VDR.

With the above assumptions, we have:

$$\text{Indicated Level} = 100 - 100 \times \text{VLR} \tag{1}$$

Since VLR is affected by the gas:

$$\text{Compensated Level} = 100 - 100 \times (\text{VLR} / \text{VDR}) \tag{2}$$

Solve for VLR:

Equation (1):

$$\text{VLR} = (100 - \text{Indicated Level}) / 100$$

Equation (2):

$$\text{Compensated Level} = 100 - 100 \times (100 - \text{Indicated Level}) / (100 \times \text{VDR})$$

Therefore:

$$\text{Compensated Level} = 100 - 100 / \text{VDR} + \text{Indicated Level} / \text{VDR} \tag{3}$$

The equation used for compensation can be written as:

$$L_{comp} = (100 \times \text{VDR} - 100 + L_{uncomp}) / \text{VDR}$$

Special Equation

The special equation allows us to use the following formula:

$$X = \frac{D_1 \times V_a + E_1 \times F_{1o} + F_1 \times V_a \times F_{1o} + H_1}{D_2 \times V_a + E_2 \times F_{1o} + F_2 \times V_a \times F_{1o} + H_2}$$

where:

X = Lcomp

V_a = Luncomp

F_{lo} = VDR

D_1 = 1

E_1 = 100

H_1 = -100

E_2 = 1

There are three special measurement codes that invoke the special equations function. The special equations allow the value from the 4–20 mA auxiliary current input (e.g., from a pressure sensor or density gauge) to be combined with a function of the level measurement from the gauge, f(level), to create a new measurement value. The special equations have the following form.

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

$M_1 = A_1 * f(level) + B_1 * Aux + C_1 * f(level) * Aux + D_1$.

$M_2 = A_2 * f(level) + B_2 * Aux + C_2 * f(level) * Aux + D_2$.

$A_1, B_1, C_1, D_1, A_2, B_2, C_2, D_2$ = user-entered constants.

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 level (f(level)) depends on the special measurement code as shown below.

Table F–1. Special equations

Special Measurement Code	f(level)
147	f(level) = level
148	f(level) = sqrt(level)
149	f(level) = $(level)^2$

Gauge Setups

Density Gauge Setup

Set up the DensityPRO / DensityPRO C gauge in the order shown below. For instructions on how to use direct access codes, refer to "The Direct Access Method" in Chapter 2.

Table F–2.

Direct Access Code	Action
025020	Set to "DO" to enable service only items.
048003	Enter tank ID in inches at gauge location.
051022	Use left arrow to set to "special".
018022	Enter "1039" to set up Channel 2 to VSENS.
138023	Enter "1.1" as the 20 mA output value for Channel 2.
115023	Enter "0.5" as the 4 mA output value for Channel 2.
112022	Use left arrow to set to 3 decimal places (0.000).
062002	Use right arrow to make "MEAS 2 to OUT 0 in Normal Mode" (may be OUT 1, depending on the model of density gauge).

Note The values for direct access codes 138023 and 115023 should be estimated realistically. A ratio higher than 1.0 for 138023 means the standardization was done with a vapor phase that was not at the minimum density value, for example, the tank was at some pressure. ▲

The signal (VDR) from the DensityPRO / DensityPRO C gauge is connected via the 4–20 mA output to the AUX input (J10, pin 1(+) and pin 2(-)) on the LevelPRO.

LevelPRO Gauge Setup

Table F–3.

Direct Access Code	Action
025020	Set to "DO" to enable service only items.
113002	Use right arrow to set "Current Input".
035003	Enter "4" mA as the minimum current.
033003	Enter "20" mA as the maximum current.
034003	Enter "0.5" as the 4 mA input value (must match density gauge).
117003	Enter "1.1" as the 20 mA input value (must match density gauge).
051022	Use left arrow to set Channel 2 for "special".
018022	Enter "147" to set for special equation.
112022	Use left arrow to set 1 decimal place (000.0).

In addition to the normal calibration of the level gauge, the density gauge should be referenced at the same time as the level gauge. The reference should be taken keeping in mind its maximum and minimum values (making sure it will not go past these limits at a later stage).

Wiring

Table F–4. LevelPRO gauge to DensityPRO gauge wiring

LevelPRO	DensityPRO Gauge
J10 pin 1	J10B pin 6
J10 pin 2	J10B pin 8

Table F–5. LevelPRO gauge to DensityPRO C gauge wiring

LevelPRO	DensityPRO C Gauge
J10 pin 1	J2 pin 1
J10 pin 2	J2 pin 2

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Appendix G
Using the DensityPRO Gauge as a Point Level Gauge

Overview

A point level setup has been built into the software of the DensityPRO system. With this setup, the gauge can be used as a reliable and accurate point level gauge. In this configuration, the gauge is more dependable and responds quicker than a standard point level switch, especially in low radiation fields. Either the 4–20 mA current output or the optional relays can be used for point level indication. This appendix describes the steps necessary to set up the gauge as a point level switch.

Point Level Setup

This procedure assumes that the DensityPRO gauge has been installed and commissioned and that the source shutter is in the on position.

1. Apply power to the gauge. The screen below should be on the display. If any other screen is displayed, it is recommended that memory be erased so that all settings will reset to the factory default.

```
  Unit has not
  been set up!

 For setup, press►
```

Figure G–1.

To erase memory, press the **EXIT** key and the following screen should appear.

```
Key in entry ID or
command code then ▼

Press   to exit.
```

Figure G–2.

Enter **82** and press the down arrow. The following screen will appear.

```
Erase all entries!!!
(except COMM setup)
◄Reject command
        EXECUTE CMD
```

Figure G–3.

Press the right arrow twice and the memory will be erased, factory defaults will be loaded into memory, and the "Unit has not been setup!" screen will appear. Now the gauge can be set up as a point level device.

2. Access the main menu screen, which is shown below.

```
Set up density, den.
alarms, & flow▼
◄Exit setup.
    Other functions
```

Figure G–4.

3. Press the right arrow six times to access the Primary Measurement screen. You will scroll past other parameters used for density applications. Do not change any of these values.

```
primary measurement:
density
  To change, press►
         NEXT
```

Figure G–5.

4. Press the right arrow to change the primary measurement to **Pt Level**.

```
primary measurement:
Pt Level
  To change, press►
         NEXT
```

Figure G–6.

5. Press the down arrow until the Pipe ID screen appears. Enter the approximate diameter of the vessel in inches. It does not have to be accurate, but the parameter must not be left at zero.

```
pipe inside diameter
0.000 in

         NEXT
```

Figure G–7.

6. Press the down arrow until the 20 mA Output screen appears. Set the value to 1.000.

```
Meas #1 reading for
20.00 mA output:
1.000 pt lev
         NEXT
```

Figure G–8.

7. Press the down arrow until the 4 mA Output screen appears. Verify that the value is still 0.000.

```
Meas #1 reading for
4.000 mA output:
0.000 pt lev
         NEXT
```

Figure 11–9.

8. Press the down arrow until the Decimal Placement screen appears. Press the left arrow once to set three decimal places.

```
Position of decimal
in readout 1   0.000
{pt lev}          ¦
    NEXT▼   ◄CHANGE
```

Figure G–10.

9. Press the down arrow until the Standardize On screen appears. Press the right arrow to select **pipe empty**.

```
standardize on: pipe
 empty
  To change, press►
         NEXT
```

Figure G–11.

10. Press the down arrow until the Start Standardize Cycle screen appears. The vessel will need to be empty (or at the condition that the application considers to be empty) to standardize properly. If ready, press the right arrow to execute the command. The standardization cycle will begin.

```
Start standardize
 cycle

 NEXT▼  EXECUTE CMD
```

Figure G–12.

11. The following screen will appear and show a countdown timer counting down from 1028 seconds.

```
972.0 sec
◄Exit during STD
Abort STD►
Continue setup
```

Figure G–13.

12. When the standardization cycle is complete, the measurement screen will appear and show “0.000 pt lev”.

```
 0.000 pt lev


 For setup, press
```

Figure G–14.

13. Now that the gauge is calibrated, the indication and output will go from 0.000 (4 mA) at empty to 1.000 (20 mA) at the background radiation level. With the 4–20 mA going into a PLC or DCS, an alarm trip point can be set between 0.000 and 1.000. This allows for almost infinite adjustability for the alarm trip point. If you are going to use the 4–20 mA output as the point level indication, the gauge is ready to put into service. You can stop at this point in this procedure. To use the optional relays to designate the level condition, continue with the procedure.

14. Press the right arrow and then the down arrow until the Set up Alarm 1 menu appears. Press the right arrow again to enter the menu.

```
Set up alarm 1
(Alarm point, etc.)►

         NEXT
```

Figure G–15.

15. Enter the value for the alarm set point. A good starting point is .7500, which means when 75% of the radiation is blocked, the alarm relay will trip.

```
◄Exit alarm 1 setup
Alarm 1 set point
.7500 pt lev
         NEXT▼ HELP
```

Figure G–16.

Note The difference between the alarm set point and alarm clear point (next step) values should be a minimum of 0.1. This is to keep normal statistical noise on the detector signal from causing false trips or “chattering” of the relay. ▲

16. Press the right arrow until the Alarm 1 Clear Based On screen appears. The default condition for clearing the alarm relay is clear point (clr point). In the point level application for this gauge, the deadband alarm clearing feature is disabled. Leave this item in the clear point mode.

```
Alarm 1 clear based
on clr point
Chng to "dead band"►
Continue as is.
```

Figure G–17.

17. Press the down arrow until the Alarm 1 Clear Point screen appears. Enter the value at which the alarm will clear. A good starting point is .5000, which will cause the alarm condition to clear when the radiation level goes back up to half of its empty value. If the clear point is lower than the set point, then the alarm is considered a high limit alarm. If the clear point is higher than the set point, it is considered a low limit alarm. High and low limit alarms are discussed further in Chapter 3.

```
Alarm 1 clear based
on clr point
Chng to "dead band"►
Continue as is.
```

Figure G–18.

18. Press the down arrow until the Alm1 Indicated By screen appears. Press the right arrow to change the selection to **controlling relay 1** (or 2).

```
Alm1: pt lev
is indicated by
controlling relay 1
       NEXT▼ CHANGE
```

Figure G–19.

19. Press the down arrow once and then the up arrow once to access the Relay 1 On/Off selection screen. In the on condition, the relay is normally not pulled in and pulls in on an alarm condition. If a failsafe condition is required, change the selection to off by pressing the right arrow once. With this setting, the relay will be released if an alarm condition occurs or if power is lost to the gauge.

```
Relay 1 turns on
when alarm occurs.
Change to "off"►
 Exit alarm 1 setup.
```

Figure G–20.

20. Press **EXIT** to store the changes made and return to the main screen. Once alarm 1 has been set up, alarm 2 will now be available for setup. Follow the same procedure, if needed.

21. Refer to wiring section of the DensityPRO gauge installation manual (p/n 717774) to wire the relays for proper alarm indication.

Appendix H
X-ray Safeguard Software Setup

Note For DensityPRO software versions 5.10 and higher. ▲

Overview

When radiography or other gamma / x-ray sources are used in the vicinity of the DensityPRO gauge, the gauge interprets the additional energy sensed at the detector as a sudden process variable change. This results in a sudden drop in the reported density.

With the Xray Safeguard feature enabled, the gauge will sense when a high energy radioactive source is used to make x-ray examinations of objects in the nearby area. The gauge will hold the process value while the examination is occurring and then go back to normal operation when the x-ray examinations have stopped.

Setup

The Xray Safeguard computes the difference between the Vsens slow (actual signal / signal at ref) filtered by the time and Vsens fast filtered by the time constant / 16. The difference is computed four times per second. If the difference exceeds the set threshold, the current output and high voltage will hold at the last valid value.

This section describes how to set up and access the Xray Safeguard feature.

Note Direct access codes are used in this appendix. For instructions on how to use direct access codes, refer to Chapter 2. ▲

Note This feature must be setup using the 9734 HHT or the TMT Comm communication software connected to the RS485 or RS232 port. It cannot be setup using the HART or FOUNDATION fieldbus options. ▲

1. Enable the service only items by entering **025020**. Press the right arrow to change the selection to **Do enable**. Press **EXIT** to store the change and return to the main screen.

2. For the x-ray safeguard to work smoothly, Dynamic Tracking must be **disabled**. Enter **001010** and change to **Do disable** if necessary.

3. Perform a standardization (Chapter 3). If the vessel is not empty, the parameters from the previous (empty) standardization and calibration should be entered manually. **Do not defer standardization.**

4. Enter **007004** and set the time constant at 16 or 32 seconds (ideally). The x-ray safeguard works best on a relatively stable process that does not change rapidly under normal process conditions. The filling and emptying rate of the vessel should be slow (i.e. the time it takes the gauge to move through its full operating range). Typically, on a vessel that takes 20 minutes to fill or empty, the time constant should be set to 32 seconds and on a vessel that takes 10 minutes to fill or empty, the time constant should be set to 16 seconds.

5. Go to the Gauge Fine Tuning menu and enter the Xray Safeguard Setup menu. The menu items are described below.

    a. Xray Safeguard Threshold: Set the threshold. If the signal change within one time constant reaches the threshold, the gauge will enter the x-ray safety HOLD mode. In this condition, the current output and high voltage control signal are held at their last known good value. For example, if the minimum value is set to 0.053, then the minimum signal change to activate the x-ray safeguard is a 5.3% change of the current signal within one time constant. Enter the threshold value, and press the down arrow. The value will be automatically converted to scientific notation. It is recommended that you start with a value of **0.2**.

    b. Xray Safeguard Min Hold Time: Enter the minimum time that the gauge will hold after X-ray detection. The default is 20 seconds. At the end of this time setting, the gauge will compare its current signal to its last known good signal. If the signal change is below the threshold setting, the hold will be cleared. If the signal change is still above the threshold setting, the gauge will stay in the hold condition for another minimum hold time. It will continue to do this until it reaches the value entered as the Max Hold Time (next step).

    c. Xray Safeguard Max Hold Time: The default is 300 seconds. When the timer reaches the maximum hold time, the x-ray safeguard will be disabled for one minute to allow the gauge to recover. The gauge will then assume the new signal level is a real process condition and act accordingly. After that one minute, the x-ray safeguard will activated again and respond to future events.

    d. Do / Do not enable Gauge Xray Safeguard: Change to enable, but **do not enable this feature during setup and calibration.**

The feature will now be active. Verify this by entering **074001** to display the x-ray safeguard status. It should display **armed**.

Figure H–1.

When the feature is triggered, the display on the 9734 HHT or the 9723 remote display will be as shown below.

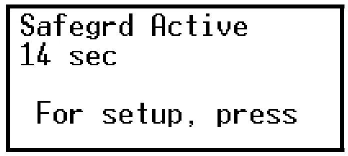

Figure H–2.

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