LevelPRO

Continuous Gamma Level System
User Guide
P/N 717778

Revision F

Part of Thermo Fisher Scientific

Thermo SCIENTIFIC

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Revision History

Revision Level	Date	Comments
1.0	03-1999	Initial release.
2.0	08-2001	Revised per ECO 7570.
A	02-2006	Revised per ECO 5101.
B	10-2007	Revised per ECO 6000.
C	05-2008	Revised per ECO 6366.
D	05-2009	Revised per ECO 6940.
E	04-2010	Revised per ECO 7323.
F	12-2011	Revised per ECO 7875.

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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 LevelPRO continuous gamma level system is designed to provide reliable, accurate level and volume measurements for even the most challenging applications. The gauge is mounted on the outside of the process vessel and never contacts the process material.

The gauge consists of the source head that contains the radioisotope source and the detector-transmitter that 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 level of the process material by measuring the amount of radiation arriving at the detector, which varies with the level of the process material.

The source head and detector-transmitter are mounted on opposite sides of the tank as illustrated below.

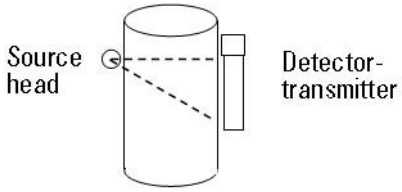

Figure 1–1.

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).

Detector-Transmitter

The gauge 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 (PMT) 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 absorbed by the process material and fewer light pulses are generated by the scintillator material. The PMT 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

Communications & Measurement Display

You communicate with the gauge via the RS485 or the RS232 serial ports using a Thermo Scientific Model 9734 Handheld Terminal (HHT), a PC running TMTComm for Microsoft® Windows® or other terminal emulation software, 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 HART 275 or 375 communicator. Refer to the LevelPRO HART Operation Guide (p/n 717817) for instructions.

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

Once the gauge has been set up, the primary (level) 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 gauge are summarized in the table below.

Table 1–1.

Type	Characteristics	Comments
Current output	3.8–20.5 mA DC. Standard configuration: - Isolated, loop-powered, 24 Vdc input, 700 ohm max. load. Alternate configurations: - Non-isolated, self-powered, 700 ohm max. load. - Isolated, self-powered, 700 ohm max. load.	Default range is 4–20 mA DC. One current output is provided on the CPU board. To reconfigure current output: - Move a jumper for non-isolated, self-powered - Add a piggyback board (p/n 886595) for isolated, self-powered.
Serial communications	RS232: one terminal block. RS485: one terminal block and one RJ11 jack.	Full duplex communication with remote terminal or PC. Half-duplex communication to PC or HHT.
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 SPDT, isolated, 8 A, 220 Vac.	Process alarms and system fault or warning alarms can be assigned to control (open/close) relays.
Contact closure inputs	Two contact closure inputs are provided on the CPU board.	Execute system commands based on a user-provided contact switch opening or closing input.
Auxiliary current input	0–20 mA DC current input.	Current input value can be used to adjust the level measurement by using the special equations.
Optional Thermo Scientific Model 9723 display	Optional 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 LevelPRO gauge 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.

Instantaneous Response

Thermo Fisher'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.

Built-In Volume Measurement

Select from a list of predefined tank shapes, enter the tank dimensions, and the gauge computes tank volume from an internal equation library. Alternately, you can define volume as a polynomial expression based on the level (height) or as a table of volume and height value pairs.

Multiple Readouts

Select up to eight measurement values for display: level, volume, ullage (unfilled volume), percent full, percent empty, percent level, mass, and the rate of change of any of these measurements.

Process Alarms

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

Fault Detection

Automatic verification and error correction software continuously monitors system operations. System faults can be programmed to trigger alarms.

Required Documentation

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

- LevelPRO installation guide, p/n 717760
- LevelPRO HART operation guide, p/n 717817 (if using HART)
- Model 9734 HHT user guide, p/n 717797 (if using the HHT)
- Gamma Radiation Safety Guide, p/n 717904
- LevelPRO with FOUNDATION™ Fieldbus Application Guide, p/n 717915 (if FOUNDATION fieldbus option is installed)

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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 LevelPRO 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). ▲

Note When first applying power to the gauge or when applying power after the gauge has been off for several hours, it is recommended that you allow the gauge to warm up for one hour before setting it up. ▲

Note The need for background acquisition was removed in version 5.07. Therefore, if you purchased the gauge after April 03, 2003 or if the EPROM is version 5.07 or higher, you do not need to establish a background reading if prompted to do so. The only exception is if you are using the HART interface. If you are using the HART interface, the background cycle must **always** be performed. ▲

Communications Setup

This section assumes that the system has been properly installed and all required connections have been made (reference LevelPRO installation guide, p/n 717760).

Serial

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 TMTComm software or other terminal emulation software, such as HyperTerminal.

The Model 9734 HHT and optional TMTComm software both provide the capability to upload the gauge setup parameters to the HHT or to a PC file and download a previously saved file to the gauge. The uploaded PC file can serve as a backup file for the gauge setup parameters or can be used to quickly setup additional gauges. The default communication settings for the gauge are 7 data bits, even parity, 1 stop bit (7-E-1), and 9600 baud.

HART

The HART communication protocol is supported over the 4–20 mA current output and requires an optional daughter board. As practical, the HART menu structure mirrors the menu structure as described in this guide.

Once the optional 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 HHT or a computer with RS232/RS485 converter and the TMTComm communication software to access the technical troubleshooting capabilities of the LevelPRO. ▲

Gauge Operation

The Measurement Display

The first time you apply power to the instrument (after establishing communication with the gauge), the message below is displayed.

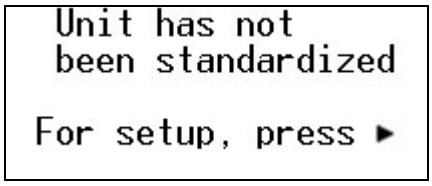

Figure 2–1.

After you have standardized the gauge, the measurement display will show the level measurement along with any additional measurements that have been defined. The following example shows the level measurement readout in centimeters.

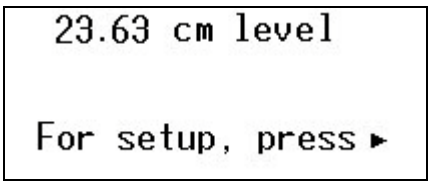

Figure 2–2.

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" in Chapter 8 for instructions.

Entering Data

Following are descriptions of the keys used to operate the instrument:

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. 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.
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. 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 you made up to that point are saved and used by the instrument. Continue with the setup by using the arrow keys to return to the menu most recently accessed.

To exit the setup menus, press the EXIT SETUP key on the HHT or press x on the terminal keypad. This saves any changes you made and returns you to the measurement display.

The Direct Access Method

The direct access method allows you 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.

Note 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. At the screen shown in Figure 2–3, press the decimal key. Figure 2–4 is then displayed. Note the keypad code: 025010. This is the DAC. Press the down arrow to return to the previous screen.

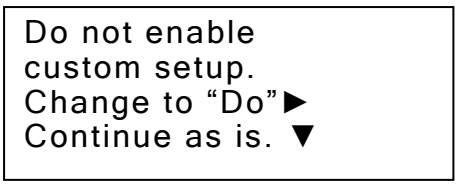

Figure 2–3.

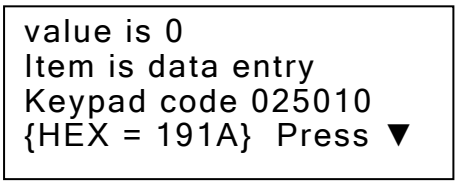

Figure 2–4.

Figures 2–5 and 2–6 illustrate how to locate a DAC for a decimal (floating point) data entry item. At the screen displayed in Figure 2–5, press decimal followed by up arrow. Note the keypad code (065003) on the next screen. Press the down arrow to return to the previous screen.

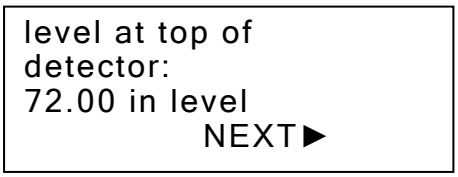

Figure 2–5.

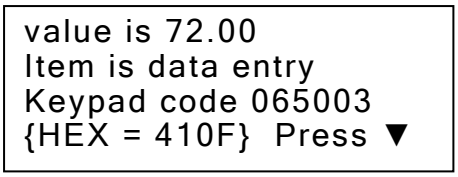

Figure 2–6.

Using Direct Access Codes

Use the DAC found in the previous section to view and/or modify the value for the level at the top of the detector:

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

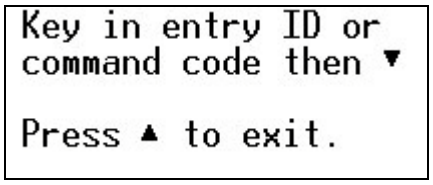

Figure 2–7.

2. Enter the DAC (065003) and press the down arrow.

3. If the level shown is correct, press EXIT SETUP to return to the measurement display. If not, correct the value and press the down arrow. Verify the value is correct and press EXIT SETUP. The corrected value is stored and used by the instrument.

Resetting 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.

Additional Menu Items

The menu structure contains two “layers” of menu items. The user layer is the default layer and is adequate for most applications. The service layer provides numerous special purpose menu items and can be enabled using the Special Functions menu (Chapter 8).

Saving Entries

If you exit the setup menus at any time, any changes or entries you made are automatically saved and used by the software. To exit the setup menus, press EXIT SETUP on the HHT or x on the terminal keypad.

If you do not exit the setup menus, entries or changes are stored and used by the software after five minutes of inactivity.

Chapter 3
Set up Level, Level Alarms, & Volume

Note When first applying power to the gauge or when applying power after the gauge has been off for several hours, it is recommended that you allow the gauge to warm up for 24 hours before setting it up. ▲

The Set up Level, Level Alarms and Volume menus takes you through the steps required for basic system setup:

- Define parameters for the primary (level) measurement.
- Specify the measurement (level) values corresponding to the maximum and minimum values of the current.
- Set up one or more process alarms for the level measurement.
- Specify the parameters for the volume measurement.
- Perform a background measurement (see note below).
- Perform a standardization measurement.
- Perform a calibration measurement.

Note The need for background acquisition was removed in version 5.07. Therefore, if you purchased the gauge after April 03, 2003 or if the EPROM is version 5.07 or higher, you do not need to establish a background reading if prompted to do so. The only exception is if you are using the HART interface. If you are using the HART interface, the background cycle must **always** be performed. ▲

Level Measurement Setup

The Set up Level, Level Alarms and Volume 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 Level, Level Alarms and Volume 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 Level and Volume."

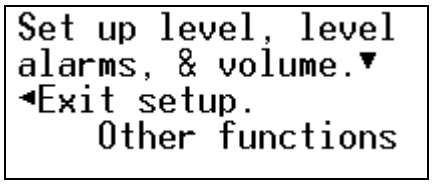

Figure 3–1.

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.

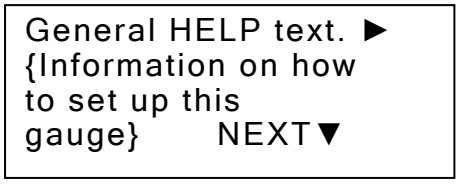

Figure 3–2.

3. Press the right arrow to specify units other than percent and to enable the Tank Volume Setup submenu.

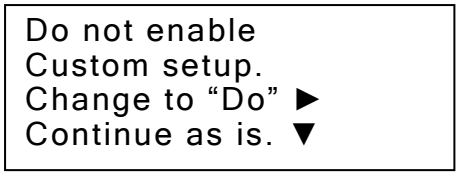

Figure 3–3.

4. This item is displayed if you enabled the previous item (custom setup). Select the units system: all, English, or metric.

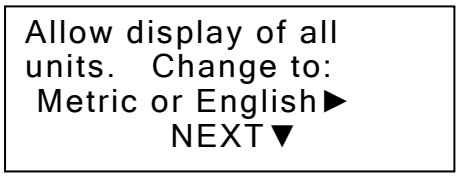

Figure 3–4.

5. Press the right arrow to scroll through the list of available measurement units. If you selected **All** in the previous item, both English and metric units are available. If you selected **English**, available units are in (inches), ft (feet), or yd (yards). Available **metric** units are mm (millimeters), cm (centimeters), or M (meters).

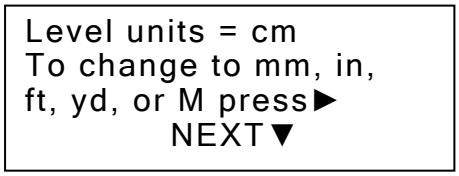

Figure 3–5.

6. Enter the tank level at the top of the detector. If custom setup was not enabled (step 3), the units will be measured as a percentage, and the default value will be 100.0%.

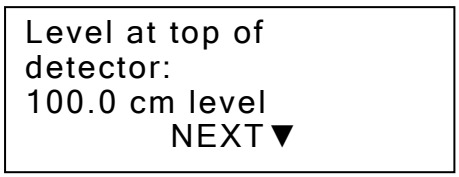

Figure 3–6.

7. Enter the tank level at the bottom of the detector. If custom setup was not enabled (step 3), the units will be measured as a percentage, and the default value will be 0.0%.

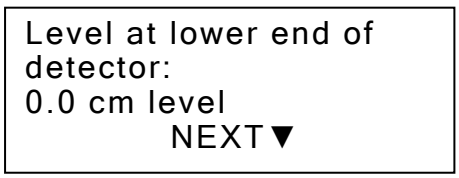

Figure 3–7.

8. Set the measurement range for the current output.

   Meas #1 is associated with the level 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 level value at which the current output will be at maximum. The default maximum current output value is 20 mA.

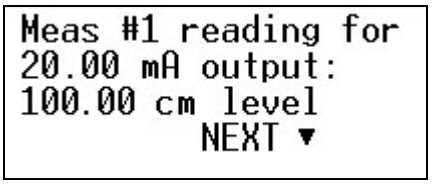

Figure 3–8.

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

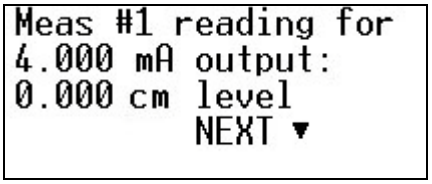

Figure 3–9.

The operational range for current output can be set anywhere within the range from 3.8 to 20.5 mA. The default range 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/Reassign Current Output" in 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 1000 so that the displayed values do not exceed the limits of the four-digit numerical display. See "Display Scaling" in Chapter 4.

9. 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.

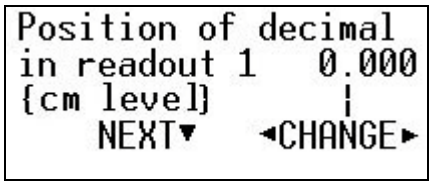

Figure 3–10.

Multiple Setups

The following menu items are displayed within the Set up Level menu when you enable multiple setups in the Special Functions menu (Chapter 8).

1. The Commands to Store Setup item provides access to commands that enable you to select the desired data set and then to store calibration data.

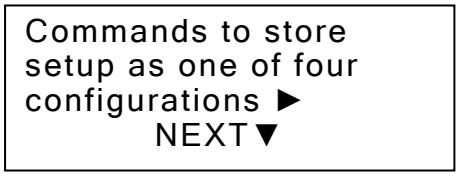

Figure 3–11.

2. The Commands to Retrieve a Stored Setup item provides access to commands that enable you to retrieve calibration data previously stored in a data set.

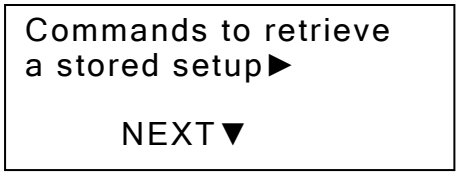

Figure 3–12.

3. Access the item shown below to view the calibration values in previously stored data sets.

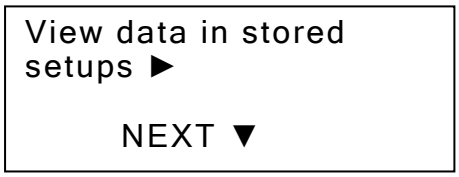

Figure 3–13.

Alarm Setup

The Set up Alarm 1 submenu heading appears in the Set up Level, Level Alarms and Volume menu after the level measurement items. Enter this submenu to set up an alarm.

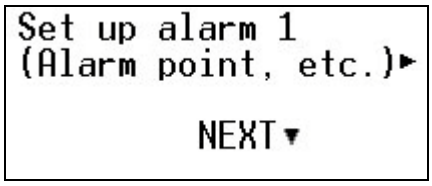

Figure 3–14.

This subgroup allows you to assign and set up a process alarm for the level 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. After you set up additional measurements (see "Special Functions" in Chapter 8), you can assign process alarms for any additional measurements you have set up. The procedure is the same as the procedure detailed below.

Note If relays are not installed, the Set up Relay menu item is not displayed. You can still set up a process alarm to perform a function other than control a relay, such as execute a command. See "Special Functions" in Chapter 8 for details on enabling alternate alarms. ▲

1. Enter the process level at which the alarm will activate. Note that 80% is shown as an example only. Alarm 1 can be set as either a high level alarm or low level alarm.

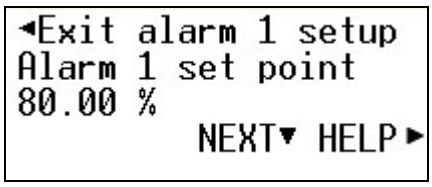

Figure 3–15.

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

2. Select a clear point or dead band to clear the alarm. Using clear point is recommended and is used in this section. The clear point is the process level where you want the alarm to stop alarming.

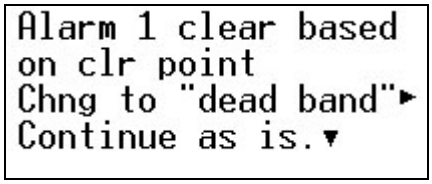

Figure 3–16.

If you select a process value lower than the alarm set point (as shown in Figure 3–17), the alarm will be considered a high (Hi) alarm.

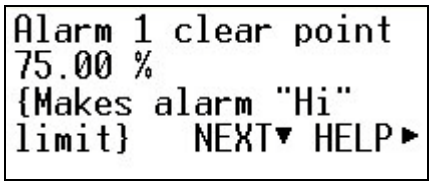

Figure 3–17.

If you select a value higher than the alarm set point (as shown in Figure 3–18), the alarm will be considered a low alarm.

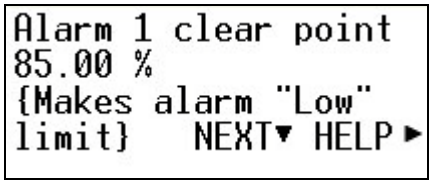

Figure 3–18.

3. Use the right arrow key to cycle through actions that can be used to indicate the alarm has been triggered. The default action is to do nothing. Other actions are listed below.

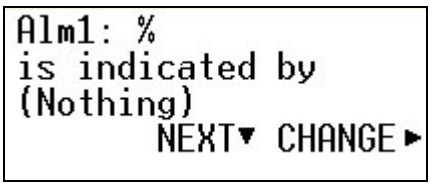

Figure 3–19.

- Control relay 1: Turns the relay on when alarm is activated and off when alarm clears. This option is only displayed if relays are installed and is repeated for each relay installed.

  If selected, the item shown below is displayed. By default, the relay turns on when the alarm is activated and off when the alarm clears.

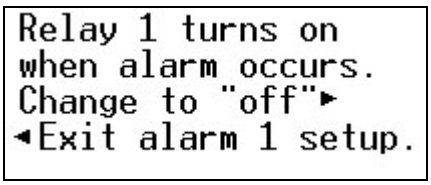

Figure 3–20.

  If you want a fail safe condition, you will need to change the selection to “off” by pressing the right arrow key. This way you will get an alarm if the gauge loses power.

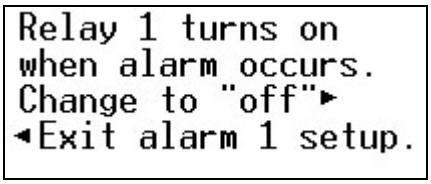

Figure 3–21.

- Out1 to FAULT LOW: Force current output 1 to the fault low condition (3.6 mA or less) while the alarm is active.

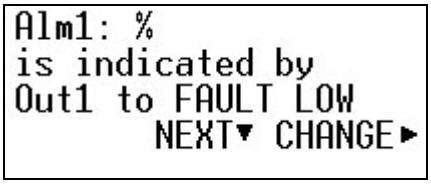

Figure 3–22.

- Out1 to FAULT HIGH: Force current output 1 to the fault high value (21.0 mA or greater) while the alarm is active.

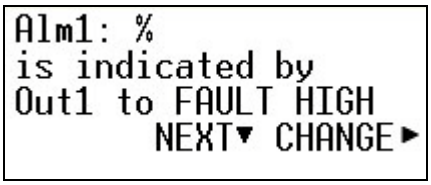

Figure 3–23.

- #1 act on ALM action: Executes the command assigned as the "#1action" (if one is assigned) when the alarm is activated. This option is repeated for #2 and #3 actions if actions have been assigned. These actions are set up in the Setup Fault Alarms menu (Chapter 6).

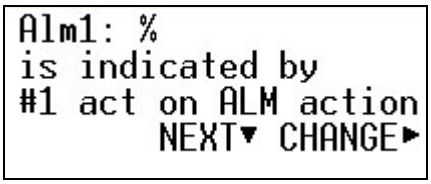

Figure 3–24.

4. With alarm 1 set up, the menu for setting up alarm 2 appears. The procedure for doing so is the same as for alarm 1.

Tank Volume Setup

The Tank Volume Setup is a menu subgroup heading that appears in the Set up Level, Level Alarms, and Volume menu if you have enabled a custom setup (step 3 in "Set up the Level Measurement"). This menu group allows you to describe your tank by:

- Selecting a tank shape from a list of predefined shapes
- Describing the tank as a combination of predefined shapes
- Setting up a break table for volume, a table that defines volume as a function of the height (level of the process material) for up to 16 values
- Defining volume as a polynomial (up to sixth order) expression of height (level)

Note After you set up tank volume, the volume measurement is displayed. However, you must assign the volume measurement to a measurement number using the Set up Additional Measurements menu (Chapter 4) before you can assign a process alarm to the volume measurement or assign the volume measurement to drive the current output. ▲

1. Press the right arrow to enter the Tank Volume Setup menu.

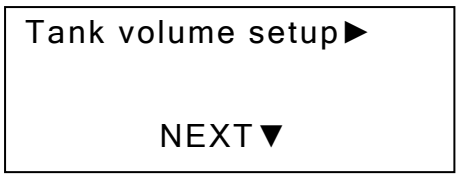

Figure 3–25.

2. Access the HELP screen to obtain assistance with the setup procedures. Press the right arrow to enter the HELP screens or the down arrow to move to the next menu item.

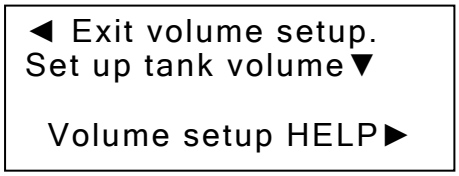

Figure 3–26

3. Specify the tank shape to enable the remainder of the menu items. If your tank does not fit any of the options listed in the table below, select **For Other Shapes or Compound Shapes**. Reference "Other Tank Shapes" later in this section.

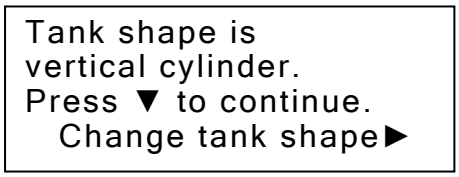

Figure 3–27.

Table 3–1. Basic tank shapes

Tank Shape	Required Dimensions
Vertical cylinder (type 1)	Diameter
Vertical rectangle (type 2)	Width, length
Vertical cone (type 3)	Top diameter, bottom diameter
Horizontal cylinder/flat ends (type 11)	Length, diameter
Horizontal cylinder/domed ends (type 12)	Length (without ends), total length, diameter
Sphere (type 18)	Diameter

Note After you select a tank shape, the instrument calculates and displays the volume. This value is correct only if you entered all the required dimensions. ▲

Note The various tank shapes and required dimensions are illustrated in "Tank Shape Drawings" later in this chapter. ▲

4. Select the measurement units for the volume. The available options depend on the units you selected (step 4 in "Level Measurement Setup").

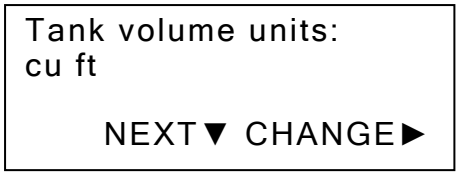

Figure 3–28.

The following table lists the options that would be available if you selected **All** as the units. Abbreviations may be different from those listed below due to space constraints on the display.

Table 3–2.

Abbreviation	Unit
ml	ml or cm^3
cu M	1 m^3 (1000 L)
cu in	1 in^3 (16.39 ml)
cu ft	1 ft^3 (28.32 L)
cu yd	1 yd^3 (764.6 L)
US Gal	1 U.S. liquid gal (3.785 L)
UK Gal	1 UK gal (4.546 L, 1.2 U.S. liquid gal)
MGal	1 megagallon (1,000,000 U.S. gal)
Ber Gal	1 beer gallon (4.620 L)
liter	1 liter (1000 ml)
acre ft	1 acre-foot (43,560 ft^3)
pint	1 U.S. pt (473.2 ml, 1/2 U.S. qt)
qt	1 U.S. qt (946.3 ml, 1/4 U.S. liquid gal)
oz	1 U.S. liquid oz (16 U.S. oz per 1 U.S. pt, 29.57 ml)
acre in	1 acre-inch (3630 ft^3)
KGal	1 kilogallon (1000 U.S. liquid gal)
UK qrt	1 UK qt (1137 ml, 1/2 UK gal)
UK pint	1 UK pt (568.3 ml, 1/2 UK qt)
UK oz	1 UK oz (20 UK oz per 1 UK pt, 28.41 ml)
Oil Brl	1 oil barrel (159 L, 42 U.S. liquid gal)
Ber Brl	1 beer barrel (136.3 L, 36 U.S. liquid gal)
US Brl	1 US barrel (119.2 L, 31.5 U.S. liquid gal)
UK Brl	1 UK barrel (163.7 L, 36 UK gal)

5. Use the left and right arrows to set the decimal point position.

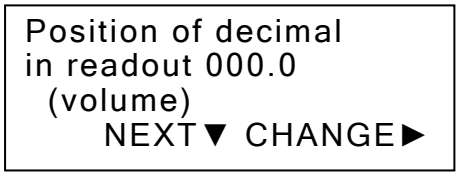

Figure 3–29.

6. Select the units for displaying the tank dimensions. The available options depend on the units you selected (step 4 in "Level Measurement Setup").

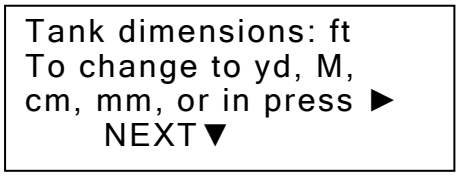

Figure 3–30.

7. Enter the requested dimensions. The number and type of dimensions depend on the tank shape you selected (step 3 of this procedure).

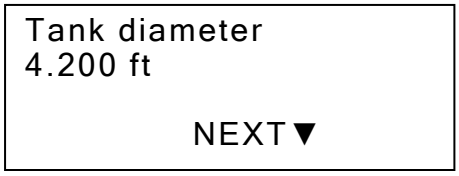

Figure 3–31.

Other Tank Shapes

If you selected **For Other Shapes or Compound Shapes** in the Tank Shape menu item, **a**dditional menu items will be displayed that allow you to select other shapes, define the tank as a combination of shapes, or define volume as a polynomial expression of height or as a table of volume versus height (level) data pairs.

1. Press the right arrow to change the tank shape or the down arrow to set up tank volume using compound shapes.

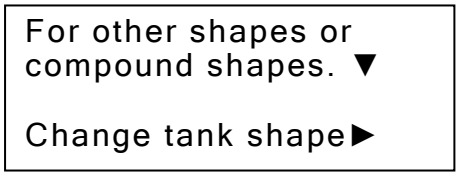

Figure 3–32.

2. Select the units for the volume measurement.

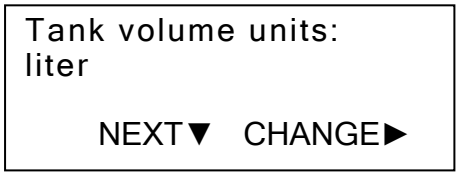

Figure 3–33.

3. Select the units for tank dimensions. Available options are: ft (feet), yd (yards), M (meters), cm (centimeters), mm (millimeters), and in (inches).

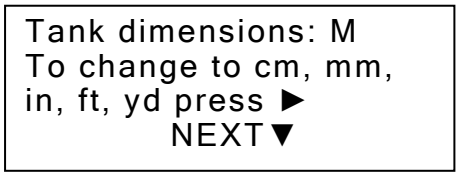

Figure 3–34.

4. If the actual volume in the tank is not zero when the instrument measures zero level, enter the correct value.

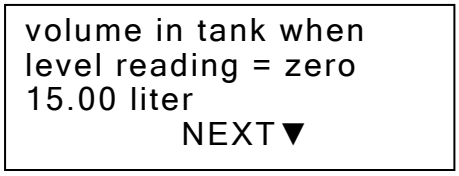

Figure 3–35.

If your tank is described by one of the basic shapes and you need to specify a non-zero volume for the zero level point, you have two options. If your tank shape is not a sphere, you can select the **For Other Shapes or Compound Shapes** option and use the Assign and Setup Tank Segment menus (next step) to specify the tank shape and dimensions for a single segment.

5. You can describe your tank shape using up to eight segments. Each segment can be assigned a different shape. After you set up segment 1, you are prompted to set up segment 2, etc. If you do not need to specify another segment, press the down arrow to scroll past the menu item.

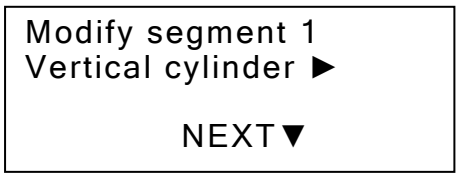

Figure 3–36.

Assign & Set up Tank Segments

The predefined tank shapes and associated dimensions are listed in the table below. It includes the basic tank shapes with the exception of sphere (type 18). You can also define the tank volume as a polynomial expression of height or as a table of volume and height (level) values.

Table 3–3. Other tank shapes

Tank shape	Required dimensions
Vertical cylinder (type 1)	Diameter
Vertical rectangle (type 2)	Width, length
Vertical conical (type 3)	Top diameter, bottom diameter
Vertical spherical (type 4)	Top diameter, bottom diameter
Vertical parabolic (type 5)	Top diameter, bottom diameter
Rectangular top and bottom (type 7)	Width and length of top and bottom
Slope bottom vertical cylinder (type 9)	Diameter, dimension C
Any shape with vertical sides (type 10)	Area of shape
Horizontal cylinder/flat ends (type 11)	Length, diameter
Horizontal cylinder/domed ends (type 12)	Length (without ends), total length, diameter
Domed end (type 14)	Width, diameter, bottom offset
Pair of domed ends (type 15)	Width, diameter, bottom offset

For each segment, select a segment type (shape), enter the dimensions for the selected shape, the starting level (level at the bottom of the segment), and the ending level (level at the top of the segment). You can assign the same type (shape) to two or more segments.

Segments may overlap. The top and/or bottom of one segment may be located between the top and bottom of another segment. This can be useful in setting up compound shapes, for example, a vertical cylinder with a rectangular appendage. Another example is two vertical cylinders that are connected so the level is the same in both. The instrument can be set up to measure the level in one cylinder, but to compute the combined volume of both cylinders.

Defining a Volume Polynomial

If you know the volume of a tank or a tank segment as a function of the height (level), the volume polynomial enables you to specify the tank volume as a polynomial function of height using up to a sixth order polynomial. To define a tank segment polynomial, select **Volume = polynomial of height**, and menu items will prompt you to enter the values for the polynomial coefficients. The coefficients must be selected so that the polynomial gives the correct volume in the specified units for a given level value. The coefficients must also be selected to ensure that the volume polynomial is well-behaved over the entire range of possible levels.

In particular, the following criteria must be met:

- The volume polynomial should track the height-to-volume relationship over a relatively broad range, extending beyond the range of interest.
- The slope of the polynomial should be positive (volume should increase as the level increases) over the entire range of possible levels.

The volume polynomial has the following form:

$$\text{Volume} = Ah + Bh^2 + Ch^3 + Dh^4 + Eh^5 + Fh^6$$

where

Volume is in units specified.

h = height of material in the segment, in dimension units specified.

A, B, C, D, E, F = user-entered polynomial coefficients. For many applications, a second order polynomial (using only A and B coefficients) is adequate.

Setting Up a Volume Break Table

If you can determine the tank's volume as a function of height (level), you may opt to use a volume break point table. The menus detailed below prompt you to enter the level at the top and bottom of the segment and to enter up to 16 pairs of level/volume values that characterize the tank's volume as a function of the height (level).

Two types of break tables are provided. The first order break table uses linear interpolation in the table to find volume. The second order break table uses second-order (curved) interpolation and may be more accurate if the segment has curved sides. If the sides are straight or rather complex, the first order break table is generally more accurate. Try to define a table point wherever there is a break or change in the segment's shape.

Note Only one volume break point table can be defined. ▲

As an example, segment 3 is currently set up as a first order volume break table.

1. Press the right arrow to modify setup.

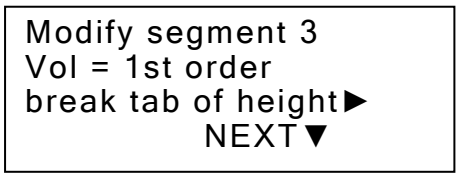

Figure 3–37.

2. Press the right arrow to set parameters for the volume break table.

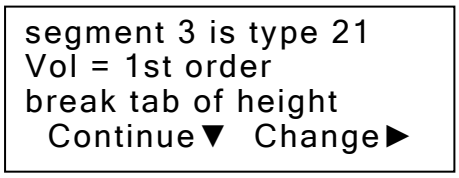

Figure 3–38.

3. Specify level at the bottom of the segment.

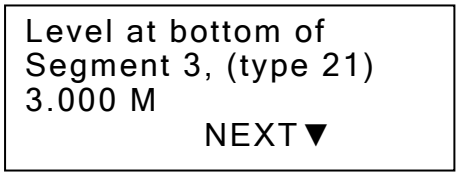

Figure 3–39.

4. Specify level at the top of the segment.

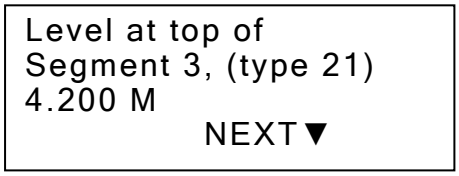

Figure 3–40.

5. Press the right arrow to enter/modify table values. Only one volume break table may be defined; however, the same break point table may be used for several segments if required.

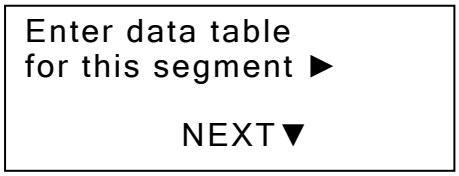

Figure 3–41.

6. Specify the number of volume/height data pairs to enter.

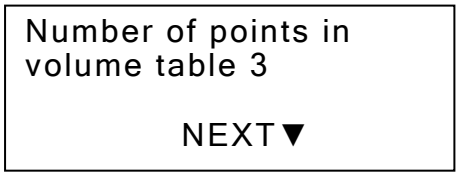

Figure 3–42.

7. Enter the height for the first point. This menu item repeats for the number of points you specified in the previous step.

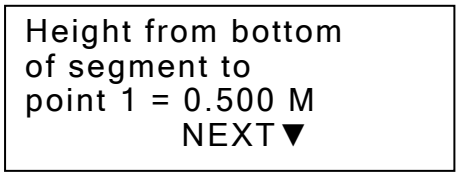

Figure 3–43.

8. Enter the volume corresponding to the height value. This menu item repeats for the number of points you specified. Continue to follow the menu instructions or press EXIT SETUP to exit and save the entries.

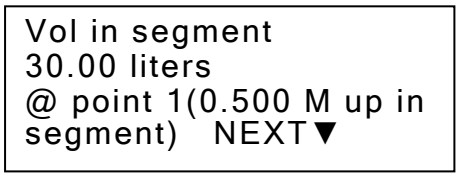

Figure 3–44.

Tank Shape Drawings

The following illustrations depict the predefined tank shapes and required dimensions.

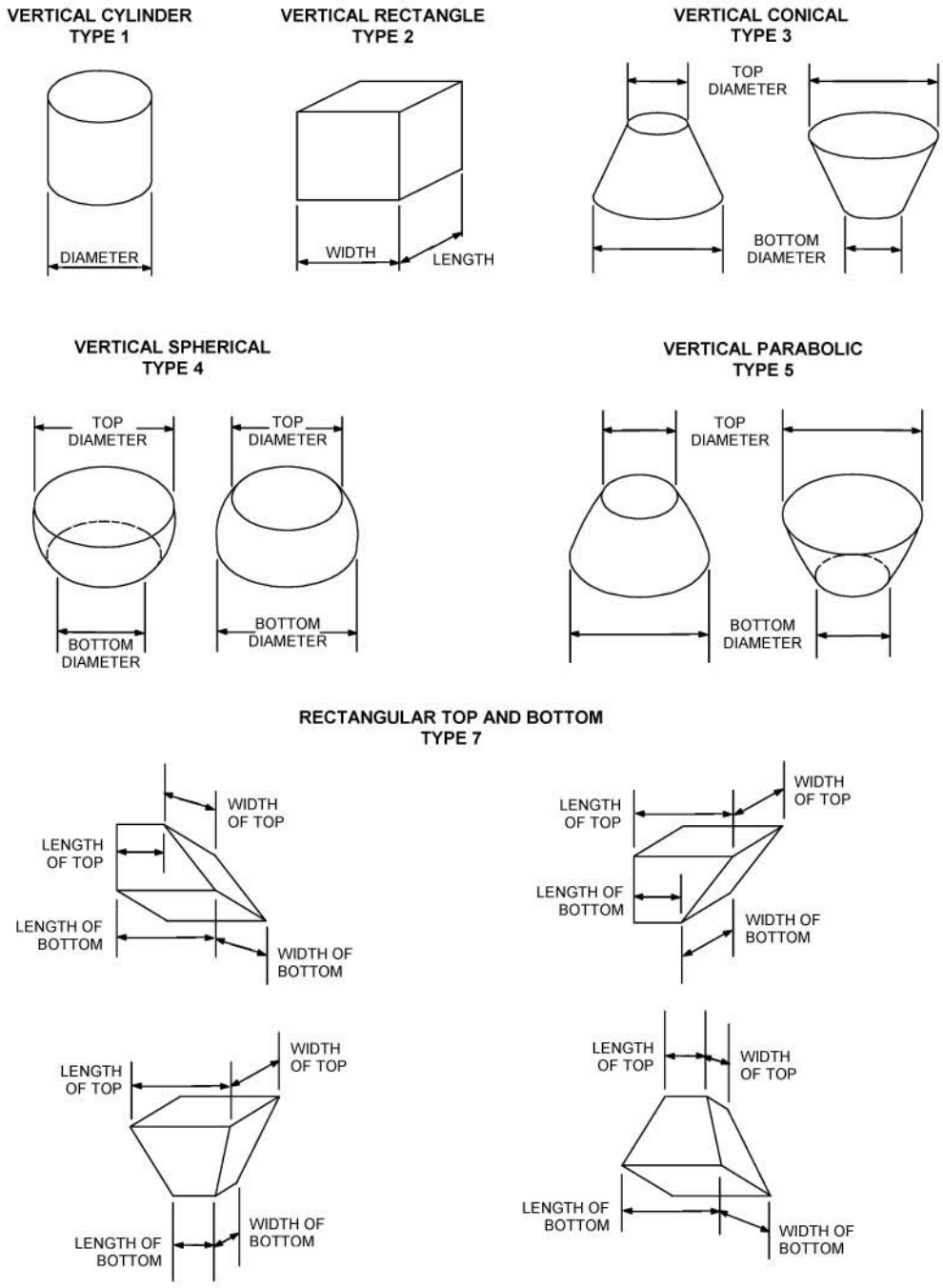

Figure 3–45. Predefined tank shapes & required dimensions, part 1

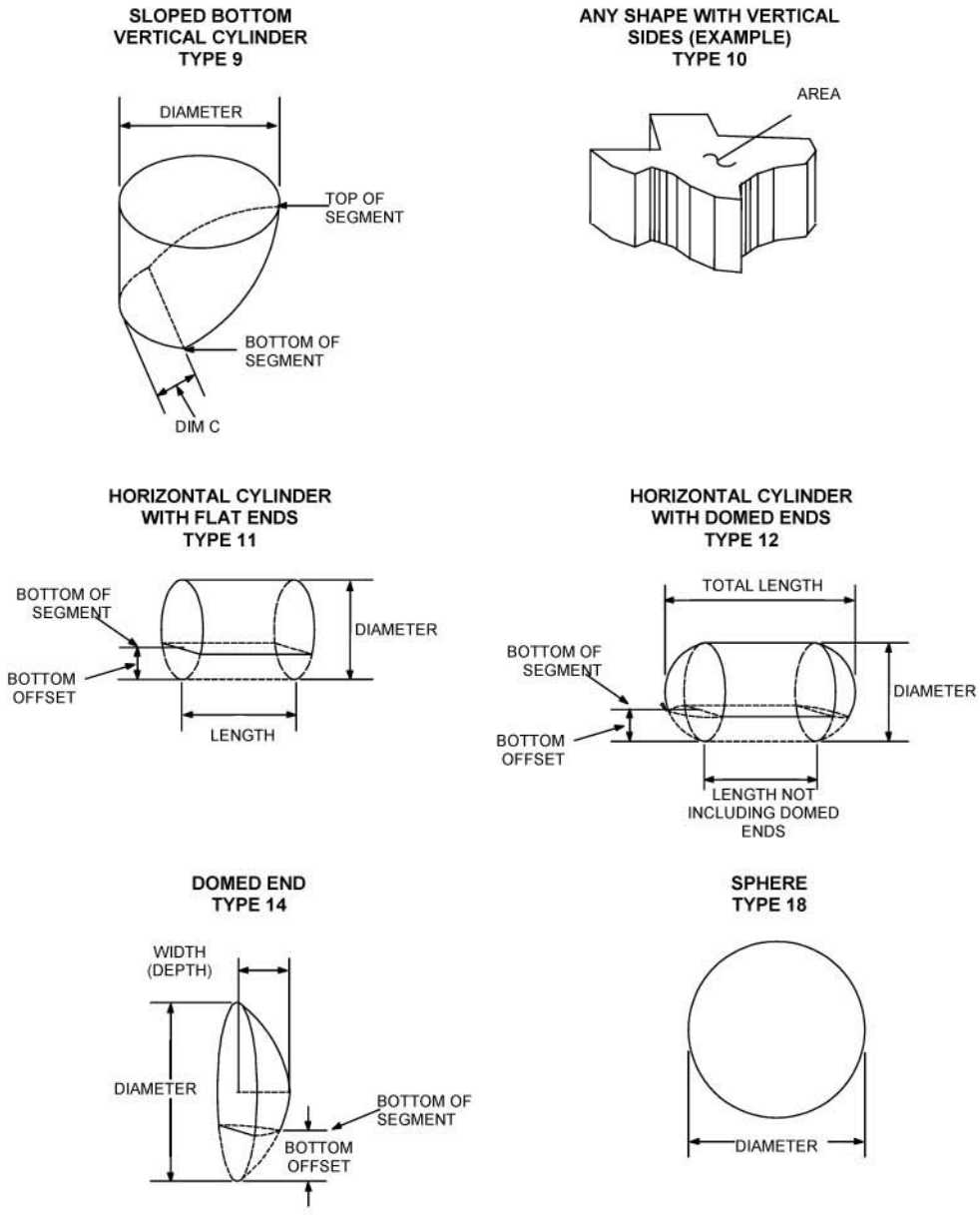

Figure 3–46. Predefined tank shapes & required dimensions, part 2

Background Measurements

Note The need for background acquisition was removed in version 5.07. Therefore, if you purchased the gauge after April 03, 2003 or if the EPROM is version 5.07 or higher, you do not need to establish a background reading if prompted to do so. The only exception is if you are using the HART interface. ▲

Note When using the HART interface, the background cycle must **always** be performed. ▲

The background cycle makes a very repeatable measurement of the signal produced by background radiation. All subsequent radiation measurements are corrected by subtracting the background value from the measured value.

When the process level is at or above the top of the detector, the measured radiation level is typically very close to the background radiation level. Thus, the background measurement is used as the default calibration point at the top of the detector (tank full).

The background measurement averages the measured radiation over a time period equal to 8 times the length of the time constant. By default, the measurement time is about 17 minutes (8 x 128 seconds).

To perform the background measurement:

1. Close the source shutter(s).

2. Enter the Set up Level, Level Alarms and Volume menu. Scroll to the Start Background Cycle menu item (below).

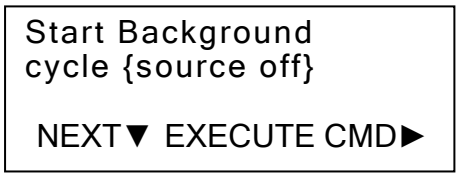

Figure 3–47.

3. Press the right arrow to begin the background measurement.

   The background cycle must finish before you can continue setting up the instrument. When finished, press the down arrow or EXIT SETUP to accept the reading and return to the normal display.

Standardization & Calibration

Before the gauge can convert the measured radiation value to a measurement of the process level in the tank, the amount of radiation arriving at the detector must be measured for at least two known levels of the process material (tank empty and tank full).

Normally, the standardization measurement is performed with the tank empty (process level at or below the bottom of the detector) when the maximum amount of radiation reaches the detector. The standardization value establishes a reference measurement point that can be easily repeated later to maintain the calibration of the gauge.

Once the standardization (0%) and calibration (100%) measurements are complete, the gauge uses these values to convert the measured radiation into an indication of the process level. This level indication may be adequate for many applications.

For detailed procedures on standardization and calibration, refer to Chapter 5.

Note It is best practice to empty the tank and standardize during the initial setup process; however, if the situation is such that the vessel cannot be emptied, refer to "Calibration when Vessel Cannot Be Emptied" procedure in Appendix D. ▲

Chapter 4
Additional Measurements

Additional Measurements Menu

Meas #1 is set up using the Set up Level, Level Alarms and Volume 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 "Modifying/ Reassigning Current Outputs" in 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 level 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. ▲

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

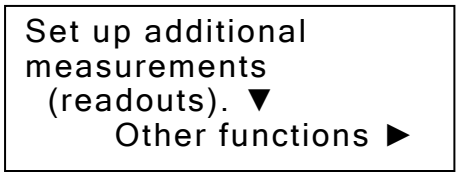

Figure 4–1.

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

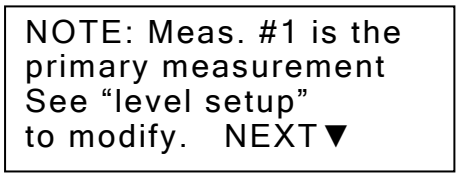

Figure 4–2.

3. This screen is only displayed if you have enabled Service Only items (Chapter 8). Enter this menu item to disable the display of Meas #1 or to modify units, alarm setup, and display scaling.

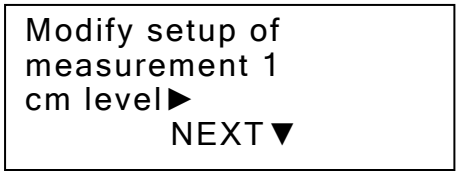

Figure 4–3.

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

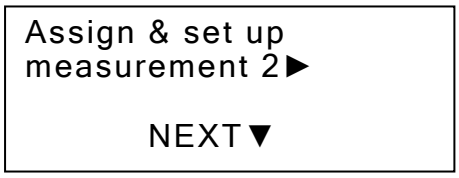

Figure 4–4.

Select the Measurement Type

The next step in setting up an additional measurement is to select the measurement type.

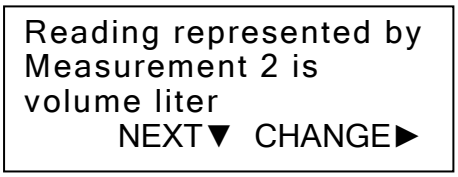

Figure 4–5.

The following table lists available measurement type options.

Table 4–1. Measurement types

Name	Description
Level	Height of contents in tank
Volume	Volume filled
Ullage	Remaining or unfilled volume
Percent full	Percentage of the volume filled
Percent empty	Percentage of the volume empty
Percent lev.	Height of contents as a percentage of range
Mass	Mass of contents in tank
Rate	Rate of change in any of the measurements
Special	Special measurements, for service diagnostics

Note Volume related measurements (volume, ullage, percent full, percent empty, and mass) are not available until you have set up tank volume (see Chapter 3). ▲

Note Special measurements are only available if you have enabled the Service Only items (Chapter 8). ▲

After selecting the measurement type, you must select the units for the measurement. In the case of the mass, rate, and special measurements, additional menu items prompt you for the parameters required to complete the measurement setup. If you leave the measurement type set to inactive no additional items are displayed for this measurement.

The units for the volume or ullage measurements cannot be changed from within the Set up Additional Measurements menu. You must use the Tank Volume Setup subgroup within the Set up Level, Level Alarms and Volume menu group (Chapter 3).

Percent Full or Percent Empty

If you select the Percent Full or Percent Empty measurement type, the menu item shown in below is displayed.

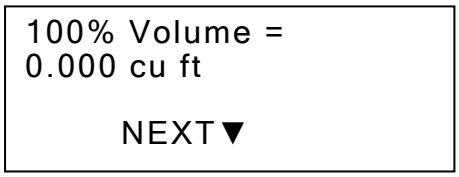

Figure 4–6.

Enter the tank volume when full. The volume of the material is computed based on the tank volume setup and the level measurement.

Mass Measurement

The mass measurement type is not available unless you have set up the volume measurement. Refer to the Tank Volume Setup subgroup within the Set up Level, Level Alarms and Volume menu group (Chapter 3).

1. Select the units for the mass measurement.

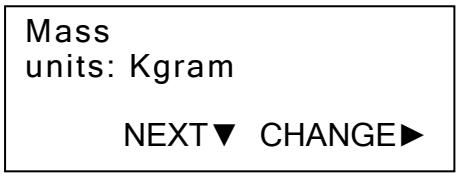

Figure 4–7.

Mass measurement options are shown in the table below.

Table 4–2. Mass measurement units

Name	Description
Gram	Grams
Kgram	Kilograms
Pound	Pounds
Metric ton	Metric tons (1000 kg)
Short ton	Short tons (2000 lb)
Long ton	Long ton (2200 lb)
Oz	Avoirdupois ounce

2. Enter the material density value (mass/volume) in terms of the units selected for mass and volume (density units = mass units/ volume units).

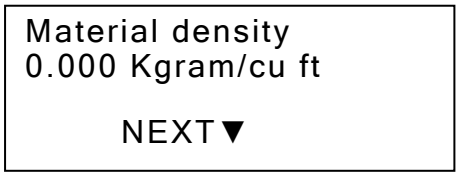

Figure 4–8.

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.

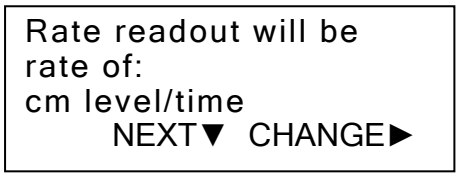

Figure 4–9.

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.

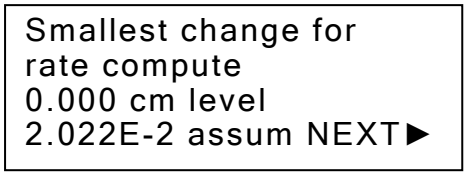

Figure 4–10.

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.

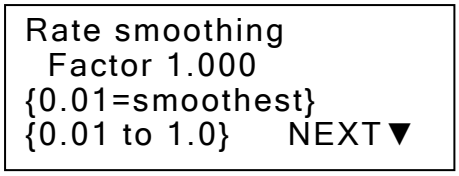

Figure 4–11.

4. Select the time interval associated with the rate measurement. Options are listed in the table below.

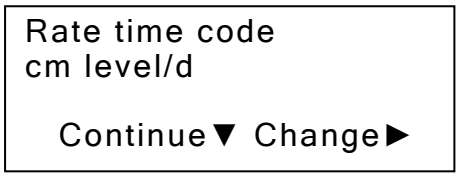

Figure 4–12.

Table 4–3. Time intervals for rate measurements

Name	Description
S	Seconds
m	Minutes
h	Hours
d	Days
w	Weeks
M	Months
y	Years

5. Select whether to display the rate measurement.

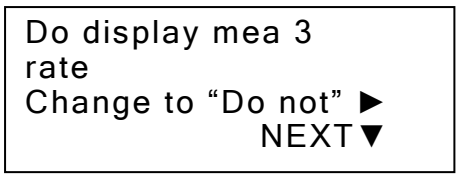

Figure 4–13.

Special Measurements

The Special Measurement items are only available if Service Only items have been enabled. If you select the special measurement type, you will be prompted to enter the code for the measurement. These special measurements are typically used for diagnostic purposes. A list of these codes is provided in Appendix C.

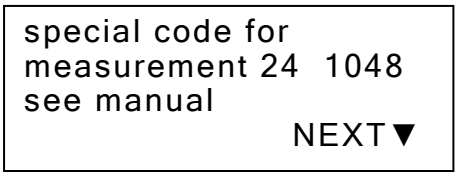

Figure 4–14.

Special Equations

There are three special measurement codes that invoke the special equations function. These equations allow the value from the 4–20 mA auxiliary current input (from the pressure sensor) to be combined with a function of the level measurement from the instrument to create a new measurement value. Special equations have the following form:

$$Value = M_1 / M_2,$$

where

$M_1 = A_1 * f(level) + B_1 * Aux + C_1 * f(level) * Aux + D_1.$

$M_2 = A_2 * f(level) + B_2 * Aux + C_2 * f(level) * Aux + D_2.$

$A_1, B_1, C_1, D_1, A_2, B_2, C_2, D_2$ = 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 in the following table.

Table 4–4. Special equations

Special Measurement Code	f(level)
147	f(level) = level
148	f(level) = sqrt(level)
149	f(level) = $(level)^2$

Note To use special equations for vapor density compensated level, refer to Appendix F. ▲

Set Up Alarms for Additional Measurements

By default, all alarms are assigned to the primary measurement, but once you have set up an additional measurement, you can assign an alarm to it. Set up an alarm for an additional measurement by following the same steps detailed in "Set up Alarms" in Chapter 3.

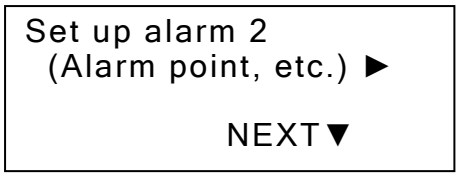

Figure 4–15.

Display the Additional Measurement

The screen after the alarm setup menus allows you to choose whether you want the additional measurement value to appear on the measurement display. If you choose not to display the measurement, you can still use the measurement to drive alarms or current output.

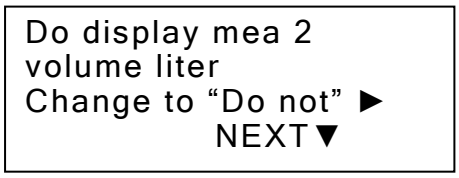

Figure 4–16.

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. They are enabled when a value greater than 9999 is entered as the highest expected reading (Figure 4–17). For example, you can scale volume measurement readings in the range of 30000 to 40000 liters by a factor of 1000 so that the range of volume readout is 30.00 to 40.00. Display scaling does not change the units displayed for the readout.

1. If you expect the maximum measurement readout to exceed four digits (value greater than 9999), enter an estimate of the maximum measurement value as the highest expected reading.

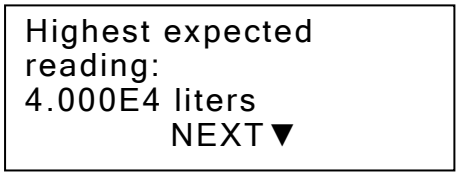

Figure 4–17.

If you set a highest expected reading value of 10000 or greater (more than four digits), three additional menu items are displayed allowing 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 40000 liters is scaled by a factor of 1000 to read 40.00 on the display, if the gauge measures 43875 liters, the displayed value is 43.88. Any value up to 99990 can be displayed correctly (divided by 1000 and displayed as 99.99).

2. The Lowest Expected Reading menu item is displayed if you set a highest expected reading value greater than 9999 for a measurement.

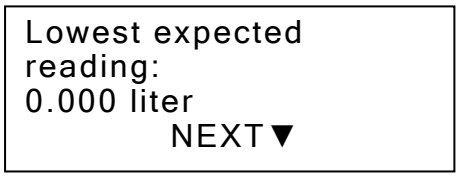

Figure 4–18.

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.

3. 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 40000 to a display value of 40.00, enter 40.00.

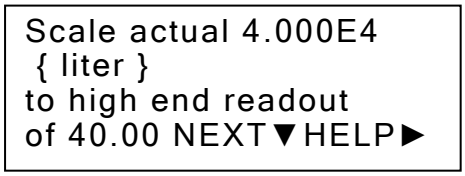

Figure 4–19.

4. 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.

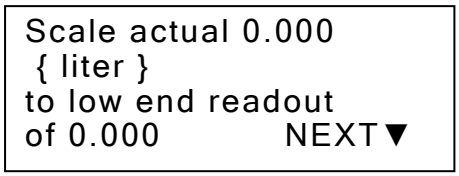

Figure 4–20.

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

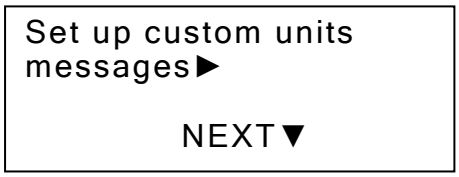

Figure 4–21.

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 ten characters long.

If the volume measurement with units of liters is scaled by a factor of 1000, the displayed value has units of kiloliters. In this case, you can set up a custom units message to read “kilter”.

You can set eight custom messages using any combination of ASCII characters. Refer to “Custom Units Messages” in Chapter 8 for instructions.

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Chapter 5
Gauge Fine Tuning

After completing the basic setup, you can use the Gauge Fine Tuning menu to modify the gauge's time constant or to perform standardization or calibration cycles.

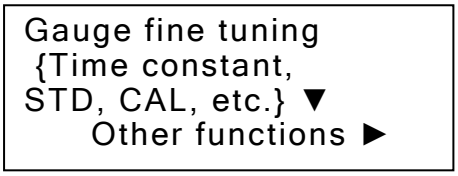

Figure 5–1.

Press the down arrow to access the related menu items.

Time Constant Setup

The Time Constant Setup menu lets you modify the instrument time constant and related items.

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

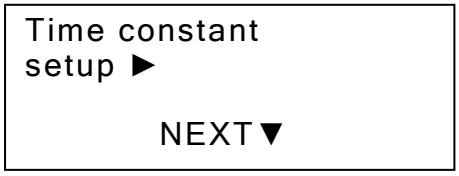

Figure 5–2.

2. Enter the time constant. The default setting for the time constant is 128 seconds.

Figure 5–3.

Time Constant

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

If you decrease the time constant, you can increase the responsiveness of the gauge, but measurement stability will suffer, as 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.

Note Precision is not accuracy. With a properly selected time constant, the gauge can give a stable and responsive readout, but the accuracy of the readout depends on how carefully the gauge has been standardized and calibrated. ▲

3. **Do not disable dynamic tracking during normal operation.** This is a Service Only item.

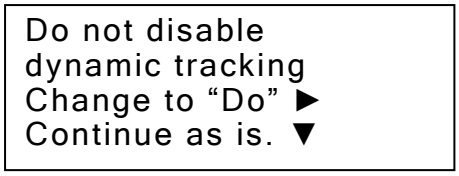

Figure 5–4.

4. The Source Half-Life menu item is only displayed if Service Only items are enabled. This value is used 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.

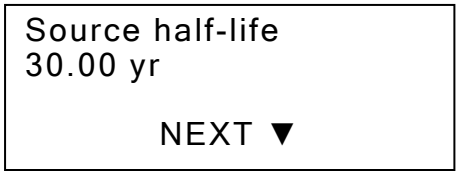

Figure 5–5.

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.

Figure 5–6.

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).

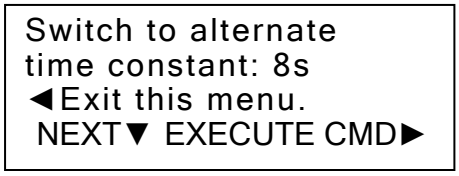

Figure 5–7.

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

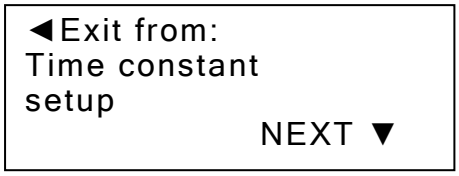

Figure 5–8.

Sensor Head Standardization

Standardization was introduced in Chapter 3, as you can initiate a standardization measurement from the Set up Level, Level Alarms and Volume menu group. It is also best practice to empty the tank and standardize during the initial setup process.

Note If the situation is such that the vessel cannot be emptied, refer to "Calibration without Empty Vessel" procedure in Appendix D. ▲

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

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. After setting up the instrument, periodically check the tank's actual level (if possible) and compare it to the displayed measurement. A consistent error in the level measurement may indicate that the instrument requires standardization. There are several factors that may make it necessary to standardize:

- Tank wall wear caused by corrosive or abrasive materials
- Buildup of process material on the tank walls
- Cleaning or spontaneous breakup of built-up material
- Repairs or changes to the tank or source head mount
- Shifting of the instrument head mount (must be aligned and securely mounted)
- Repair or replacement of source or detector parts
- Installation or change in commission of nearby nuclear gauges
- Change in the storage, handling, or use of radioactive materials nearby

Procedure

1. Empty the tank entirely or to a level that is well below the bottom of both the source and detector.

2. Open the shutter(s).

Note The shutter(s) will need to be open and the vessel empty (maximum radiation on the detector) for at least 30 minutes prior to performing the standardization or calibration cycle. This wait time is necessary for proper orientation of the gauge. ▲

3. From the measurement display, press the right arrow to move to the Set up Level, Level Alarms and Volume menu. Press the down arrow until you reach the Standardize On menu item. Keep this set to **Tank Empty**.

Note There is a selection called "Defer Standardization." **Do not make this selection. Always select Tank Empty for the standardization.** ▲

Figure 5–9.

4. The following item is a read-only screen that indicates the status of the last standardization cycle.

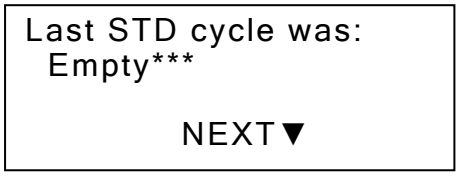

Figure 5–10.

5. Specify the number of time constant periods used for the standardization measurement. 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). You can change the duration of the standardization cycle by altering the time constant value (reference "Time Constant Setup" earlier in this chapter) or by changing the number of time constant periods used.

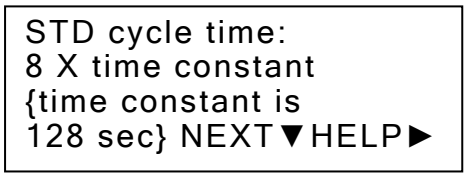

Figure 5–11.

The precision of the measured radiation level improves as the measurement time is increased. Since any error in the standardization value results in a corresponding error in the measurement readouts, it is recommended that you do not decrease the default standardization cycle time.

Note The standardization cycle time must be set to at least two time constant periods or the gauge automatically aborts the standardization cycle. ▲

6. The Time Since Last Standardization displays the amount of time in weeks since the last standardization cycle was performed.

Figure 5–12.

The value is automatically adjusted to account for the reduced source level due to the radioactive decay of the source. The counter that tracks this value stops when power is removed from the transmitter. However, the source decay continues. If power is removed for a significant length of time (for more than several weeks), it is recommended that you update this value. Add the length of time in weeks that the power was off to the displayed value, and enter the new value here.

If you use a Cs-137 source (30-year half-life) and standardize periodically, the accuracy of the value entered here is not particularly important. However, if you use a Co-60 source, source decay has a greater effect due to the shorter half-life (5.3 years). If the gauge is not on all the time and you do not plan to standardize for several months, you should record the date when you perform the standardization cycle. Periodically check this value and adjust it as necessary. Also make sure the correct source half-life value is entered.

7. While the gauge is on, it tracks elapsed time to adjust the standardization value for source decay. By default, this counter assumes that power is applied to the instrument continuously. If the instrument is shut down periodically, such as over the weekend, an error will accumulate in the counter over time. To improve the decay counter accuracy, enter the number of days per week that power is applied to the gauge.

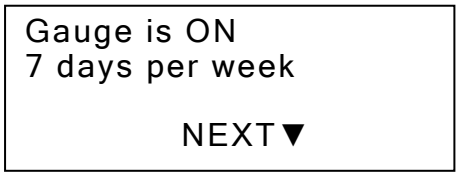

Figure 5–13.

8. After starting the standardization, a menu item is displayed that allows you to abort the cycle or exit the menus during the cycle. A countdown timer is shown on the display that indicates the remaining cycle time in seconds.

Service Only Items

The following items are displayed in the Sensor Head Standardization menu if Service Only menu items are enabled.

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. At the next screen, 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. This type of standardization is useful if the tank level or conditions may change during the cycle.

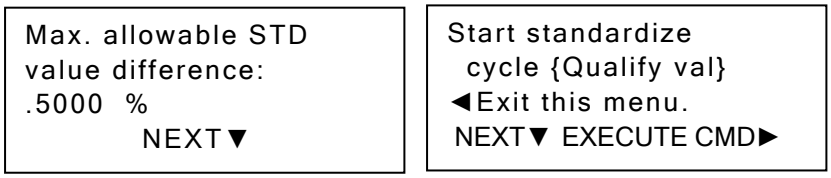

Figure 5–14.

2. A hold standardization cycle performs a standardization measurement, but the measured value is held, rather than used to replace the current value. This type of standardization can be used as a manual version of the qualify standardization.

Figure 5–15.

3. This item 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.

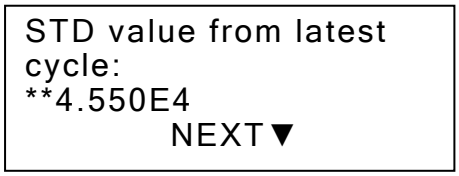

Figure 5–16.

4. This read-only menu item displays the standardization value currently in use. This value will differ from the latest value if several weeks have passed since the last standardization.

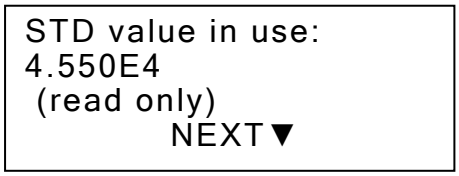

Figure 5–17.

5. 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.

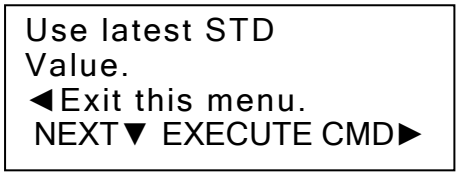

Figure 5–18.

Level Gauge Calibration

General

The Level Gauge Calibration menu enables you to tune the gauge's level measurement. During calibration, the gauge measures the tank at one or more different process levels. At each level (calibration point), the gauge matches the signal it records to the actual level you enter. To measure levels in between, the instrument interpolates from the adjacent calibration points to find the correct level measurement.

After being standardized, the gauge uses two default calibration points to relate signal strength to level. For the "tank empty" point, the gauge assumes the tank is empty if the detected radiation matches the standardization signal. For the "tank full" point, the gauge assumes the tank is full if the radiation reaches zero (falls below normal background radiation).

Caution If you do not calibrate the gauge, some tanks might overflow without reaching the tank full level. This can occur if the radiation measured at the detector when the tank is full (process level at the top of the detector) is greater than the assumed background radiation. If your application requires accurate level measurements, perform a calibration. ▲

You can further improve accuracy by calibrating additional points between tank empty and tank full. Additional calibration points may be at levels where the tank shape changes or where fixtures in the tank might affect the radiation signal. If you have multiple sources or detectors, consider calibrating at each point where a source is mounted or at each point where detector ends meet.

Why Separate Standardization & Calibration

You can spend a lot of time setting levels and calibrating the gauge. If the gauge stored calibration points as absolute measurements, you would need to repeat the calibration process whenever wear or buildup changed the tank's characteristics. Instead, the gauge stores your calibration using a ratio relative to the standardization (STD) reference point. When you perform a calibration, the calibration signal is stored as a new CAL/STD ratio. The most important difference between these processes is that standardization sets an absolute reference point while calibration sets ratios based on that reference.

You can standardize again to account for changes in the tank. Because your calibration is stored using a ratio to the standardization, setting the new standardization reference automatically adjusts the calibration to compensate for the change. The only reason you may need to repeat calibration is if buildup or other factors affect readings differently at different levels.

The gauge also adjusts the standardization reference automatically to account for radioactive decay of the source. The adjustment is based on a decay clock that resets when you standardize the gauge. See the Time Since Last Standardization menu item (step 4 in "Sensor Head Standardization").

The Procedure

You can calibrate up to 16 calibration points. A new calibration measurement or recalibration of an existing point can be done at any time.

Note Accuracy of the gauge depends on how accurately the level can be held. Any error can affect subsequent measurements. ▲

Note It is a good idea to calibrate at the tank full level first, then at several intermediate levels, especially where the tank or gauge geometry changes. ▲

Note Measurements above the highest calibration point can be extremely inaccurate. ▲

Follow these steps for each calibration point.

1. If necessary, set up the gauge according to Chapter 3.

2. Perform a standardization according to "Sensor Head Standardization" earlier in this chapter.

3. Fill the tank with process material to a particular level you are interested in. Measure the level accurately and keep it steady as possible.

4. From the measurement display, press the right arrow to step to the Gauge Fine Tuning menu (or the Set up Level, Level Alarms and Volume menu).

5. Press the down arrow to step to the Level Gauge Calibration menu. Press the right arrow to enter the menu.

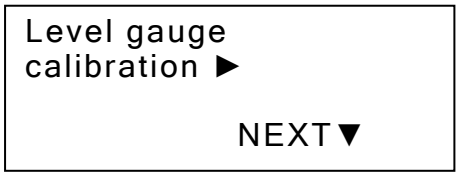

Figure 5–19.

6. If you have not enabled Service Only items, skip to step 7. If you have enabled Service Only items, the following two menus are available.

   a. The Table Points to be Used screen allows you to select the number of calibration points to use. A value of zero causes all the points to be used. During normal operations, it is better to erase any undesired calibration points.

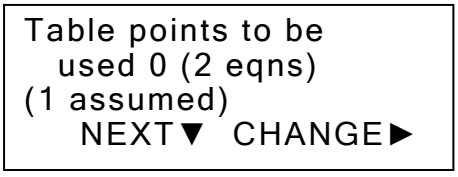

Figure 5–20.

b. This CAL Override Menu allows you to manually enter background, standardization, and calibration values that are normally learned by the system during the corresponding measurement cycles.

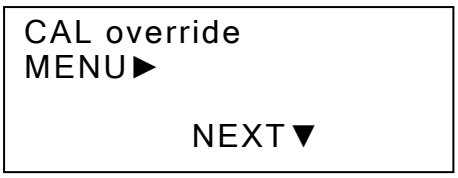

Figure 5–21.

7. After standardization, there are zero points assumed, and calibration point 1 will be the next (first) calibration point. Note that this number will increase as you add points. Select the desired calibration point.

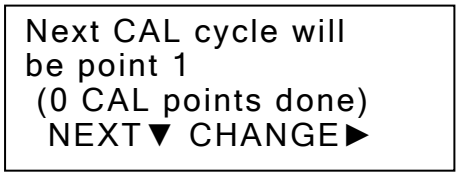

Figure 5–22.

8. Enter the actual level at which you are holding the process. Write down the data point number of the item.

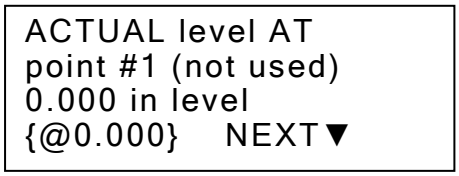

Figure 5–23.

9. Press the down arrow to step to the Next CAL Cycle Will Run On item. You can skip the CAL/STD Ratio menu items, as they are primarily for information. At the Next CAL Cycle Will Run On item, select the data point number you wrote down in the previous step.

10. Press the right arrow to begin the calibration measurement. When the cycle is finished, return to the Level Gauge Calibration menu and step down to the CAL/STD ratio item that corresponds to the level you just calibrated (corresponding level shown in brackets). Keep a list of each data point's level and CAL/STD values so that you can enter them manually if you ever need to reproduce the same calibration.

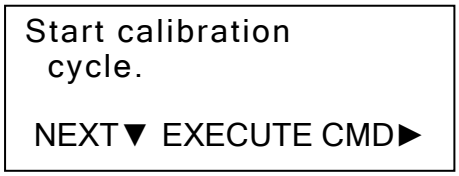

Figure 5–24.

11. Repeat this procedure for each calibration point.

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Chapter 6
Current Output & Alarm Setup

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

Modify/ Reassign Current Output

Overview

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

- Set the span for the current output.
- Specify which measurement should drive the current output in normal mode.
- Specify which measurement 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 level range of 5.0–10.0 feet during one portion of the process and a level range of 5.0–20.0 feet during another part of the process, you could set up the measurements and current output as follows:

1. Set up Meas #1 as level and assign it to drive the current output in normal mode with a level range of 5.0–10.0 feet.

2. Set up Meas #2 as level and assign it to drive the current output in alternate mode with a level range of 5.0–20.0 feet. 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.

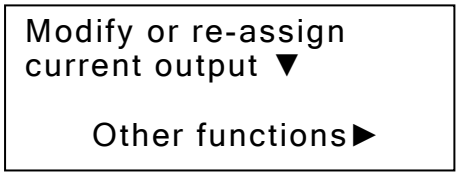

Figure 6–1.

2. The maximum current output value ranges from the minimum current output value (4.0 mA by default) to 20.0 mA. The default value for the maximum current output is 20.0 mA.

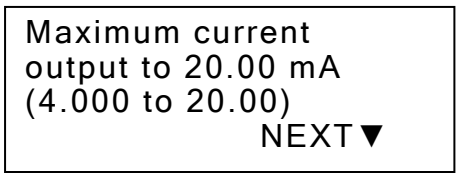

Figure 6–2.

3. The minimum current output value ranges from .0001 mA to the maximum current output (20.0 mA by default). The default value for the minimum current output is 4.0 mA.

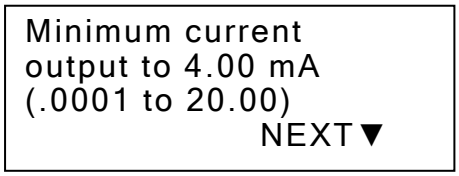

Figure 6–3.

Note Entering a value of exactly 0.0 sets the minimum current output to the default value of 4.000 mA. It is recommended that this value be set to 2.0 mA or greater. ▲

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

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

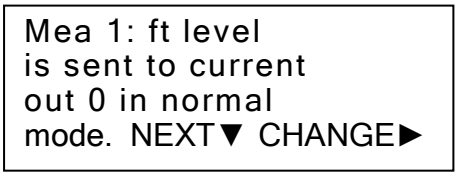

Figure 6–4.

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

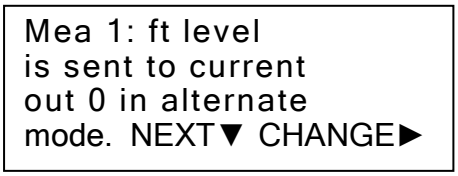

Figure 6–5.

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 you enter here.

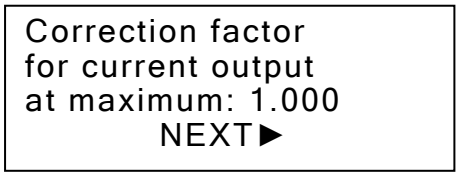

Figure 6–6.

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 you enter here.

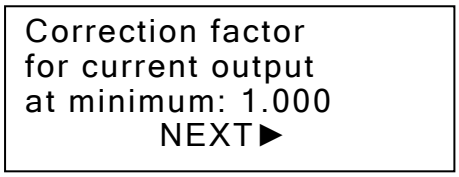

Figure 6–7.

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%.

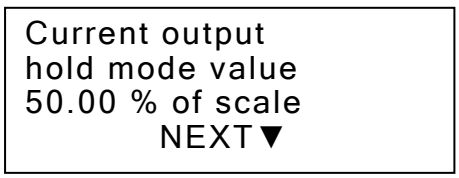

Figure 6–8.

Set up Fault Alarms/Change Process Alarms

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

- Set up alarms to execute commands.
- Assign relays to warning and fault alarms.
- Assign relays to mode alarms.
- Choose whether to show the relay status on the measurement display.
- Set up fault alarms or change process alarm assignments.

Note If relays are not installed, the various alarm setup options will not be displayed. To enable display of alarm setup menu options, go to the Special Functions menu and change the Do Not Enable Alarm Related Selections (Chapter 8). You will then be able to assign any of the alarm indicators with the exception of relay control. ▲

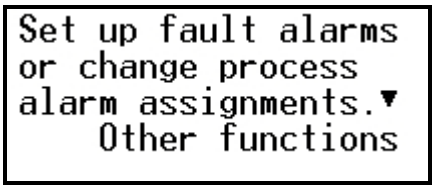

Figure 6–9.

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 set to a process measurement alarm, you must have set up the measurement and assigned an alarm to the measurement. ▲

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 to step to the Set Up for Alarms to Execute Commands menu item. Press the right arrow to continue.

Figure 6–10.

2. The default condition is to do nothing. Press the right arrow to scroll through the list of commands available to be executed when the alarm is activated. The available actions are listed below.

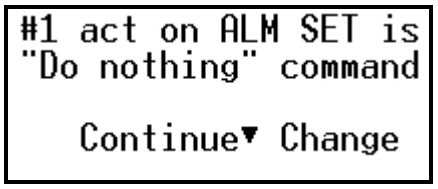

Figure 6–11.

a. Hold current output at 50% of scale (which should be 50% of level).

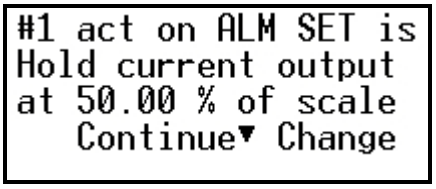

Figure 6–12.

b. Hold current output at maximum (normally 20 mA).

Figure 6–13.

(actions on alarm set)

c. Hold current output at minimum (normally 4 mA).

Figure 6–14.

d. Clear all holds.

Figure 6–15.

e. Hold current output at fault high (20.8 mA or greater).

Figure 6–16.

f. Stop data streaming on port 1 (RS232).

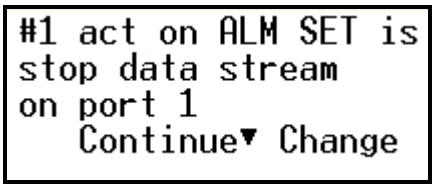

Figure 6–17.

g. Restart data streaming on port 1 (RS232).

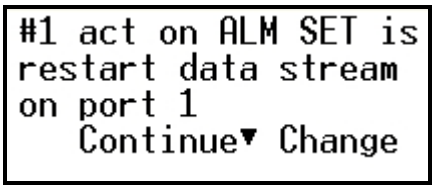

Figure 6–18.

(actions on alarm set)

h. Stop data streaming on port 2 (RS485).

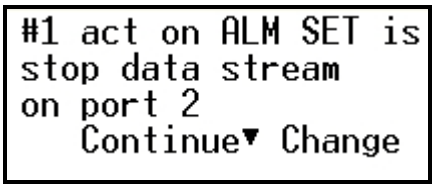

Figure 6–19.

i. Restart data streaming on port 2 (RS485).

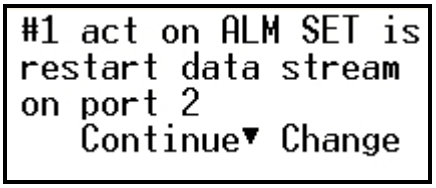

Figure 6–20.

j. Show custom message on line 4.

Figure 6–21.

k. Stop showing the custom message on line 4.

Figure 6–22.

l. Switch current output to alternate mode.

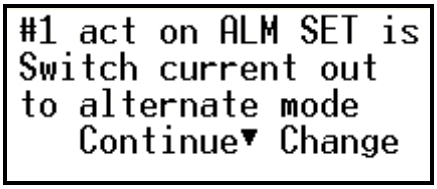

Figure 6–23.

(actions on alarm set)

m. Switch current output to normal mode.

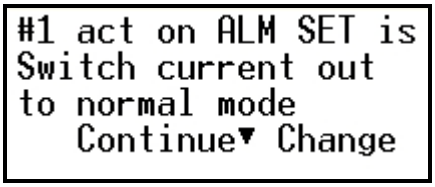

Figure 6–24.

n. Switch display to alternate mode.

Figure 6–25.

o. Switch display to normal mode.

Figure 6–26.

p. Hold current output at fault low.

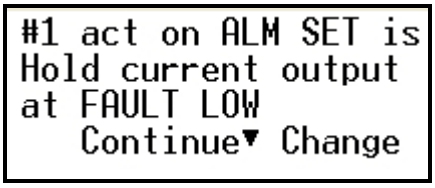

Figure 6–27.

q. Save relay data log to NV RAM.

Figure 6–28.

(actions on alarm set)

r. Update data output on port 1 (RS232).

Figure 6–29.

s. Update data output on port 2 (RS485).

Figure 6–30.

3. 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. Press the right arrow to scroll through the list of commands.

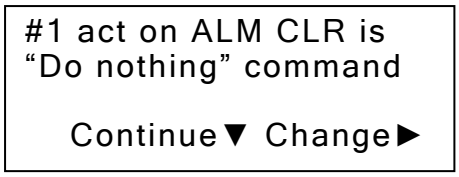

Figure 6–31.

4. The menu items shown in steps 2 and 3 are repeated for alarm action sets #2 and #3.

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.

Figure 6–32.

1. Assign an action to indicate a system fault. The default condition is to do nothing. Press the right arrow to cycle through the available actions, which are listed below.

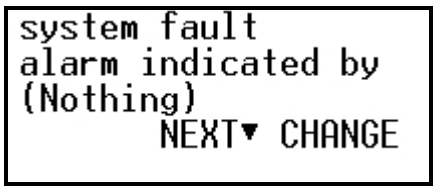

Figure 6–33.

   a. Control relay 1.

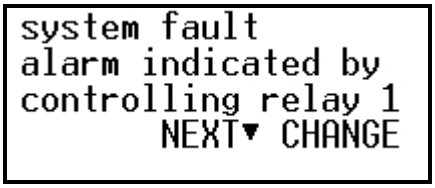

Figure 6–34.

   b. Control relay 2.

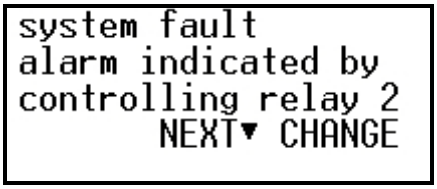

Figure 6–35.

(assign action to indicate system fault alarm)

c. Set current output 1 to fault low.

Figure 6–36.

d. Set current output 1 to fault high.

Figure 6–37.

e. You can also assign one of the three alarm action sets (if configured) to indicate a system fault.

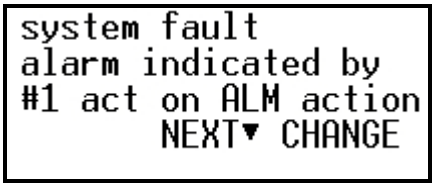

Figure 6–38.

2. Set an indicator for the CAL cycle aborted alarm. The actions available are the same as for the system fault alarm.

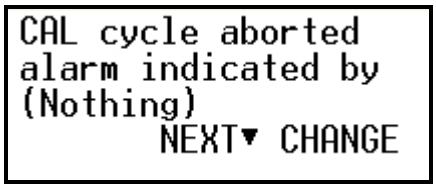

Figure 6–39.

3. Set an indicator for the sensor under range alarm (alarm occurs during a standardization measurement if the radiation level is less than the background level). The actions available are the same as for the system fault alarm.

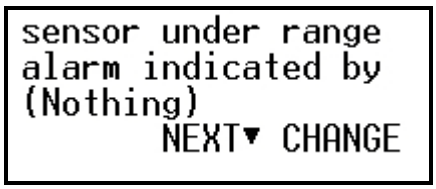

Figure 6–40.

4. Set an indicator for the sensor over range alarm. The actions available are the same as for the system fault alarm.

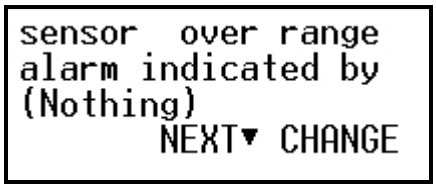

Figure 6–41.

5. Set an indicator for the current max or min alarm (alarm occurs when the current output has reached the maximum or minimum value). The actions available are the same as for the system fault alarm.

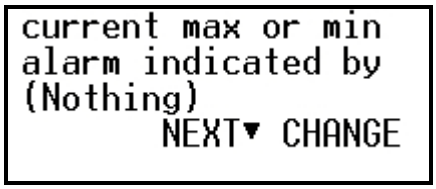

Figure 6–42.

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.

Figure 6–43.

1. Assign an action to indicate the system is in standardization mode (STD). The default condition is to do nothing. Press the right arrow to cycle through the available actions, which are listed below.

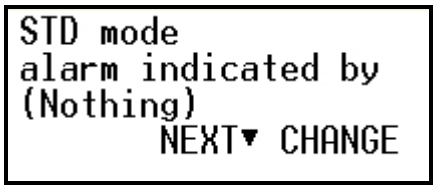

Figure 6–44.

   a. Control relay 1.

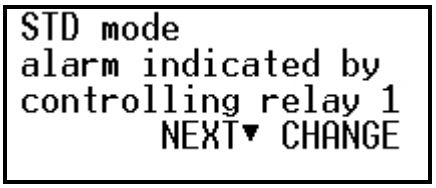

Figure 6–45.

   b. Control relay 2.

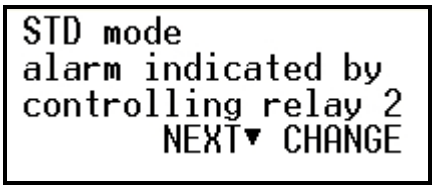

Figure 6–46.

(assign action to indicate mode alarm)

c. Set current output 1 to fault low.

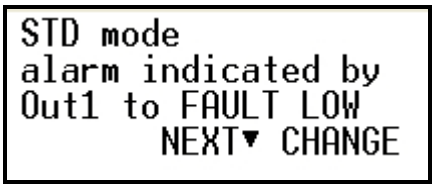

Figure 6–47.

d. Set current output 1 to fault high.

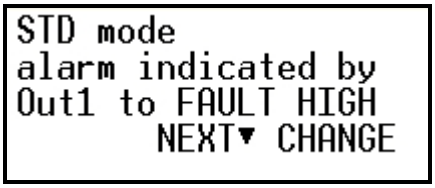

Figure 6–48.

e. You can also assign one of the three alarm action sets (if configured) to indicate a mode alarm.

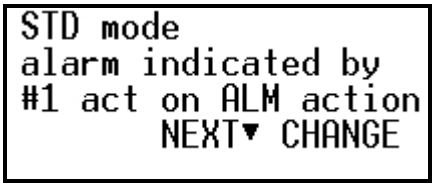

Figure 6–49.

2. Set an indicator for the CAL mode alarm. The actions available are the same as for the STD mode alarm.

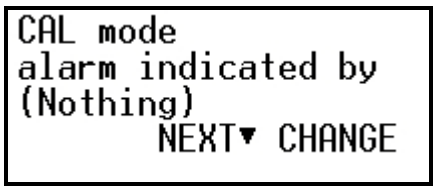

Figure 6–50.

3. Set an indicator for the holds are active mode alarm. The actions available are the same as for the STD mode alarm.

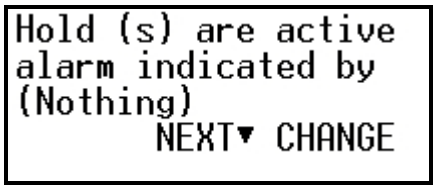

Figure 6–51.

4. Set an indicator for the current output on alternate mode alarm. The actions available are the same as for the STD mode alarm.

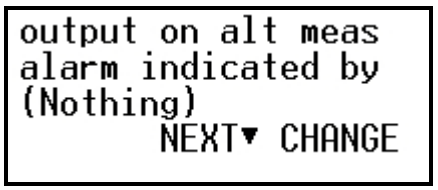

Figure 6–52.

5. Set an indicator for the alternate time constant mode alarm. The actions available are the same as for the STD mode alarm.

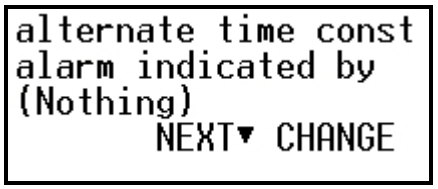

Figure 6–53.

6. Set an indicator for the keypad is in use mode alarm. The actions available are the same as for the STD mode alarm.

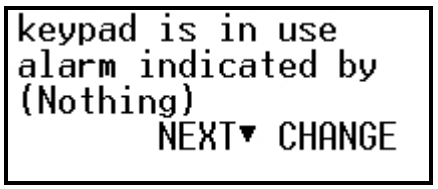

Figure 6–54.

7. Set an indicator for the power has been off mode alarm. The actions available are the same as for the STD mode alarm.

Figure 6–55.

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.

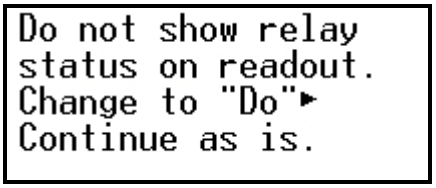

Figure 6–56.

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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

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.

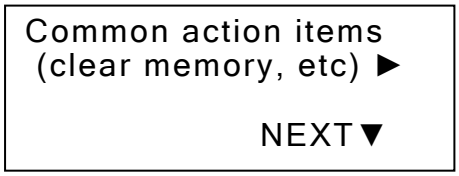

Figure 7–1.

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.

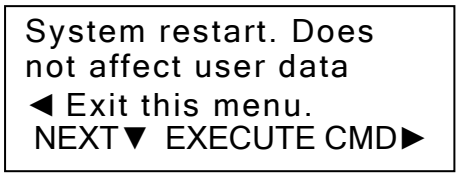

Figure 7–2.

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.

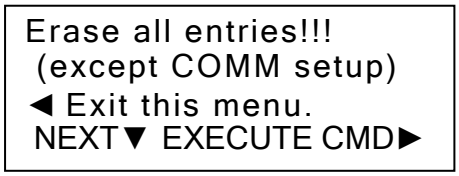

Figure 7–3.

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

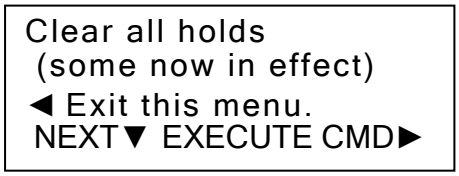

Figure 7–4.

5. 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 or by switching the display to normal mode.

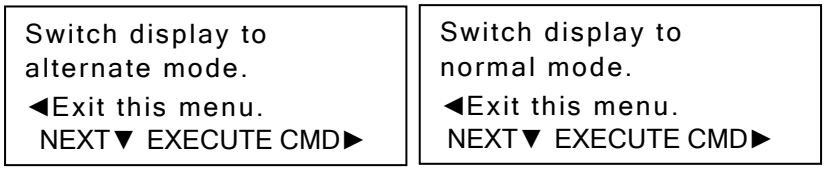

Figure 7–5.

6. 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.

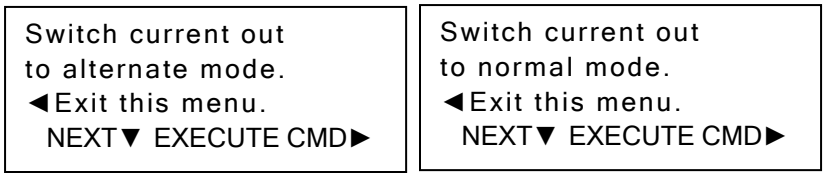

Figure 7–6.

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 subgroup.

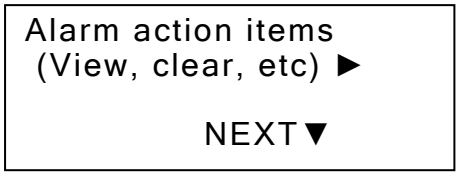

Figure 7–7.

2. The View Alarm Status and View Alarm History screens allow you to review all alarms currently in effect and the history of all alarms that have occurred since the last Clear All Alarms command. Both menu items include process, warning, fault, and mode alarms.

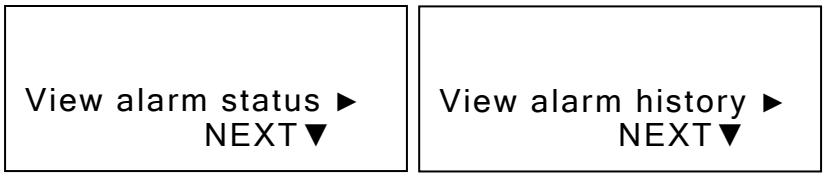

Figure 7–8.

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

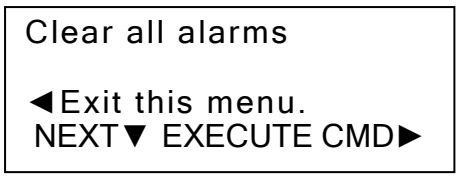

Figure 7–9.

4. 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.

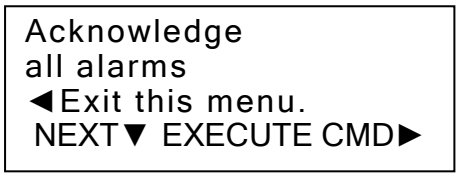

Figure 7–10.

5. 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.

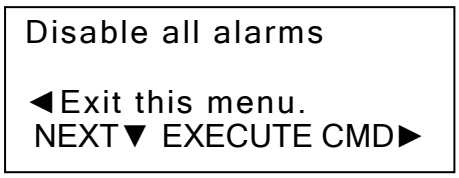

Figure 7–11.

6. 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.

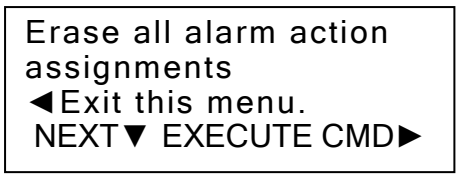

Figure 7–12.

Hold Action Items

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

1. Press the right arrow to enter the menu.

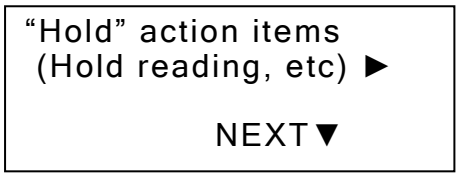

Figure 7–13.

2. Execute the Clear All Holds command to clear any holds currently in effect.

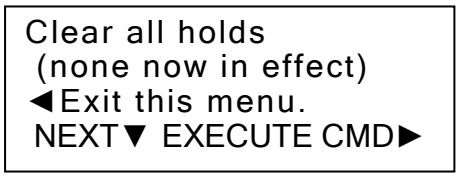

Figure 7–14.

3. The Hold Current Output at Max/Min commands allow you to hold the current outputs at maximum/minimum output values.

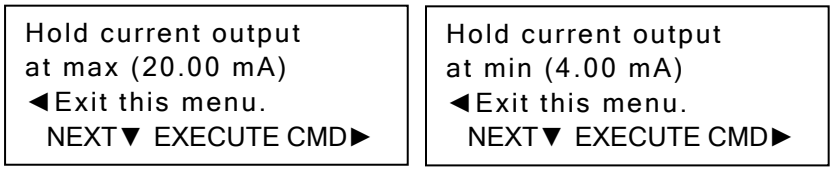

Figure 7–15.

4. The Hold Current Output at FAULT LOW/HIGH commands allow you to hold the current outputs at the FAULT LOW (3.6 mA or less) or FAULT HIGH level (20.8 mA or greater).

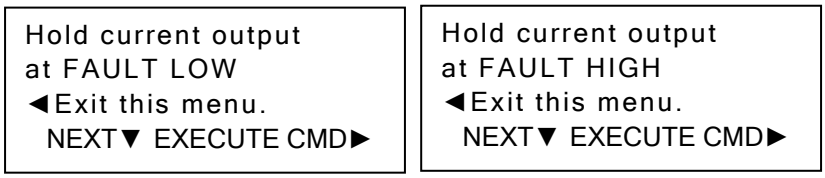

Figure 7–16.

5. Enter the value (in percentage) of the midrange current output hold value. The default value is 50.00%. Execute the Hold Current Output command to hold the current output at the midrange value you specified.

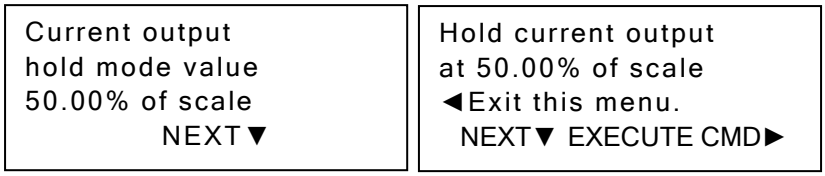

Figure 7–17.

6. Enter the hold value for the level measurement. Press the down arrow. At the next screen, press the right arrow to hold the level measurement value at the hold value specified in the previous menu item.

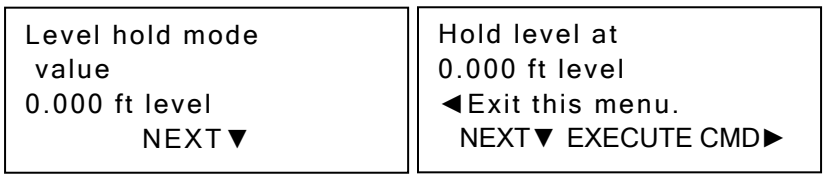

Figure 7–18.

7. Enter the hold value for level used to test the absolute level. Press the down arrow. At the next screen, press the right arrow to hold the primary measurement value at the hold value specified in the previous menu item.

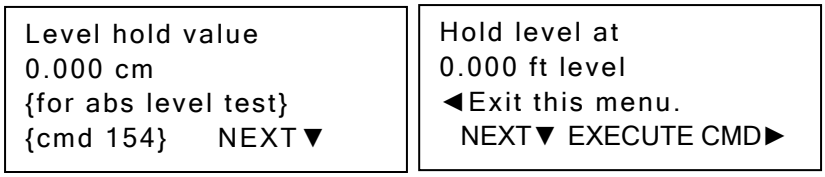

Figure 7–19.

8. This menu item is only displayed if you have set up tank volume (Chapter 3). Enter the volume hold value. Press the down arrow. At the next screen, press the right arrow to hold the volume measurement value at the hold value specified in the previous menu item.

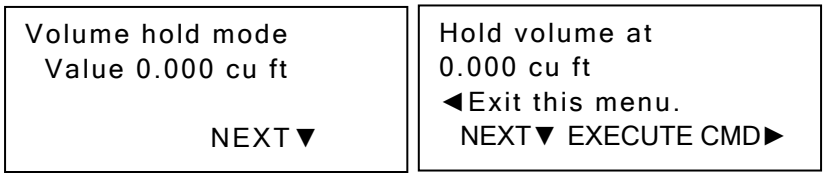

Figure 7–20.

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.

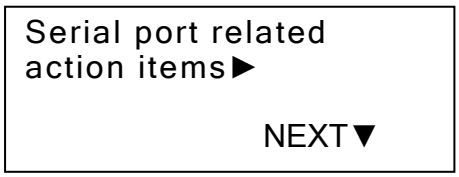

Figure 7–21.

2. The commands shown in the screens below will send a data set to the RS232 or the RS485 port.

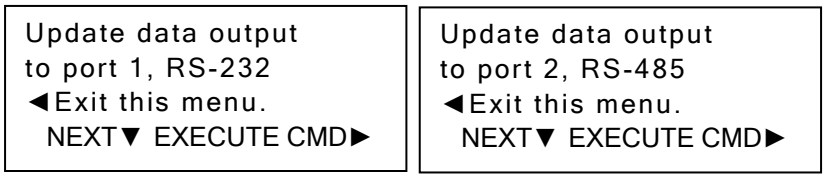

Figure 7–22.

3. The Clear Flags commands are available if Service Only items have been enabled (Chapter 8).

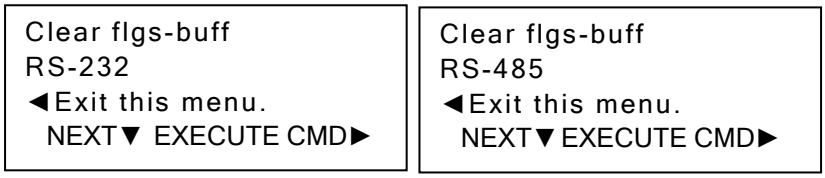

Figure 7–23.

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.
- Control relay operations, 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.

You can connect the RS232 port of the gauge 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 a Thermo Scientific 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.

- Remote 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 Thermo Scientific HHT or the TMTComm software emulation of the HHT.
- Blind mode: Only available if Service Only menu items are enabled. 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 installation guide.

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

3. Access the Set Up Data Transmission 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.

   c. Configure each slave unit.

Modes

The party-line has three distinct modes of operation: unconnected, connected, and sleep.

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.

Commands

Several useful escape codes are provided in the table below.

Table 8–5.

Code	Description
ESC [Z# #	CONNECT command. ## = unit number, i.e. 01 or 24.
ESC O 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 O 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.

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 Set up Data Transmission menu. Unselecting 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.

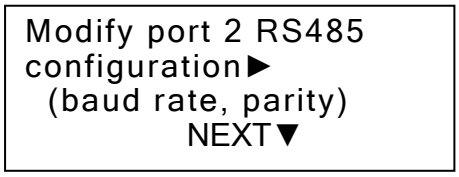

Figure 8–1.

2. Enable/disable the port.

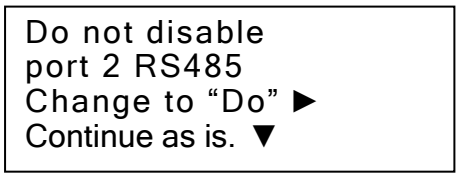

Figure 8–2.

3. The item shown below appears for the 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.

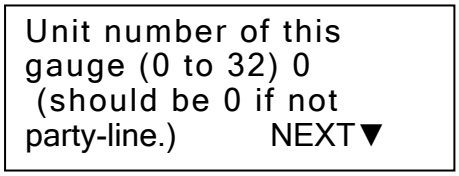

Figure 8–3.

4. 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.

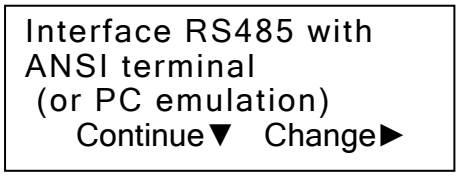

Figure 8–4.

5. Set the baud rate (1200, 2400, 4800, or 9600 bps).

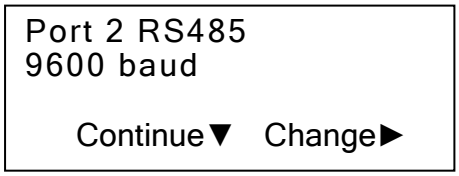

Figure 8–5.

6. Set the word length (7 or 8 bit).

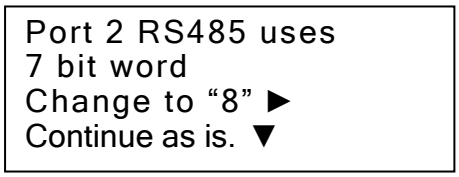

Figure 8–6.

7. Set the parity (even or none).

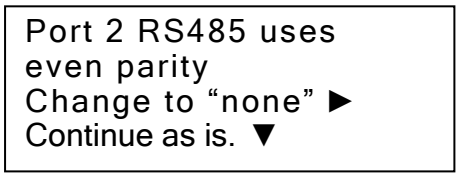

Figure 8–7.

8. Specify whether to send a LINEFEED (ASCII character 10) after a carriage return (ASCII character 13) for a NEWLINE.

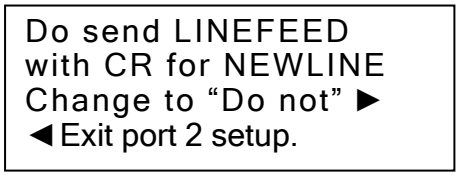

Figure 8–8.

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 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.

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.

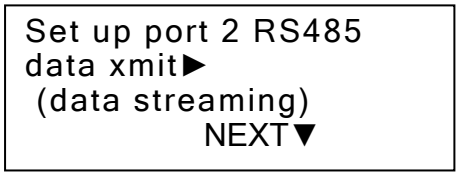

Figure 8–9.

2. Turn data streaming on or off.

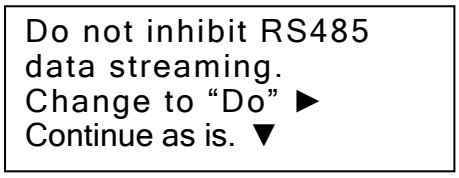

Figure 8–10.

3. Enable or disable transmission of the data for each measurement you have set up.

Figure 8–11.

4. The menu item shown below appears for the RS485 port only. Select **Do** to allow the gauge to continue data streaming while in connect mode.

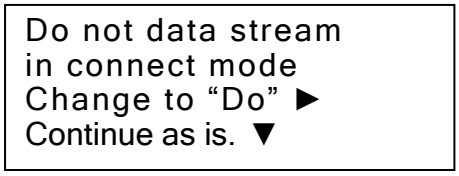

Figure 8–12.

5. The menu item shown below appears for the RS485 port only. Specify whether this gauge is a slave or the Master for party-line communications.

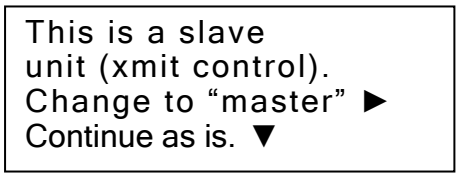

Figure 8–13.

6. The item shown below is a menu subgroup heading. The individual menu items are discussed in “Data Format Setup” later in this chapter.

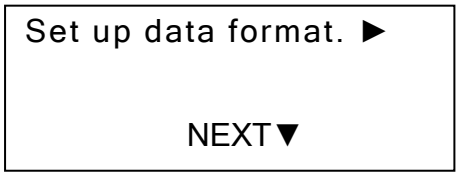

Figure 8–14.

7. 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.

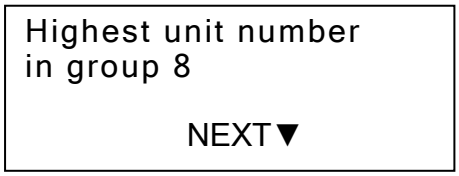

Figure 8–15.

8. 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 setting up data streaming for an RS232, set the time between updates (in seconds).

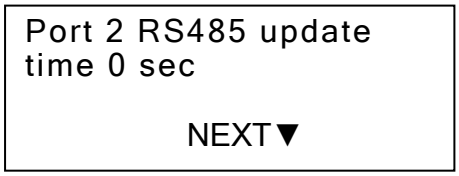

Figure 8–16.

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.

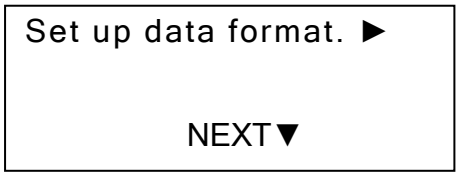

Figure 8–17.

A data set contains all the readings (measurements) sent by a particular unit. By default, a NEWLINE is sent after each reading. A HOME and a CLEAR are sent after each set. This causes the data to update the same place on the screen.

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

- Put the measurement number before each reading.
- Send a logical NEWLINE after transmission of the data set.
- Send the measurement's unit string (ft level, sig str, cu M, etc.) after each reading.
- Send the unit number with each reading (for units on an RS485 party-line only).
- Send a TAB (ASCII character 9) after each reading. This setting is useful for sending columnar data to a printer.
- Send an ANSI clear/home escape string after a data set.
- Send a custom (user-defined) message before each data set.
- Send the gauge unit number before transmission of each gauge's data set for units on an RS485 party-line only).
- Send a custom data set message (only displayed if you enabled custom messages).
- Send an ANSI command to position the readout start on the specified row number (not available in blind, printer, or HHT terminal modes).
- Send an ANSI command to position the readout start in a specified column number (not available in blind, printer, or HHT terminal modes).

Contact Inputs

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

1. Enter the menu to assign commands to the contact closure.

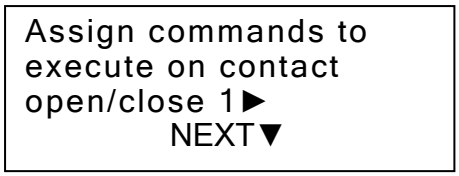

Figure 8–18.

2. Scroll through the list of commands until the one you want to execute with the switch closure is displayed.

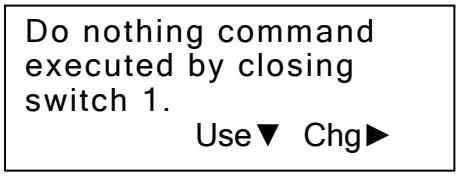

Figure 8–19.

3. 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.

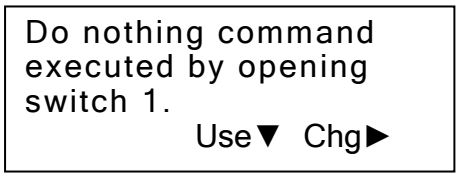

Figure 8–20.

Special Functions

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

1. Enter the menu to access the special functions.

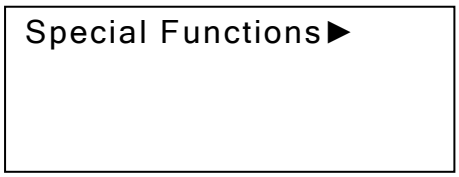

Figure 8–21.

2. The Relay Latching item is only displayed if relays are installed. Choose whether to enable relay latch mode entries in menus that set up process limit alarms.

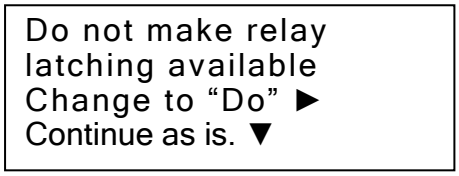

Figure 8–22.

3. You can disable the “For setup…” message on the fourth line of the normal readout through the menu item shown below. Doing so allows all four lines to be used for measurement readouts.

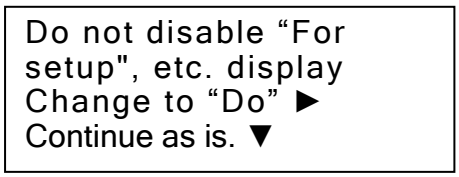

Figure 8–23.

4. Choose whether to display relay status on the measurement display. The numbers of the relays currently turned on are displayed along with the normal measurement readouts.

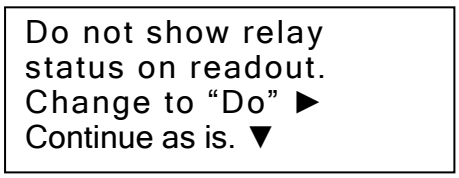

Figure 8–24.

5. **Leave dynamic tracking enabled.**

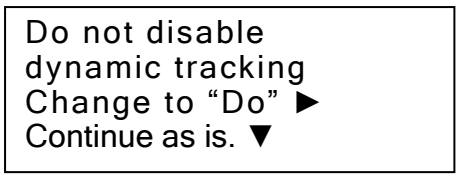

Figure 8–25.

6. Enable/disable Service Only menu items.

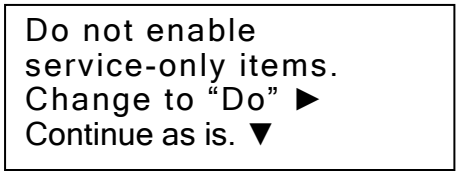

Figure 8–26.

7. Enabling multiple setups allows the instrument calibration data to be stored in one of four data sets and displays the Store/Retrieve Multiple Setups menu chain under the Set up Level menu (Chapter 3).

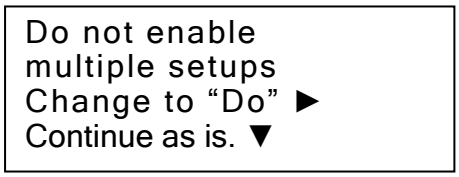

Figure 8–27.

8. The Special Span Entries Level menu item 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.

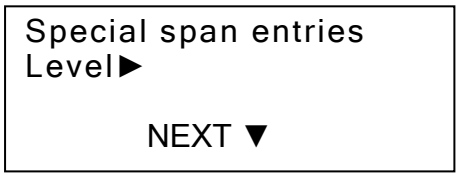

Figure 8–28.

9. Custom messages are detailed in the section titled "Custom Units Messages" (later in this chapter).

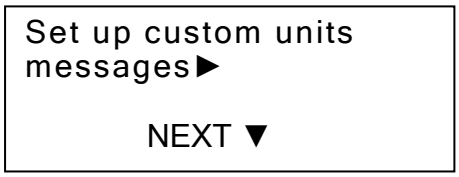

Figure 8–29.

10. Enable the second order calibration break table to use second order rather than linear interpolation between calibration points. This may provide better level estimates for one or two calibration points equally spaced along the length of the detector. For closely spaced calibration points, use linear interpolation.

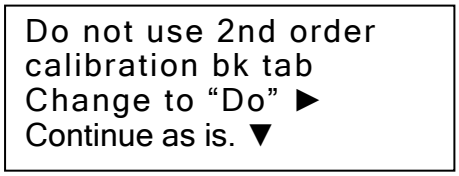

Figure 8–30.

Custom Units Messages

You can use custom messages to redefine units and to provide headers for serial data. For example, if you apply a display scaling to scale the tank volume readout by a factor of 1000 (10000 ft^3 displayed as 10 ft^3), you can set up a custom units message such as "K_CU_FT" and set that message to be displayed for the volume units.

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 of the Set up Data Transmission menu. This menu option is also displayed when you enable display scaling. In each case, you can select any of the custom messages that have been entered. You can also modify an existing message or add a new message.

You enter message characters by using the right and left arrow keys to scroll through the available character selections or by using the ASCII codes for the characters given in the following table.

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

Table 8–6. 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
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	–		

1. Enter the menu to set up custom messages.

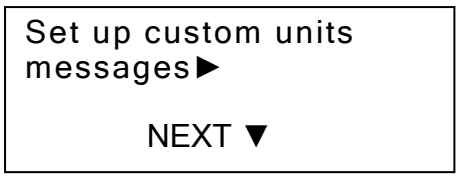

Figure 8–31.

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.

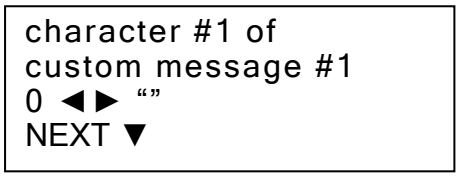

Figure 8–32.

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

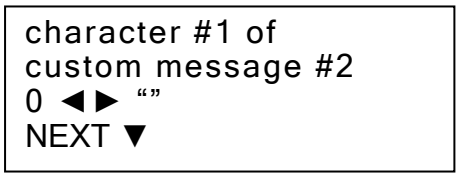

Figure 8–33.

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 (“ft level”). This menu item is repeated for each measurement that you have set up.

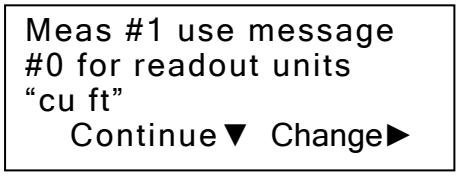

Figure 8–34.

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

1. Security items allow you to set a password to prevent unauthorized personnel from making new setup entries or changing existing entries in the setup menus. Press the right arrow to access the menu items.

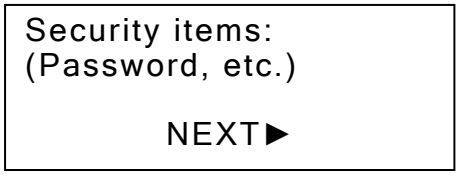

Figure 9–1.

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).

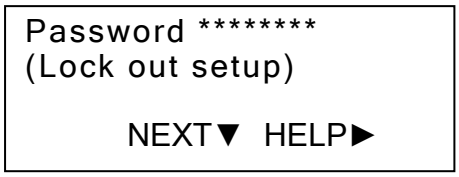

Figure 9–2.

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 Figure 9–3 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.

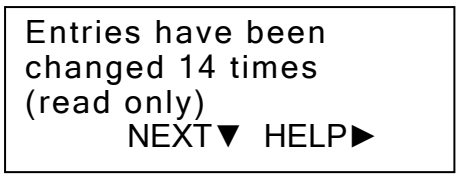

Figure 9–3.

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.

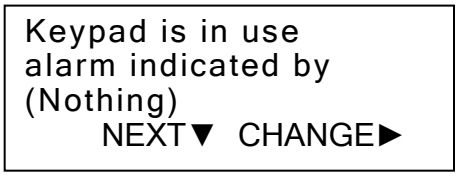

Figure 9–4.

Diagnostics

The Diagnostics menu provides diagnostic tools if you encounter a problem with the gauge.

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

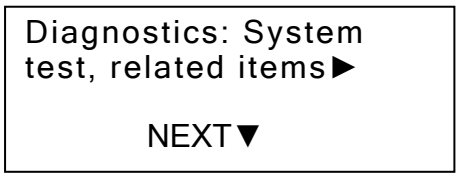

Figure 9–5.

2. The Self Test 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 double stored and periodically cross-checked. Errors are automatically corrected, and an alarm is activated when an error is detected.

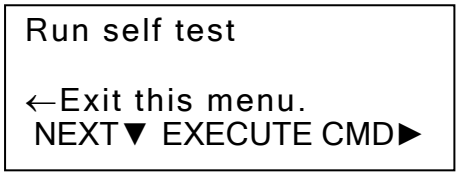

Figure 9–6.

3. The two menu items shown below allow you to review all alarms currently in effect and the history of all alarms that have occurred since the last Clear All Alarms command. Both menu items include process, warning, fault, and mode alarms.

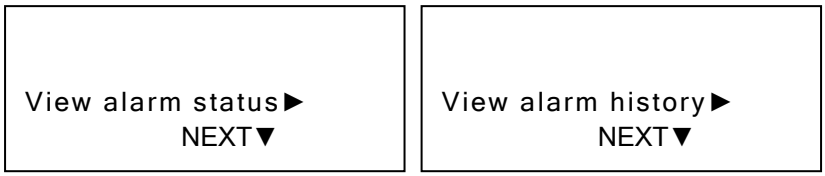

Figure 9–7.

4. Review the error logs for the RS232 and RS485 serial ports.

Figure 9–8.

5. The Relay History Logs item is only displayed if relays are installed. It contains logs of relay activity.

Figure 9–9.

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.

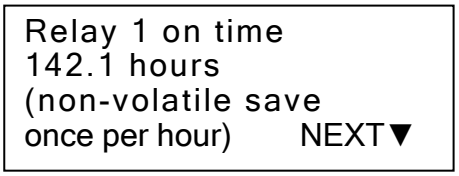

Figure 9–10.

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.

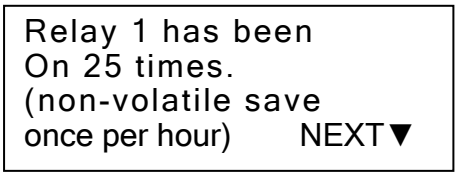

Figure 9–11.

6. 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).

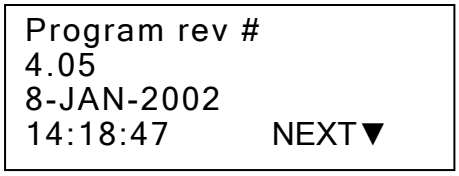

Figure 9–12.

7. The Snapshot Menu is a Service Only item (Chapter 8) that displays instantaneous values of various dynamic internal parameters. Refer to "The Snapshot Menu" later in this chapter for additional information.

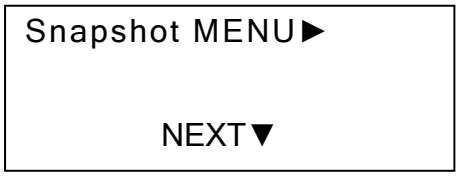

Figure 9–13.

8. The View Internal Constants screen is a Service Only item (Chapter 8) that displays values of various internal constants that are computed based on user entries.

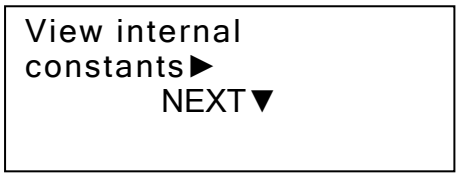

Figure 9–14.

9. The screens shown below are read-only items that indicate the standard configuration during the last standardization and CAL cycles.

Figure 9–15.

The Snapshot Menu

Access the Snapshot Menu items to view the instantaneous value of various dynamic internal parameters. This menu only appears if you have enabled Service Only menu items 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.

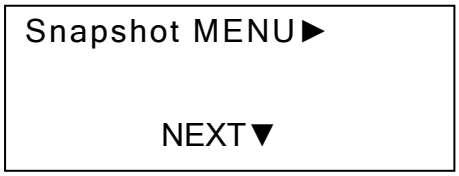

Figure 9–16.

2. The Readout from Measurement displays the snapshot of the measurement readout. The menu item is repeated for each measurement set up.

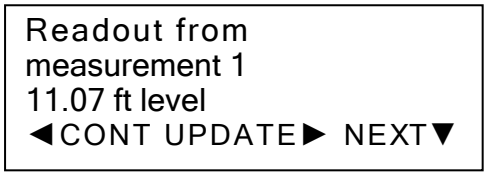

Figure 9–17.

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.

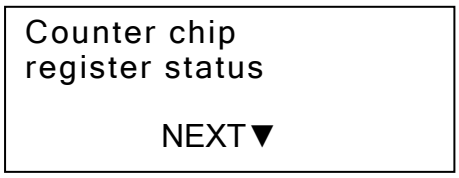

Figure 9–18.

4. The item shown below displays the current value of the auxiliary current input.

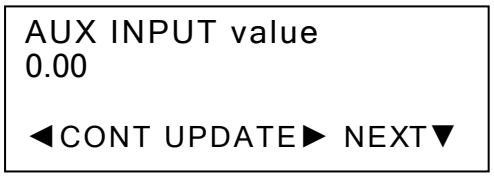

Figure 9–19.

5. The item shown below displays the current value of the auxiliary current input – internal software value.

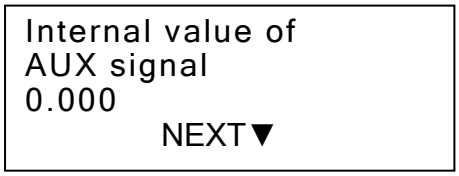

Figure 9–20.

6. The internal value of sensor signal is the filtered value of radiation level (counts per second) measured by the scintillation detector after background level has been subtracted.

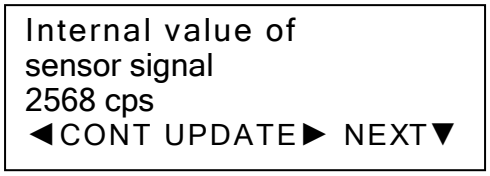

Figure 9–21.

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

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

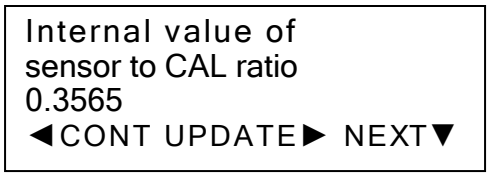

Figure 9–22.

8. The Internal Value of I out % screen displays the internal value of the current output as a percentage of range.

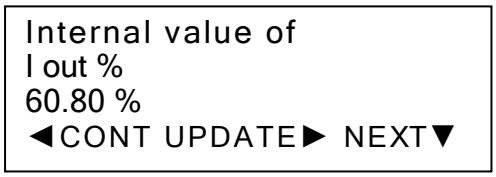

Figure 9–23.

9. The Interval Value of I Out Flt screen displays the internal value of the current output relative to the range of 0–8000 (floating point).

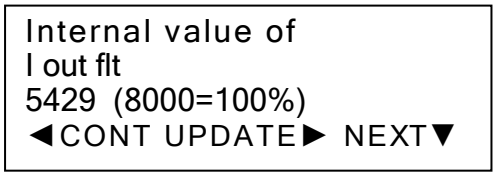

Figure 9–24.

10. The Internal Value of I Out Fix screen displays the internal value of the current output relative to the range of 0–8000 (fixed point).

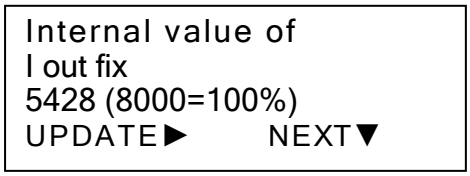

Figure 9–25.

11. HV Ctl is the current high voltage control (internal software) value.

Figure 9–26.

12. HV delta is the current high voltage control adjustment (internal software) value.

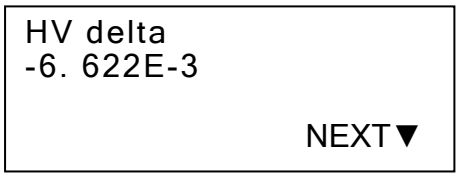

Figure 9–27.

13. HV ctl chg is the current high voltage control adjustment (internal software) weighting factor. Value can range from 1.0 to 255.0.

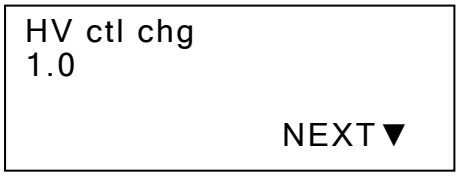

Figure 9–28.

14. The Local Data Rate screen displays the current value of the local radiation count rate in counts per second. The gauge maintains a local data rate (this detector only) and a global data rate (sum of rates from cascaded detectors).

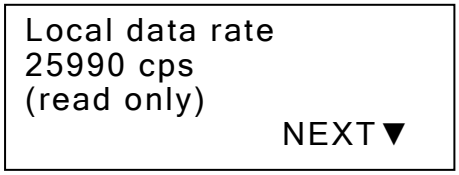

Figure 9–29.

15. The Local Rate Ratio screen displays the ratio of local count rate to the local standardization value (based on local data rate).

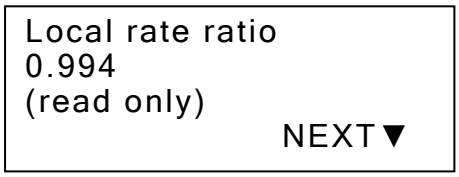

Figure 9–30.

16. The Upper Threshold screen displays the reference discriminator setting (internal software value). This value is used in the high voltage control and is for service diagnostics use only.

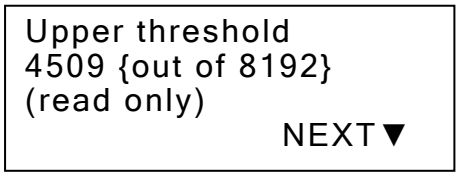

Figure 9–31.

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 outputs at maximum/minimum
- Hold current outputs at fault low/fault high
- Current output hold mode value
- Level hold mode value
- Volume hold mode value

Two additional menu items appear in the User Service menu group. They are Review Measurement Assignments (view current measurements) and Enable/Disable Service Only Items.

Factory Service & Related Items

The Factory Service & Related Items menu is accessible when Service Only items have been enabled through the Special Functions menu (Chapter 8).

1. The Program Rev item displays the program revision number and the date/time of the software build.

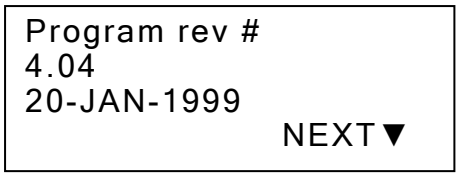

Figure 9–32.

2. The FPLA version number is shown in the item below. It is for service diagnostic purposes only.

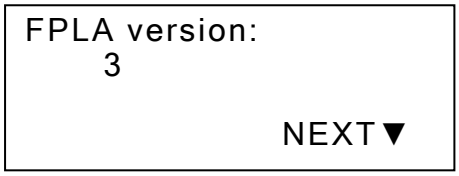

Figure 9–33.

3. The Stack Statistics item displays statistics regarding memory usage and is for service diagnostic purposes only.

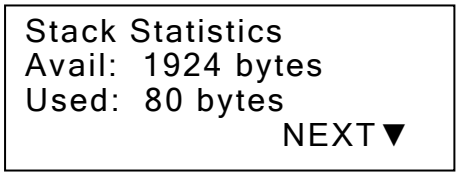

Figure 9–34.

4. The WDOG Restarts screen displays counters that indicate the number of software watchdog restarts and the number of system restarts initiated by the user (via command DAC 81). This item is for service diagnostic purposes only.

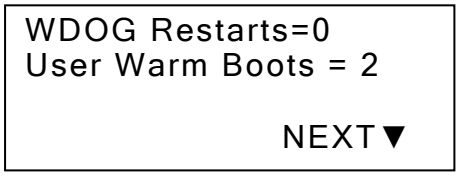

Figure 9–35.

5. Press the right arrow to view menu items indicating the length of the detector and the number of relays installed (determined by jumper settings on the CPU board).

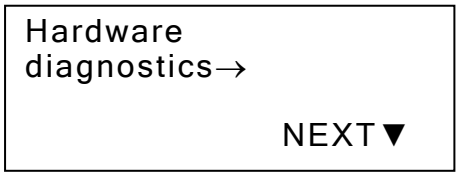

Figure 9–36.

6. Enter the menu subgroup shown below to view error status.

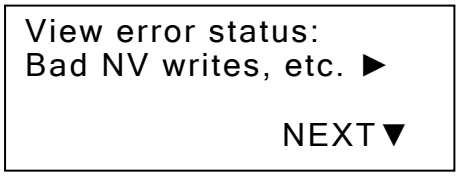

Figure 9–37.

7. The Test Relay submenu header is not displayed if relays are not installed. Reference "Testing Relays" later in this chapter.

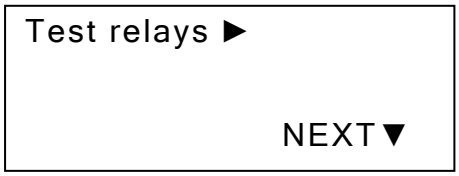

Figure 9–38.

8. The RS232 test mode is for service diagnostic purposes only. A similar menu item is shown for the RS485 test mode.

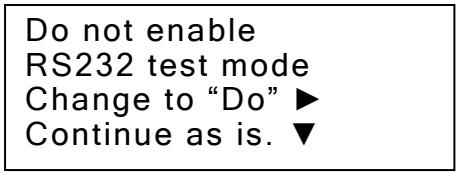

Figure 9–39.

9. Disable this menu item to allow the signal ratio (current measured radiation to standardization value) to exceed the normal maximum of 1.0. This allows negative values for the level measurement.

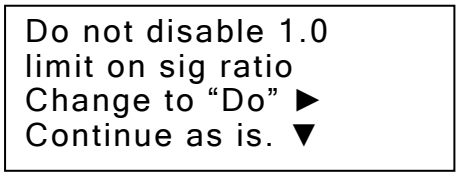

Figure 9–40.

10. Testing for invalid entries should not be enabled, except for diagnostic purposes.

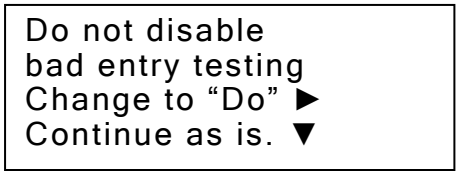

Figure 9–41.

11. Enter this menu group to view signal diagnostics. See “Signal Diagnostics” later in this chapter for more information.

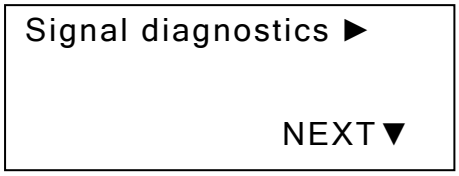

Figure 9–42.

12. Enter this menu group to scroll through a list of the command codes, special measurements, and alarms.

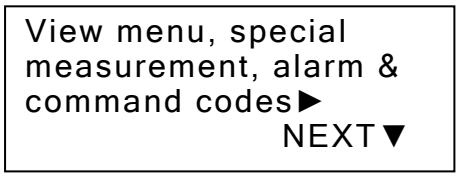

Figure 9–43.

Testing Relays

The Test Relays menu group is displayed if relays are installed.

1. Enter the relay number to test.

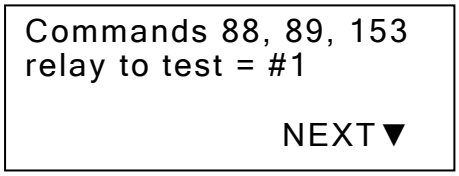

Figure 9–44.

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

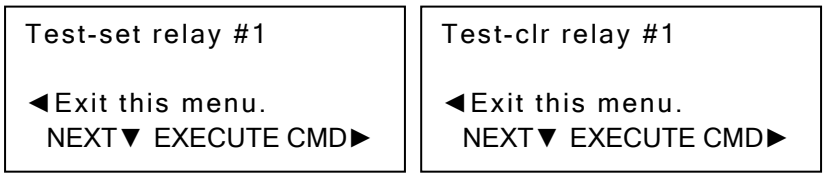

Figure 9–45.

3. Press the right arrow to test all the relays in both on and off states.

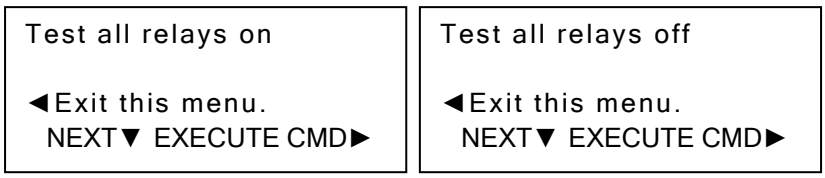

Figure 9–46.

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

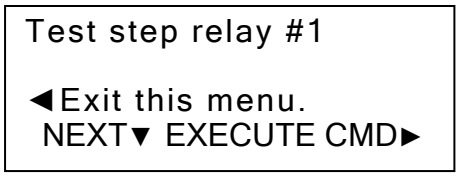

Figure 9–47.

Signal Diagnostics

The Signal Diagnostics menu group is displayed if you have enabled Service Only items (Chapter 8).

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.

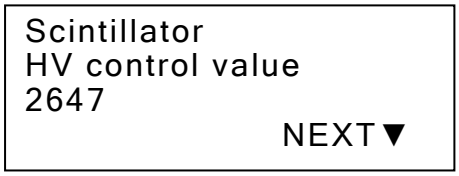

Figure 9–48.

2. The item below displays the maximum value (internal software value) for the high voltage control value. The default is 8185.

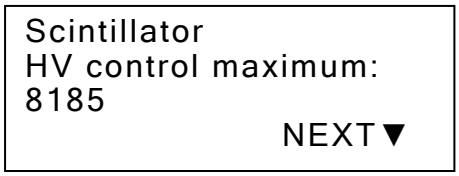

Figure 9–49.

3. Execute this command to hold the high voltage at the current saved value.

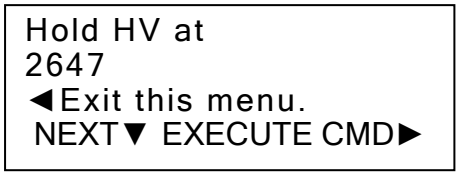

Figure 9–50.

4. Execute this command to hold the high voltage at the current value.

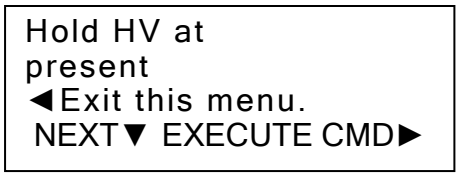

Figure 9–51.

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.

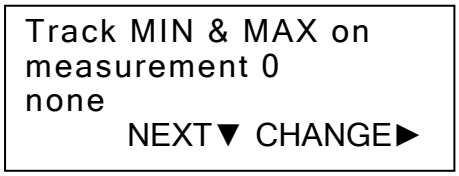

Figure 9–52.

Chapter 10
Maintenance

Overview

In general, maintenance of the LevelPRO consists of the tasks listed in the table below. These tasks are described in more detail in the sections that follow.

Table 10–1. Maintenance schedule

Task	Interval
Complete a shutter check.	Every 6 months.
Complete a tag check.	Every 6 months.
Complete a source housing check.	Every 6 months.
Check gauge calibration.	Every 12 months.
Complete a leak test.	Every 36 months for U.S. or every 12 months for Canadian installations.

Shutter Check

The shutter check consists of two steps.

1. Slide the shutter to each position to make sure it functions properly.

2. Visually inspect the shutter, ensuring it has not been damaged and that all of the lead plates are in place.

Tag & Label Check

Complete a tag and label check every six months. All labels and tags attached to the source must be visible per radiation safety standards. All labels and tags 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.

The Source Housing

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).

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. ▲

Gauge Calibration Check

It is recommended that on a regular basis, not to exceed 12 months, process samples be taken and compared to the gauge readings to verify gauge calibration.

Leak Tests

Leak testing is a regulatory requirement. It must be completed every 36 months in the United States or every 12 months in Canada.

Thermo Fisher is licensed to perform these tests and can do so through contract services. If you are currently using the leak testing service provided by Thermo Fisher or purchased the gauge after July 1, 2006, you will be mailed a notification letter 60 days prior to the due date of your leak test. Two weeks later you will receive your leak test kit in the mail. If you wish to participate in this service, follow the instructions in the kit, and return it to Thermo Fisher.

If you purchased a gauge prior to the above date, you can request to be added to Thermo Fisher's leak test service.

Chapter 11
Troubleshooting & Service

Warning Remove all power from the unit prior to opening the enclosure. Electrocution can result if power is present. ▲

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

The Scintillation Detector

Note Enable the Service Only Items in the Special Functions menu (Chapter 8) before proceeding with this section. ▲

If you suspect a problem with the scintillation detector, you can quickly check the detector output by accessing the Internal Value of Sensor Signal item in the Snapshot item of the Diagnostics menu (Chapter 9). The direct access code (DAC) for this item is **112003**. If the tank is at least partially empty, this value (the count rate in counts/s) should be much larger with the source shutter on than with the shutter off (typically more than ten times larger).

As a further check, empty the tank and compare the Internal Value of Sensor Signal item to the STD Value in Use item, which is displayed in the Sensor Standardization menu (Chapter 5). The DAC for this item is **121003**. If the gauge was working properly when it was last standardized, the two values should be similar. The match will not be exact because the STD value is filtered and corrected for background radiation and source decay.

If the displayed signal value is not behaving correctly, check the gauge head for misalignment, buildup, or wear, and check for debris in the beam path and faulty shutter operation before testing the detector signals.

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. ▲

If you can eliminate these other factors, it is likely that the cause is on the CPU board. Verify that the cable connections between the detector board and CPU board are securely seated. If the problem persists, contact Thermo Fisher Scientific Technical Support.

The Current Board

If you suspect a problem with the current output, 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, try hard booting the system.

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 setting for normal operation is shown below.

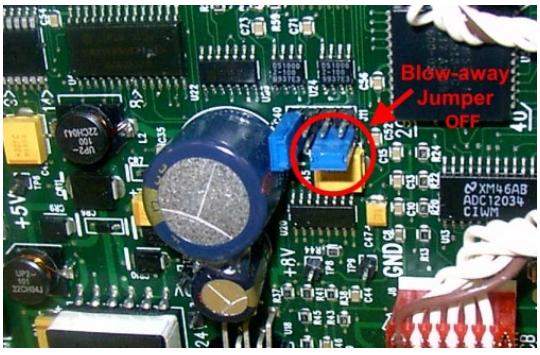

Figure 11–1. Blow-away jumper in normal operation position

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

Figure 11–2.

3. Apply power to the gauge for approximately 30 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.

Level Indication

If the gauge indicates 100% and will not change, review this section carefully and then follow the steps provided.

Equipment Required

For this troubleshooting procedure, you will need:

- One Thermo Scientific Model 9734 HHT or a PC with RS232/RS485 converter and Thermo Scientific TMTComm 1.2 installed
- One multimeter

Site Preparation

You will need to access the gauge while it is in the housing and in the radiation field coming from the radioactive source on the opposite side of the vessel. The source shutter will need to be ON and the level in the vessel should be as low as possible, without adversely affecting the process. If you cannot lower the level of the process material in the tank to a point well below the top of the detector sensitive length you may not be able to perform all the required tests. If you are in a classified area, a HOT WORK permit may be necessary.

Procedure

Warning If the gauge is powered by 120 Vac, this voltage will be present while accessing the gauge. Proceed with caution. Do not come in contact with this voltage. ▲

1. Verify that the radioactive source shutter is in the ON position.

2. Verify that the vessel is not actually full of material. If a radiation survey meter is available, use it to find the actual level. Do this by placing the survey meter detector between the vessel and detector. Starting at the top of the gauge measurement area, move the probe slowly down the length of the detector, until you see the transition from the empty radiation levels to the lower radiation levels where the beam is being blocked by the remaining material in the vessel. If you have access to the original survey document completed when the gauge was installed, you will also be able to verify whether there is any significant reduction in radiation field readings that cannot be accounted for by normal source decay. This may indicate a problem with a buildup of process material on the vessel walls.

   If a radiation survey meter is not available or it is not feasible to visually confirm the material level in the vessel, the indication of the vessel level must be accepted.

3. Connect to the LevelPRO detector. If you have to remove the detector housing lid to connect the communication device to the gauge, verify that the red power LED on the CPU board is lit (see Figure 11–3). The LED indicates that the CPU is getting the 5 Vdc required for operation. If the system is AC powered and the LED is not lit, check the fuse on the power supply board (Figure 11–4), which is a 0.125 amp slo-blow. If the system is DC powered and the LED is not lit, check the F1 fuse located on the CPU board (Figure 11–5).

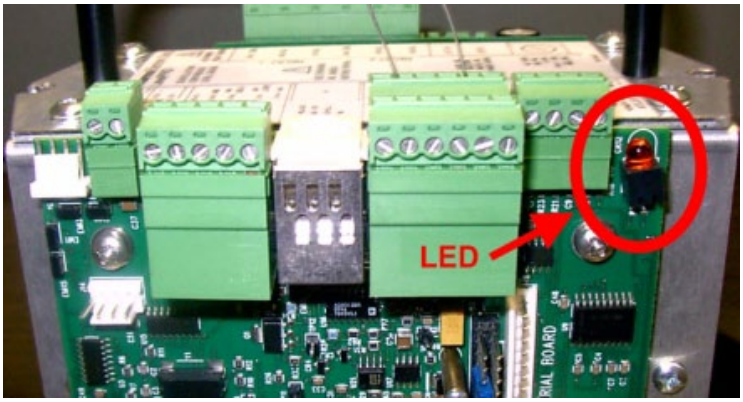

Figure 11–3. Power LED on the CPU board

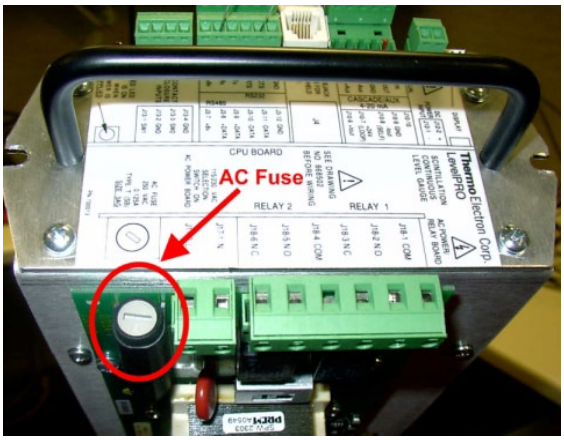

Figure 11–4. 0.125 amp slo-blow fuse on AC powered systems

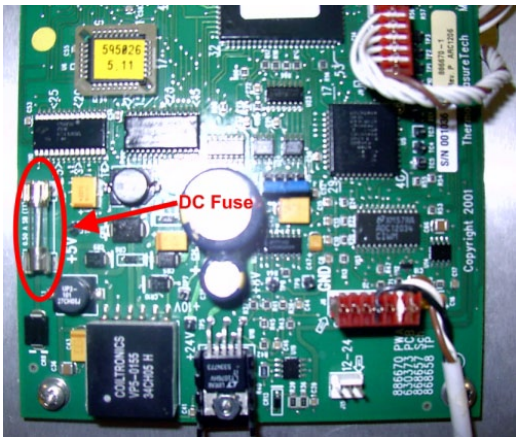

Figure 11–5. F1 fuse on CPU board for DC powered systems

4. Using DAC **112003**, bring up the Internal Value of Sensor Signal item. Depending on application, source size, vessel wall, etc., the count rate should be in the thousands. The value shown in Figure 11–6 is for example only.

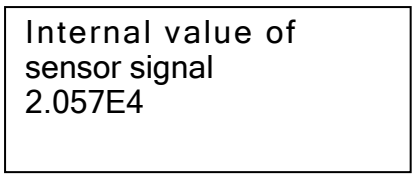

Figure 11–6. Example internal value of sensor signal

While the detector value is still displayed, close the shutter on the radioactive source. The displayed count rate should go down towards zero. Open the source shutter and the count rate should go back up to where you started. If this occurs, the detector is working properly. The problem may be programming related.

If the sensor signal does not change or is zero when you cycle the source shutter, the detector signal is getting lost or corrupted somewhere between the scintillation crystal and the CPU. The problem may be related to the PMT, the triangle board (p/n 886592), the cabling (p/n 810124), or the CPU (p/n 886670-1).

5. The next step is to turn on the diagnostic measurements feature. Use DAC **045020**. Press the right arrow once to change the selection from "Do not" to "Do" enable diagnostic measurements. Then exit.

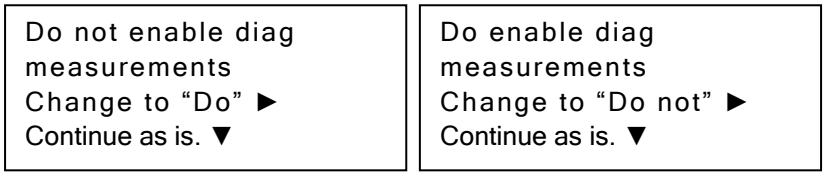

Figure 11–7. Enable diagnostic measurements

If the measurements do not show up on the screen, enter command **72**, and they will appear. With the diagnostic measurements turned on, the display will toggle between two screens (Figure 11–8).

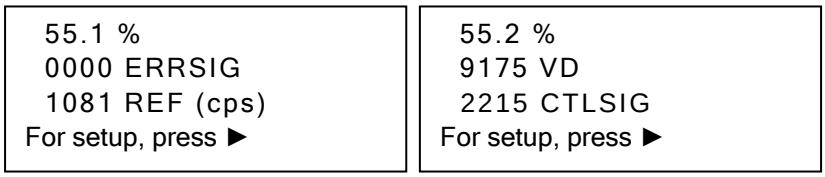

Figure 11–8. Diagnostic displays

Four new values will be displayed along with the level reading. These values are explained below.

ERRSIG: This value may also be shown as “HVCorr”, depending on the version of software in the instrument. ERRSIG is a relative value representing the length of the control pulses for the high voltage control. This number should be at or near 0. If it is staying under 10, the detector is under normal control and working correctly. If this number is running from 10 to 50, the detector may be damaged (often from being exposed to temperatures over 140°F for some 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. It is likely that the detector has failed.

CTLSIG: This value may also be shown as “HVCtrl”, depending on the version of software in the instrument. This 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 be a different value; however, it should be a steady value. If the value is ramping up or down, then the detector is faulty and not under control.

VD: This value is the “DATA” count rate in counts per second (cps). It should be the same value as the internal value of the sensor signal (DAC 112003) recalled in step 4 of this procedure. If this value is above 9999, the display will show “>9999”. To display this value, you will need to enable the R&D test items by entering DAC **025030**. The value will display in scientific notation. **Be aware that other values will also change to scientific notation and lose their names.** Therefore, it may not be desirable to leave this feature enabled very long. This value should rise with lower process level and lower with raised process level.

REF(cps): This value is the REF count rate in cps. It should be 1/8 of the VD count rate. The CPU will adjust the CTLSIG until the VD gets to 8 times the REF count rate. If it is unable to reach this 8:1 ratio, the CTLSIG will ramp up to 8000, go back to 10, and ramp up again. If the REF(cps) is a low number like 5, the reference counts are getting lost somewhere between the PMT and the CPU.

Recorded Values

The values of the following parameters are useful to Thermo Fisher Scientific Technical Support when troubleshooting the LevelPRO system.

To recall these values, press **EXIT**, enter the DAC, and press the down arrow. Record the value shown. Press **EXIT** again to return to the main screen. The first four values (ERRSIG through REF(cps)) were accessed in step 5 of the above procedure.

Table 11–1. Recorded values for troubleshooting

Parameter Name/ DAC	Description	Value
ERRSIG	Error from stable control	
CTLSIG	Control signal from CPU	
VD	Data count rate	
REF(cps)	Reference count rate	
128003	Standardization (zero) value	
112003	Snapshot of detector signal	
031001	Software version	
007004	Time constant in seconds	
054003	Weeks since standardization	
023003	Source half-life	

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.

1410 Gillingham Lane Sugar Land, TX 77478 USA Tel: +1 713-272-0404 Fax: +1 713-272-2272	14 Gormley Industrial Avenue Gormley, Ontario L0H 1G0 CANADA Tel: +1 905-888-8808 Fax: +1 905-888-8828
Ion Path, Road Three Winsford, Cheshire, CW7 3GA UNITED KINGDOM Tel: +44 (0) 1606 548700 Fax: +44 (0) 1606 548711	Unit 702-715, 7/F Tower West Yonghe Plaza No. 28 Andingmen East Street Beijing 100007 CHINA Tel: +86 (10) 8419-3588 Fax: +86 (10) 8419-3580
A-101, 1CC Trade Tower Senapati Bapat Road Pune 411 016 Maharashtra, INDIA Tel: +91 (20) 6626 7000 Fax: +91 (20) 6626 7001	On the Web www.thermoscientific.com

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In the event Thermo Fisher requests return of its products, Buyer shall ship with transportation charges paid by the Buyer to Thermo Fisher plant. Shipment of repaired or replacement goods from Thermo Fisher plant shall be F.O.B. Thermo Fisher plant. A quotation of proposed work will be sent to the customer. Thermo Fisher shall be liable only to replace or repair, at its option, free of charge, products which are found by Thermo Fisher to be defective in material or workmanship, and which are reported to Thermo Fisher within the warranty period as provided above. This right to replacement shall be Buyer's exclusive remedy against Thermo Fisher.

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Appendix A
Ordering Information

A complete LevelPRO system consists of one to four integrated detector-transmitters, any number of sources as applicable to the application, and a type of communication.

Table A–1. System ordering information

Code	**Model**
LPRO	LevelPRO integrated continuous nuclear/gamma level system
Code	**Detector/Transmitter Enclosure Type**
S	Carbon steel detector housing
W	Water-cooled jacketed steel detector housing
Code	**First Detector/Transmitter Length***
01	1 ft detector
02	2 ft detector
03	3 ft detector
04	4 ft detector
06	6 ft detector
08	8 ft detector
10	10 ft detector
12	12 ft detector
Code	**Second Detector/Transmitter Length (optional)***
XX	XX ft detector (same lengths available as first detector/transmitter)
Code	**Third Detector/Transmitter Length (optional)***
XX	XX ft detector (same lengths available as first detector/transmitter)
Code	**Fourth Detector/Transmitter Length (optional)***
XX	XX ft detector (same lengths available as first detector/transmitter)
Code	**Input Power**
A	115 Vac
B	24 Vdc
C	230 Vac

Code	Relay Output
N	No relay
R	Two SPDT relays
Code	**4–20 mA Output Type**
L	Isolated, loop-powered
S	Isolated, self-powered
N	Non-isolated, self-powered
Code	**Communications**
0	No selection
A	9734 HHT RS485 cable
B	9734 HHT RS485 & RS232 cable
C	RS232/RS485 converter
E	HART communication module
L	FOUNDATION fieldbus module
Code	**Accessories (optional)**
S	Sm SS tag (0.75 X 2.5 in), wired
L	Lg SS tag (3.3 X 2.5 in), wired
R	RJ11 modular connector jack
D	Model 9723 backlit LCD
A	3/4-in NPT to metric adapter

*Detector-transmitter lengths available in odd increments (3 ft, 5, ft, etc.) as a special order. Contact Thermo Fisher for details.

Table A–2. Spare parts

Part Number	Description
3-0702-007	Upgrade kit, FOUNDATION fieldbus, LevelPRO
88670-1	CPU
886592	Detector board. Note: If replacing an old style PCB (green "triangle" board), order kit 886776.
886595-1	ISO-24 piggyback board. Supports isolated, self-powered current output.
886568-1	AC power board, no relays.
886568-2	AC power board, 2 relays.
868568-3	Board with 2 relays, no AC power.
	AC power board fuse, F1 (LittelFuse 313.125), 250V, 0.125A (1/8A), Type T (SB), Size 3AG.

Appendix B
Specifications

Results may vary under different operating conditions.

Table B–1. Performance specifications

System performance	0.5% of span, typical

Table B–2. Gamma ray source

Source type	Cs-137 or Co-60, both stainless steel doubly encapsulated
Size	10–10,000 mCi Cs-137 or 1,000–2,000 mCi Co-60 (source size dependent upon application)
Source housing	Carbon steel, lead filled, polyurethane painted (stainless steel also available) Two-position shutter, locks in OFF (closed) position 30°, 45°, and 60° beam angle source housings available (beam angle is dependent upon application)

Table B–3. Integrated transmitter-detector

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 is 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 lengths	Standard detector lengths in 2-ft increments, up to 12 ft* Multiple detectors can be wired together for large measurement spans
Power	115/230 Vac ±10%; 50–60 Hz or 24 Vdc available Surge protected 9–35 Vdc
Operating temperature	-40°C to +60°C (-40°F to +140°F), ambient
Enclosure construction	Carbon steel polyurethane painted Optional water-cooled detector for higher temperature applications

Approvals	CSA/C-US approved Class I, Div. 1, Groups B, C, & D; Class II, Div. 1, Groups E, F, & G; Class III, Div. 1; indoor and outdoor CSA ENCL 4 Intertek ATEX approved II 2 G Ex d IIC T6 IP66 CE Mark

*Detector-transmitter lengths available in odd increments (3 ft, 5, ft, etc.) as a special order. Contact Thermo Fisher for details.

Table B–4. Outputs/Inputs

Current outputs	Standard: 4–20 mA isolated, loop-powered into 800 ohms, field scalable Optional: 4–20 mA isolated, self-powered into 800 ohms, field scalable Optional: 4–20 mA non-isolated, self-powered into 800 ohms, field scalable
Serial outputs	RS485 half-duplex, RS232 full duplex Fieldbus: A Device Description (DD) for the LevelPRO 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 outputs	2X 115 Vac/28 Vdc SPDT at 10 A (230 Vac SPDT at8 A)
Inputs	Signal from another LevelPRO detector; additional input for gas density compensation or buildup available Dry contact closure

Table B–5. Mounting Hardware

Integrated transmitter/detector	Integral bolt-on bracket
Gamma ray source	Integral bolt-on bracket

Table B–6. Model 9723 local remote 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

Fieldbus host, such as National Instruments NI-FBUS Configurator	Provides the interface between the LevelPRO and other devices on a FOUNDATION fieldbus network.
Emerson 375/475 Field Communicator	For gauge configuration and calibration. Communicates with any LevelPRO via the current loop. BEL202FSK standard.
Thermo Scientific Model 9734 HHT	For gauge configuration and calibration. Communicates with any LevelPRO 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 LevelPRO units over RS485. RS485 / RS232 converter provided.

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Appendix C
Special Measurement Codes

If the Service Only items are enabled, special measurements are available in the Set up Additional Measurements menu. This feature is normally used to monitor certain integral gauge values for specific diagnostic purposes. Some of the more useful special measurement values can also be viewed in the Snapshot item of the Diagnostics menu (Chapter 9).

If you select a special measurement type, you will be prompted to enter a code for the special measurement. The table below lists some of these codes and a description of the measurement value.

Table C–1. Special measurement codes

Code	Description
1540	V0 – Unfiltered level signal (÷ 10)
1541	V flo – Unfiltered auxiliary input value
1031	REF (cps) – Reference count rate
1032	HVCorr – Scintillator HV control change value
1033	VD – Filtered global count rate (meas. counts – bkgd. counts)
1048	HVCTL – Scintillator HV control value
1049	HVGAIN – Scintillator HV control gain value
1051	Temperature (deg C) – rough measurement
1585	REF_DISC – Reference discriminator setting (0–8192)
1075	KNORM – Inverse of STD value
1078	Cumulative ON time (hours) for relay #1
1079	Cumulative ON time (hours) for relay #2
1598	Actuation count (÷ 10) for relay #1
1599	Actuation count (÷ 10) for relay #2
1107	Current output % of scale
1109	Min. capture value
1110	Max. capture value
1111	Local data count rate (cps) – meas. 1113/meas. 1112
1112	Local update time (s) – typically 2–8 seconds

Code	Description
1113	Local data counts accumulated during local update time
1117	Local count rate (cps)
1118	Ratio of data counts to reference counts
147	Special equation form 1 (see note)
148	Special equation form 2 (see note)
149	Special equation form 3 (see note)

Note To use special equations for vapor density compensated level, refer to Appendix F. ▲

Appendix D
Calibration when Vessel Cannot Be Emptied

Follow this procedure when the vessel cannot be emptied for calibration.

1. Go through the Level Setup menu and set your level span, any custom units you require, and the position of the decimal place (reference "Level Measurement Setup" in Chapter 3).

2. When you reach the Standardize On menu, select **Tank Empty**. Make this selection no matter what the real level is in the vessel. Press the down arrow.

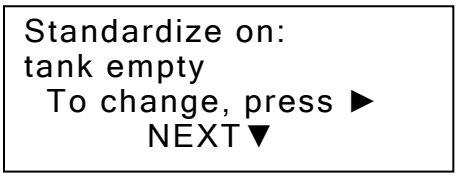

Figure D–1.

3. Execute the standardization cycle by pressing the right arrow.

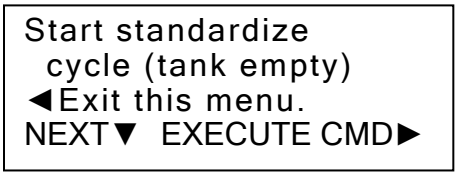

Figure D–2.

A timer value should appear on the display and be counting down to zero. The default for this time is 1024 seconds.

4. When the standardization cycle finishes, the display should read "000.0 % level".

5. Press Exit, and the display will prompt you for the entry ID or command code.

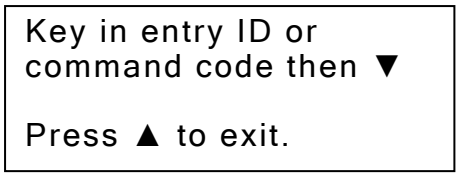

Figure D–3.

Access the value of the detector signal at zero level by entering "128003**"** and pressing the down arrow.

Then change this value by entering the new value and pressing the down arrow and Exit. Keep changing this value until the level indication is correct.

6. The unit is now calibrated to the point you set.

7. At some point in the future, if the vessel can be emptied, you should perform the standardization cycle again on the empty vessel. This will reset the standardization value from your manually entered number to the "real" empty vessel value. As a precaution, you should record the value in 128003 before you re-standardize. Use the procedure in step 5 to recall and record this value.

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 – LevelPRO

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 (LevelPRO)					
	Pb	Hg	Cd	Cr6+	PBB	PBDE
Housing	o	o	o	x	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
Instrument Board	x	o	o	o	o	o
Power Supply Board	x	o	o	o	o	o
Scintillator	o	o	o	o	o	o
Cabling	x	o	o	o	o	o

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

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

有毒有害物质名称及含量的标识格式

部件名称	有毒有害物质或元素 (LevelPRO)					
	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	x	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
仪器电路板	x	o	o	o	o	o
电源板	x	o	o	o	o	o
闪烁器	o	o	o	o	o	o
缆线连接	x	o	o	o	o	o

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

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

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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.

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. Thermo Fisher Scientific's 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:

$$\text{Indicated Level} = 100 - 100 \times \text{VLR} \quad (1)$$

Since VLR is affected by the gas:

$$\text{Compensated Level} = 100 - 1\text{–}x\ (\text{VLR}/\text{VDR}) \quad (2)$$

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:

$$\text{Compensated Level} = 100 - 100 / \text{VDR} + \text{Indicated Level} / \text{VDR} \quad (3)$$

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:

$X = L_{comp}$

$V_a = L_{uncomp}$

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.

$$Value = M_1 / M_2$$

$M_1 = A_1 * f(level) + B_1 * Aux + C_1 * f(level) * Aux + D_1$.

$M_2 = A_2 * f(level) + B_2 * Aux + C_2 * f(level) * Aux + D_2$.

$A_1, B_1, C_1, D_1, A_2, B_2, C_2, D_2$ = 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 density 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 density 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 to DensityPRO wiring

LevelPRO	DensityPRO
J10 pin 1	J10B pin 6
J10 pin 2	J10B pin 8

Table F–5. LevelPRO to DensityPRO C wiring

LevelPRO	DensityPRO C
J10 pin 1	J2 pin 1
J10 pin 2	J2 pin 2

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Appendix G
X-ray Safeguard Software Setup

Note For LevelPRO software versions 5.08 and higher. ▲

Overview

When radiography or other gamma / x-ray sources are used in the vicinity of the LevelPRO 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 Model 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 5). 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 then assumes 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 G–1.

When the feature is triggered, the display on the Model 9734 HHT or the Model 9723 remote display will be as shown below.

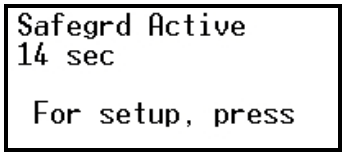

Figure G–2.

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Appendix H
Related Technical Bulletins

This appendix lists the technical bulletins related to this product that are available as of the latest release date of this document. For the most current bulletins, please go to thermoscientific.com. Enter the product name (LevelPRO) as the search term and click the Resources tab.

Table H–1. Technical bulletins

TB #	Title
TB-0416-008	Installing the FOUNDATION™ Fieldbus Option on the Thermo Scientific LevelPRO Gauge
TB-0416-012	Replacing the CPU PROM and HART® PROM on the Thermo Scientific LevelPRO Gauge
TB-0416-019	Programming Considerations when Cascading Thermo Scientific LevelPRO Gauges

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