VersaMassTer®

VM7GNX SERIES – GAS MASS FLOW METER

OPERATION AND MAINTENANCE MANUAL

DOCUMENT 7000G-OM-00

REVISION 00

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MODEL NO._____

SERIAL NO._____

DATE OF SHIPMENT:_____ INSTALLATION DATE:_____

CUSTOMER TAG NO.:_____ PO NO.:_____

OPTIONS:_____

_____

SPECIAL NOTES:_____

INTRODUCTION

THERMAL-BASED GAS MASS FLOW MEASUREMENT

The Delta M Corporation VM7GNX VersaMassTer® (VM7000 series) is a new generation mass flow meter intended primarily for high performance, low cost flow measurement of gas. It uses a patented thermal concept developed by engineers at Delta M Corporation to obtain accurate and stable measurement of mass flow. This concept includes a series of improvements, most of which are covered by Delta M Corporation patents, over conventional mass flow measurement techniques.

Key improvements include:

- A **Ratio-Thermic®** sensor excitation method (instead of constant delta-T) that virtually eliminates sensor temperature dependence,
- A dual, 4-wire sensor connection scheme that eliminates unwanted sensor lead resistance which degrades temperature performance,
- A thermal model that accounts for gas property dependence and includes critical sensor parameters.

The highly sophisticated microprocessor based electronics of the VersaMassTer converts measured sensor signals into mass flow and gas temperature by real time calculation of the governing mass flow equation derived from calibration data and a thermal model. Normalized volume flow outputs to selectable reference conditions are also available.

Selection of gaseous media, line sizes, measurement units, switch settings, 4-20mA loop calibration settings and other parameters is easily accomplished using the keypad and LCD display, or the *comprehensive* Modbus® register map and easy-to-use Windows®-based Modbus Poll application.

PRINCIPLE OF OPERATION

The unique Delta M mass flow sensor consists of two thermal resistive sensors. One sensor is self-heated to supply energy to the gas; the other provides a temperature reference. To improve both accuracy and temperature compensation the sensors are configured to provide a constant ratio between their resistances instead of the classic constant temperature difference between them. This patented **Ratio-Thermic®** excitation method, combined with dual four-wire sensor connections, essentially eliminates sensor-based temperature drift while providing precise control of the energy delivered to the heated sensor.

The heated sensor design is optimized so that high sensitivity is achieved even at very high flow rates. Non-convective probe power losses are accounted for and included in the thermal model so that high stability is maintained on the low end of the flow range.

Heated and reference sensor signals are converted to mass flow and temperature, using an equation derived from the thermal model. Gas physical properties are included in the calculations so that property-based temperature drift is minimized. This also allows the user to select other gases without the need to recalibrate simply by inserting a selected polynomial K factor from a number of selected gases.

VM7000 FEATURES

Direct Ratio-Thermic® Measurement of Mass Flow

The patented Delta M method of constant ratio of heated to reference sensor eliminates sensor temperature dependence and provides a stable high heat flux signal to the gas that enables accurate mass flow measurement over a wide flow range. Temperature, volumetric flow and total flow are also available.

Multiple Programmable Calibration for Gases

Mass flow is computed by the microprocessor from an equation developed from a detailed thermal model of the probe-gas interaction. Selected common gases can be used in the computation so transfer from one gas to another is possible, without recalibration, by selecting the Delta M K-factors for that gas. Volumetric outputs are normalized to user-selectable Reference Conditions including Normal, Metric, US/NIST, US/STP, and IUPAC options.

Dual 4-20 mA Isolated Outputs

Two 4-20 mA optically isolated outputs are standard. Mass flow, volumetric flow, temperature and hot current (for heated sensor) can be selected for each. The 4-20mA outputs have no limitations on scaling other than the 4 and 20mA points cannot be the same value. This allows the customer maximum flexibility in configuring the 4-20mA outputs.

Relay-based Switch Output

A single 1500VA-rated SPDT relay is provided. Mass flow, volumetric flow, temperature, hot current, or total flow can be selected as the source variable for the switch function. The switch output also includes a dead-band feature and a programmable delay to prevent relay “chatter”.

Continuous Diagnostics of Sensors and Electronics

An embedded microprocessor continuously monitors key signals of the sensors and electronics, and performs continuous diagnostics to determine their health. This ensures that the meter outputs during normal operation are stable and accurate. Current and latched status registers provide both present and historical data during operation.

Total Flow Computation

Total flow can be obtained when the Totalizer function is enabled from the output menu. Total mass flow is computed in the mass units selected from the configuration menu, or can optionally be converted to a volumetric equivalent for the selected Reference Conditions.

Low Flow Cut-Off

A low flow cut-off value can be configured for the mass and volume flow below which the output of the instrument is forced to zero.

Easy Configuration

Configuration is easily accomplished using an integral 400x240 pixel color LCD display and keypad, or remotely with the Windows-based Modbus Poll software. The LCD display, dual 4-20mA outputs, switch output, and pulse output can be set to the user's specific requirements. A selection of measurement units are included and the instrument configuration can be optionally password protected.

High Turndown Ratio

The highly stable sensor excitation method provides for the standard turndown ratio of 100:1. Optional turndown ratios up to 1000:1 are possible. Consult the factory for details.

Low Pressure Drop

The thermal technique inherently provides low pressure drop. Delta M's sensor designs have minimal impact on the gas flow stream so pressure drop is negligible.

REMOTE USER INTERFACE SOFTWARE

The Modbus Poll application, by ModbusTools, hosted on a Windows-based PC can be used to configure, obtain output, and perform diagnostics for the instrument using short-range wireless or an RS485 serial port connection. A custom Workspace definition for the VersaMassTer is provided that displays all user-accessible registers in a familiar spreadsheet format for viewing and editing.

If the computer does not support short-range wireless features, USB-to-RS485 converter kits that utilize a virtual serial port are available from the factory. The Modbus Poll software is supplied with a special Delta M license that allows unlimited use of supplied Workspace definitions for the VersaMassTer. General use of Modbus Poll with *any* Modbus device requires registration with Modbus Tools.

This Modbus Poll user interface also can be used by service personnel in the field to adjust sensor and media parameters as needed.

ENCLOSURE OPTIONS

The VM7000 flow meter electronics are mounted in a standard non-explosion proof, double-sided instrument housing with an integral sensor mount. The sensor may also be remotely mounted up to 100 feet away.

INSTALLATION

INSTALLATION PRECAUTIONS

The VM7000 standard probe insertion method is via a stainless steel compression fitting. Optional process connections include flange connections, low flow sensors, and spool pieces (consult the factory for details). The probe may be connected directly to the electronic enclosure or may be installed remotely from the electronic enclosure up to 100 feet away.

— IMPORTANT —

The following are precautions to observe for the installation:

- **Process temperature and pressure must be within the VersaMassTer probe specifications of -50 to 350 °C (-58 to 650 °F) for gases up to 3000 PSIG.**
- **At least ten (10) straight pipe diameters upstream and five (5) straight pipe diameters downstream are recommended.**
- **There should be no valves, elbows, reductions, expansions or other anomalies within the above mentioned 15 pipe diameter flow path that could adversely affect flow measurement accuracy.**
- **Ensure power to the electronics is disconnected before installing or removing probe.**

Maximum measurement accuracy is achieved when the process conditions match the calibration conditions.

MECHANICAL INSTALLATION

The standard VersaMassTer insertion probe is inserted into a pipe as part of a compression fitting. It is important to position the flow sensor at the correct angle with respect to the flow. An arrow on the NPT fitting indicates the proper flow angle.

NOTE: Ensure that the flow arrow is pointing in the direction of the flow; see Figure 2-1 below. Flow is correct when the sensing tips are aligned with the pipe length and short (cold) sensor tip is upstream.

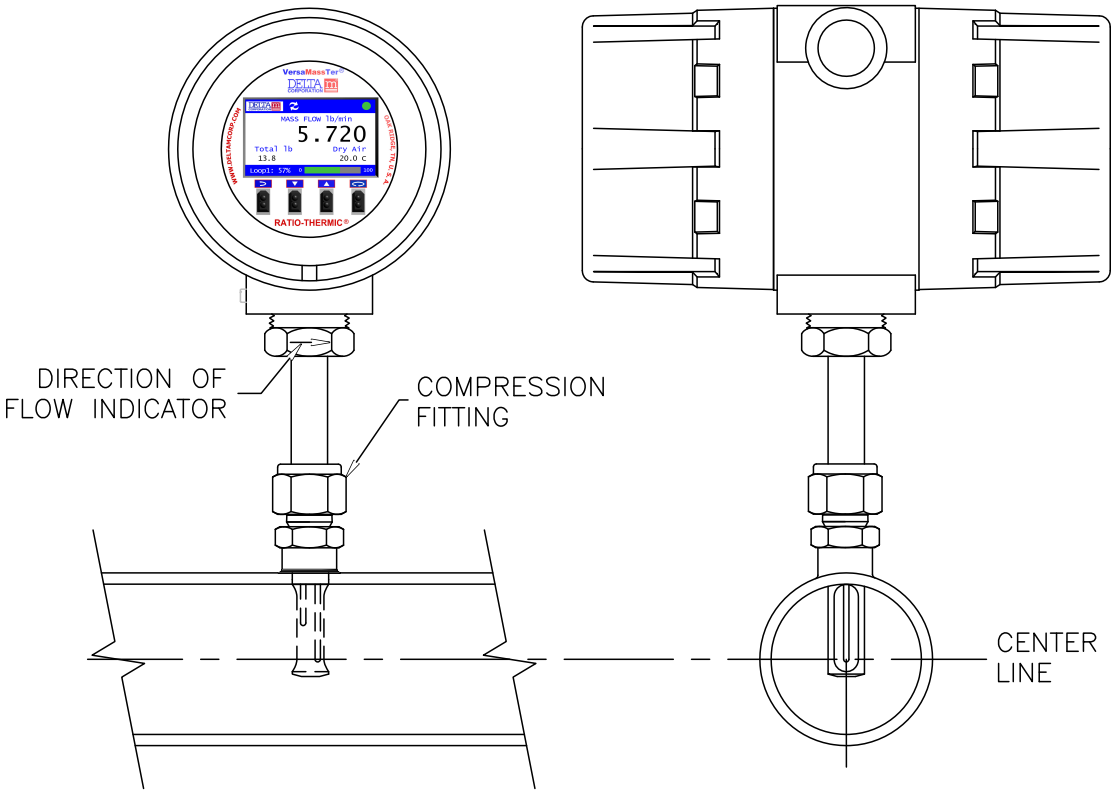


FIGURE 2-1. Probe Installation

NOTE: The probe and electronics are calibrated as a matched set. The model and serial numbers are indicated on both the electronic enclosure and the probe enclosure in the case of a remote installation. Verify that they match before proceeding.

The electronics display unit should be located in an environment where the temperature is within the range of -20 to 60°C (-4 to 140°F). **Watertight seals must be provided for wiring to the enclosure. For optimum operation power and signal leads should be in separate conduits.**

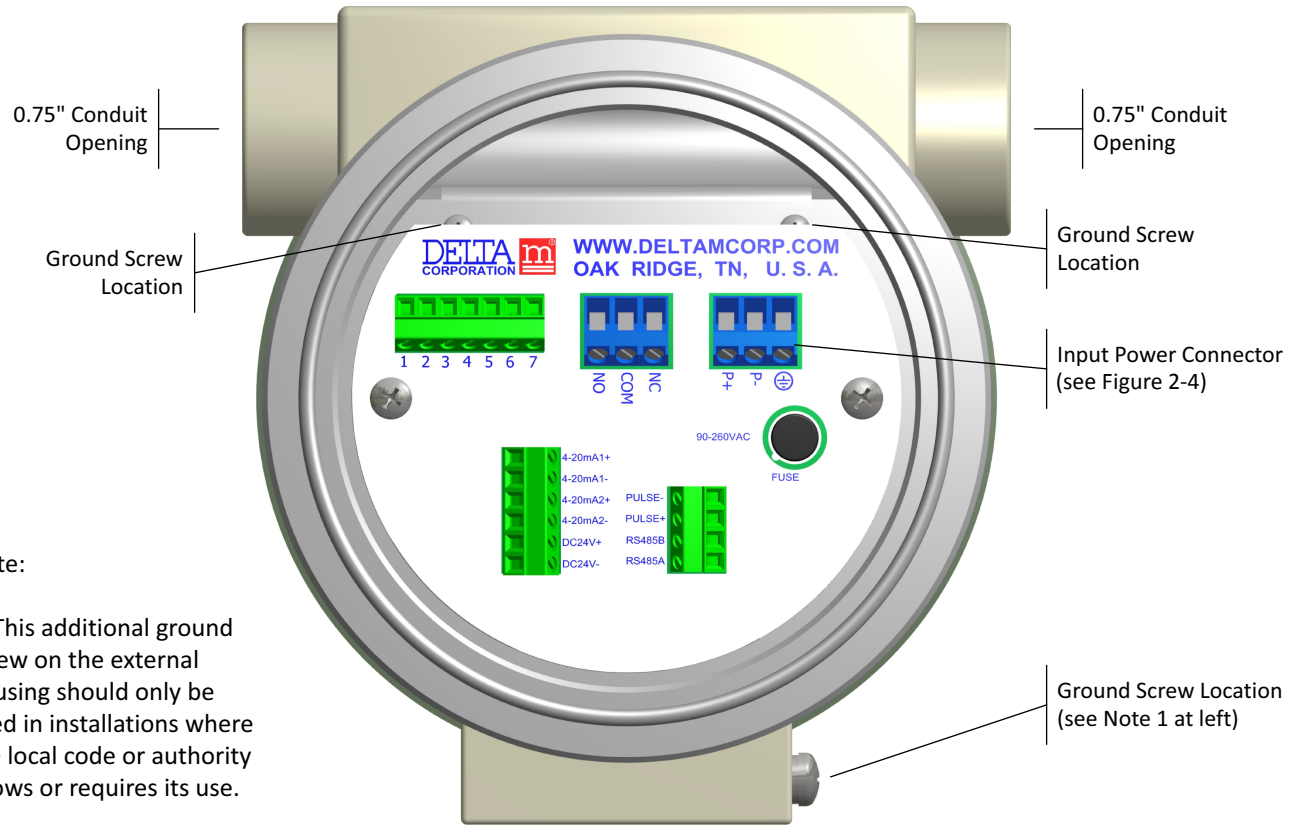
For remote installations use the optional mounting bracket provided for the enclosure to mount the electronics to a suitable surface. Elevated temperatures, excessive vibration, or better accessibility may necessitate remote mounting the electronics.

ELECTRICAL INSTALLATION

Figure 2-2 shows the *user interface side* of the double-sided head. The enclosure cover has a transparent window so that the 400x240 Color LCD is visible to observe the measurement indications. The cover does not have to be removed to access the keypad, as the keypad buttons are light sensitive, but the cover can be removed by unscrewing in a counterclockwise direction.

FIGURE 2-2. VersaMassTer® Electronics inside the Enclosure

The *field-side* of the enclosure is shown in Figure 2-3 for 90-260 VAC or 18-30 VDC power input. The cover must be removed to gain access to the power, communication, 4-20 mA transmitters, pulse, and switch outputs as well as the remote sensor input connections. It can be removed by unscrewing it in a counterclockwise direction.



Note:

1. This additional ground screw on the external housing should only be used in installations where the local code or authority allows or requires its use.

FIGURE 2-3. VersaMassTer® Field-Side Connections

FIELD POWER WIRING

CAUTION: Ensure power to electronics is disconnected before installing or removing probe.

Figure 2-4 specifies the power wiring for AC and DC field power.

The Input Power Connector terminal block on the right of the field-side as labeled in Figure 2-3 is where the power wiring is connected. A 14 gauge wire is the maximum size this connector will accommodate. Smaller gauge wire may be used depending upon the distance from the installation to the power source.

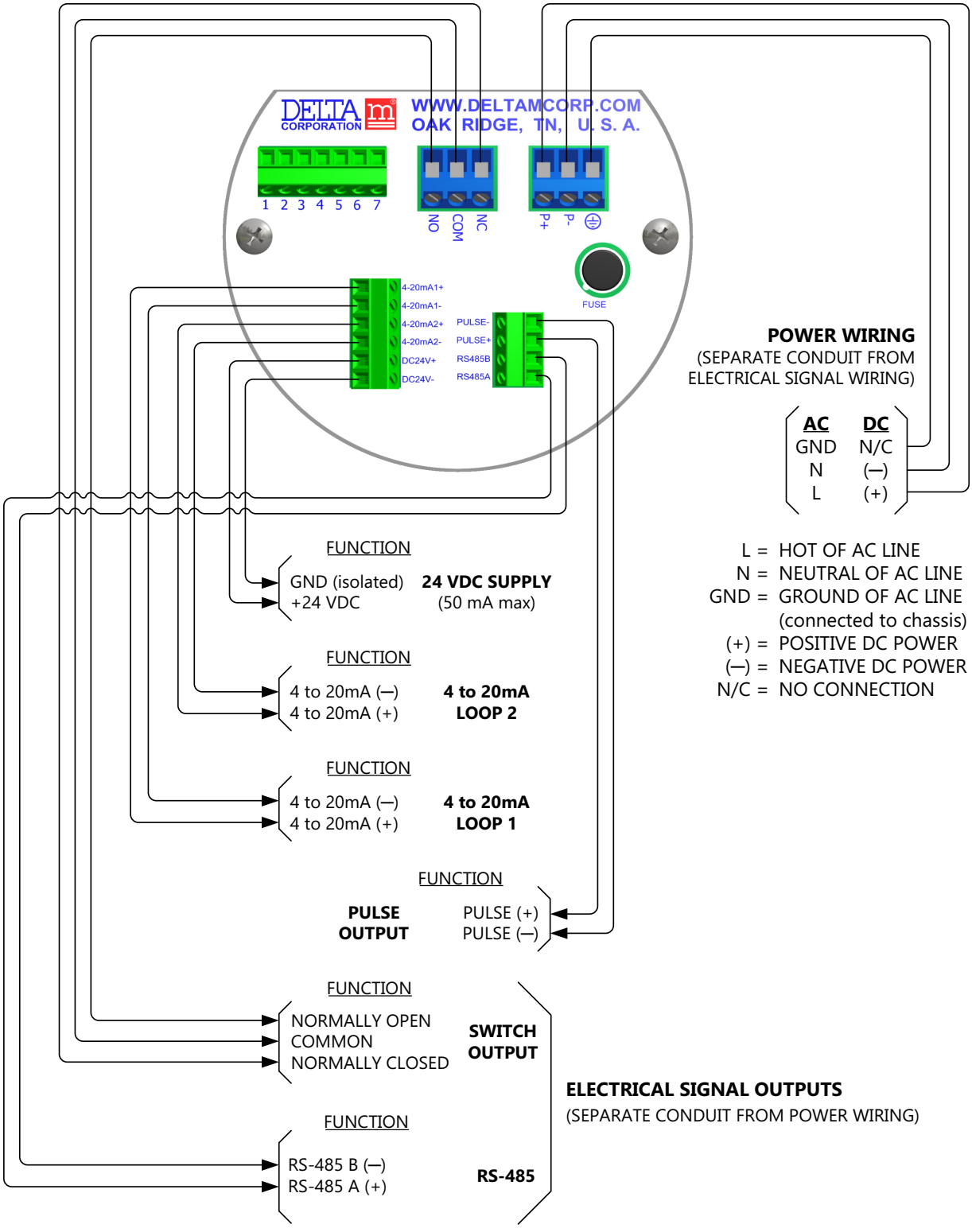


FIGURE 2-4. VersaMassTer® Power and Signal Outputs Wiring

OUTPUT SIGNAL WIRING

Dual 4-20 mA current loops, a single SPDT switching relay, and 0-1kHz pulse output are provided as well as a single RS-485 output. The electrical output signal wiring is to terminal blocks on the field-side of the instrument as shown in Figure 2-5.

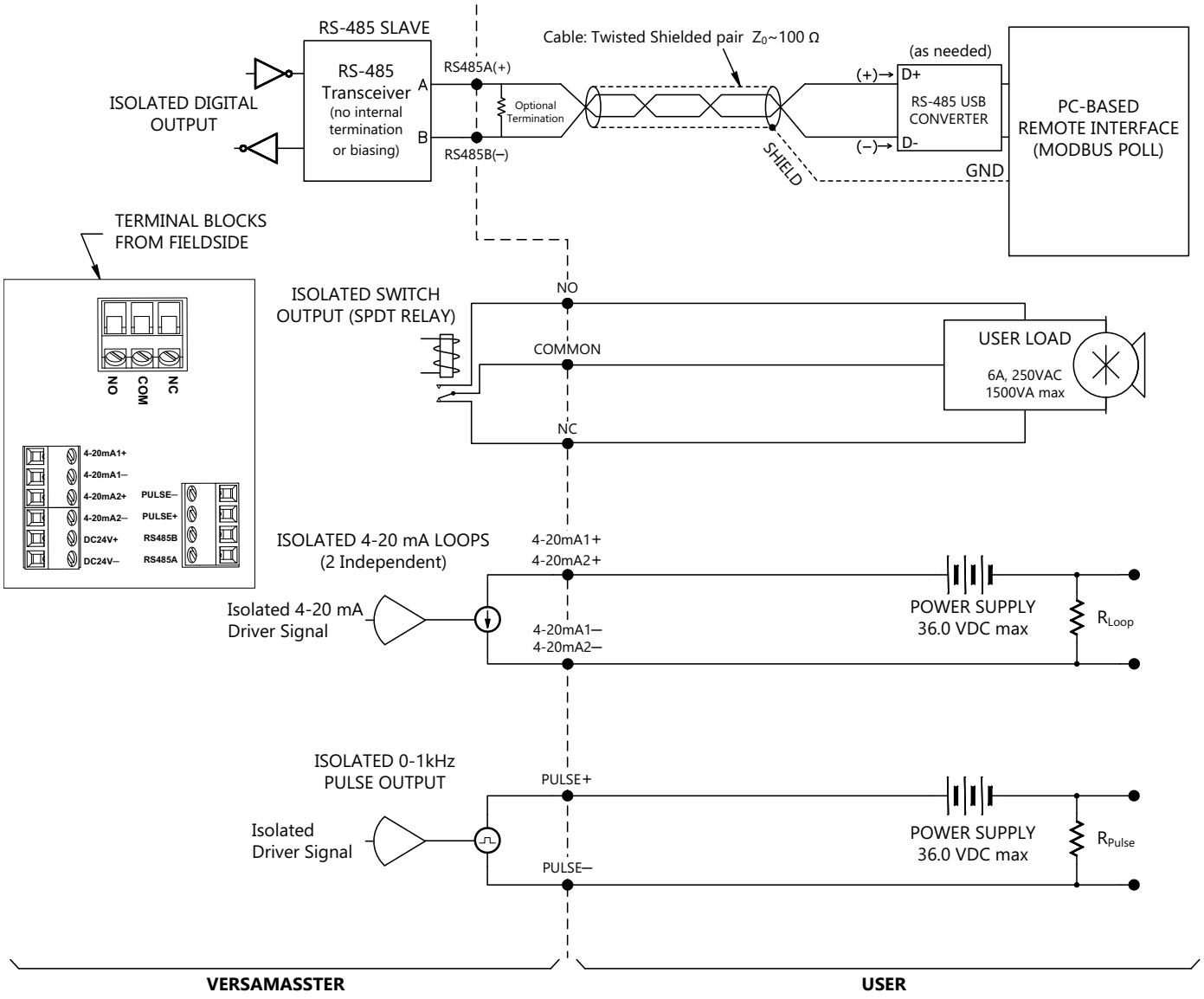


FIGURE 2-5. VersaMassTer® Outputs Wiring

NOTE: The output signal wiring should be routed in a separate conduit from the electrical power wiring.

Using Figure 2-4 and Figure 2-5 as guides, choose the desired outputs for the application and carefully connect wiring to the appropriate terminals shown.

NOTE: The isolated 4-20mA and pulse output loops are externally powered. For normal operation 6 to 36 VDC power is supplied by the user. The maximum loop resistance is dependent upon the supply voltage. The maximum loop resistance, RMAX, can be calculated from:

$$RMAX = 50 \times (VSUPPLY - 6.0V)$$

Connect the external supply and load for each as shown in Figure 2-5.

NOTE: The +24VDC output is isolated from the AC/DC mains and can be wired as an on-board power supply to "self-power" the 4-20mA or pulse outputs. The terminals are labeled DC24V+ and DC24V– but the differential voltage between the two terminals is only 24 VDC.

Twisted shielded pair cable with a characteristic impedance of 100 to 120 ohms is recommended for the RS-485 Serial Output. The shield should be grounded at the user interface end of the cable and isolated at the connection to the VM7000 field side. The VM7000 provides no internal biasing or termination as the resistor values and locations are dependent upon the specific multi-drop configuration of the user installation. Refer to Figure 4-1 on page 44 for more details regarding the physical layout of the RS-485 network.

NOTE: The VM7000 field-side is labeled according to the *pin labels of the internal IC* for the RS-485 interface which does match the TIA-485-A standard. The RS-485 standard identifies the B line as the non-inverting (+) line and the A line as the inverting (–) line. This is opposite of the labeling on the field-side of the VM7000.

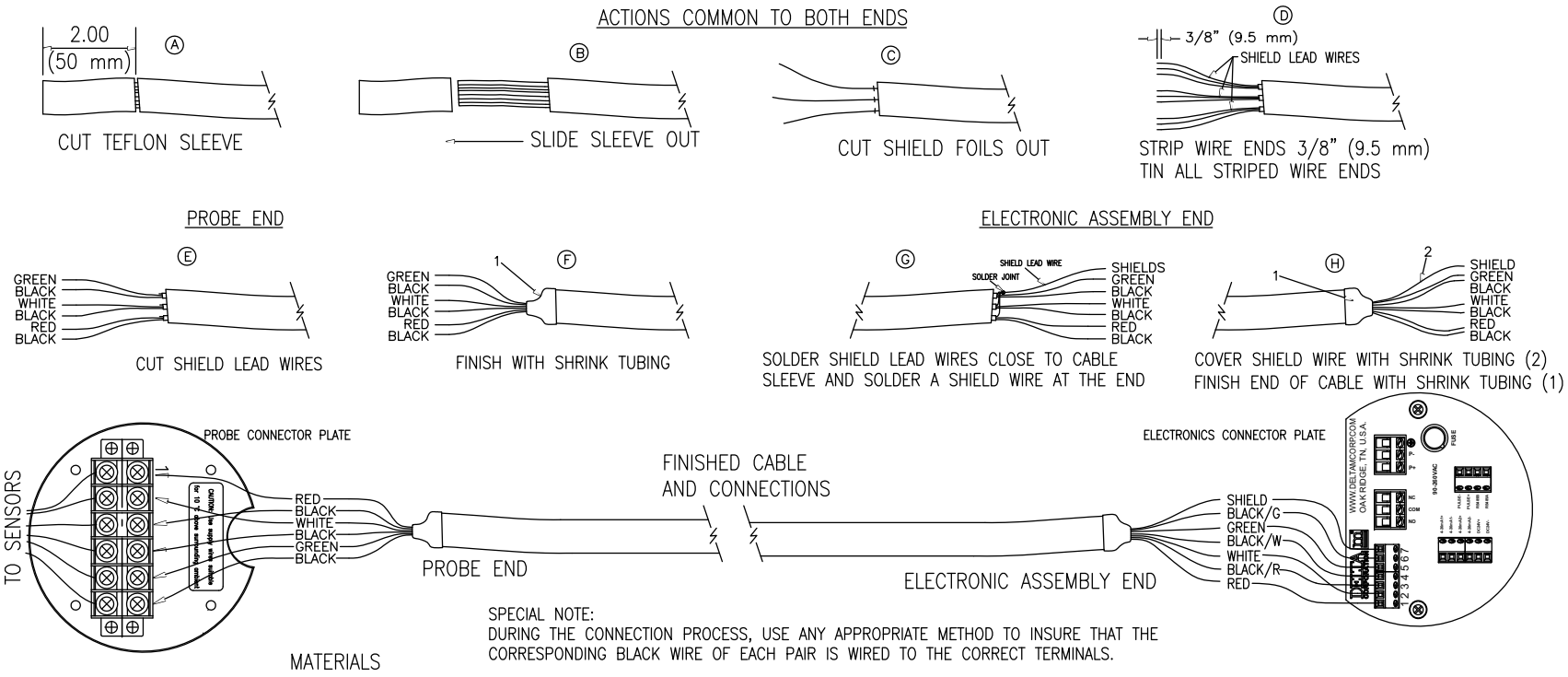
OPTIONAL REMOTE ELECTRONICS (RE) SENSOR PROBE WIRING

CAUTION: Ensure power to electronics is disconnected before installing or removing probe.

The Remote Probe (RP) must be wired through approved conduit with a three pair twisted shielded cable provided with the Remote Electronics option. Use Figure 2-6 as a guide to prepare the remote cable assembly.

Using Figure 2-7 as a guide for the connection, connect the six wires from the field-side terminal block labeled 1 through 6 in the Remote Electronic (RE) enclosure to terminal block TBC in the Remote Probe (RP) enclosure. The RP terminals are labeled 1 through 6 and the wires are color coded.

NOTE: The shields of the three paired wires must be isolated and not connected at terminal block TBC of the Remote Probe (RP) enclosure. However, at the Remote Electronic (RE) enclosure, these 3 shields must be tied together and wired to terminal 7 of the field-side terminal block labeled 1 through 7.



MATERIALS

	STANDARD TEMP. PROBE (MAX. AMBIENT / ENCLOSURE TEMP. 75 °C)	MED. & HIGH TEMP PROBES (MAX. AMBIENT / ENCLOSURE TEMP. 200 °C)
CABLE	DELTA M PART # 101567	DELTA M PART # 101539
SHRINK TUBE 1	PVC, 1/4" (13 mm) OD	TEFLON, 1/4" (13 mm) OD
SHRINK TUBE 2	PVC, 1/8" (6.5 mm) OD	TEFLON, 1/8" (6.5 mm) OD

FIGURE 2-6. Remote Electronics Cable Termination and Connections

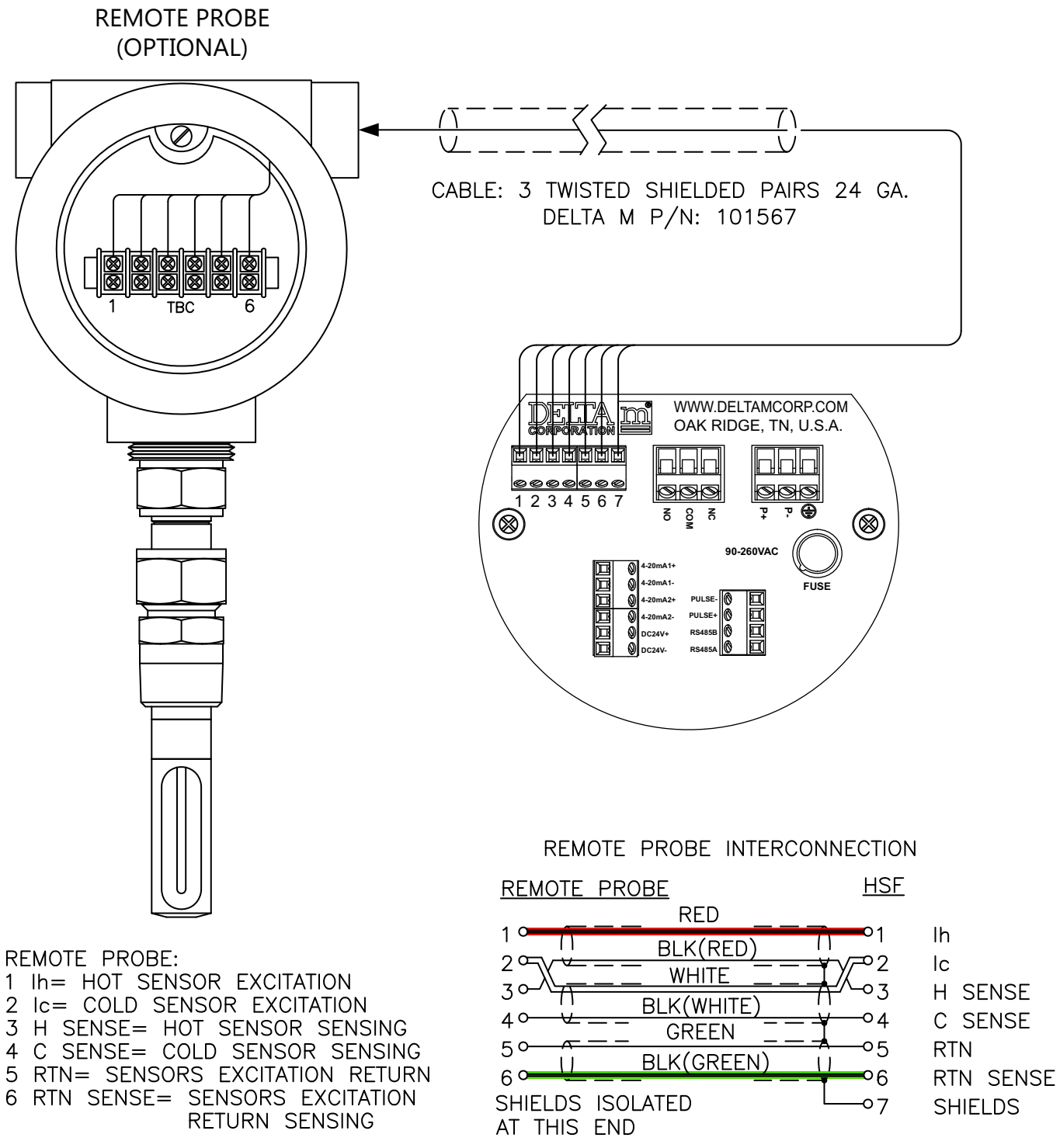
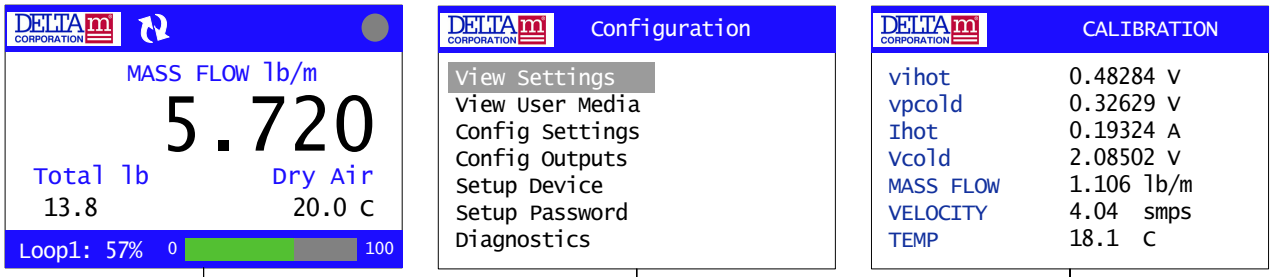


FIGURE 2-7. VersaMassTer® Field Wiring For Remote Probe

OPERATION

The VersaMassTer has three modes of local display operation: Measurement mode, Configuration mode, and Calibration Display mode as illustrated below:



Measurement mode (default)

Configuration mode
(Activate ENTER key for 2 seconds)

Calibration Display mode
(Activate UP and DOWN keys for 2 sec)

Various instrument functions can be configured using the keypad and all responses are indicated on the LCD display.

KEYPAD DESCRIPTION

The keypad consists of four light-sensitive switches: UP, DOWN, ENTER and BACK as described below. Note that a small red LED is visible above each key when a key is activated.

Touching a key is not required to activate it which allows for keypad operation with the instrument cover in place, although the user may also touch the keys if desired (however, the keys are not activated by touch). Care must be taken when activating a key to not also activate a nearby key. The "Key Sensitivity" can be adjusted to suit a particular user (see page 35).

UP arrow: Scrolls to previous menu item at the same level, moves through a pick list, or increments a digit during numerical entries.

DOWN arrow: Scrolls to next menu item at the same level, moves through a pick list, or decrements a digit during numerical entries.

ENTER: Enters the current menu level, confirms the selection of the current menu item, or enters a digit during numerical entry. ENTER *must be activated* to complete a selection or numerical entry. Activate for 2 seconds to enter Configuration mode from Measurement mode.

BACK: Back exits a sub-level or main level of a menu as well as terminating numerical entry. Exiting numerical entry or a menu selection with BACK reverts the setting to the value before editing. Activate for 2 seconds to exit Configuration or Calibration Display modes.

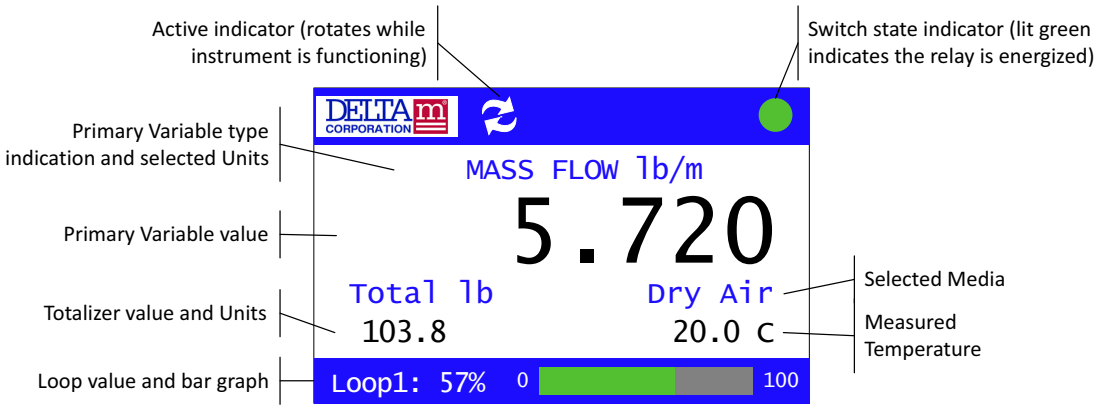
EDITING AND SAVING A PARAMETER

In order to choose a menu item for editing, the ENTER key must first be activated to select the parameter. The display will update as appropriate to indicate an active edit session, such as a flashing digit for numerical entry or a pick list for a menu-based entry. In order to *save* an entry it is necessary to activate the ENTER key. **This applies to both entered numerical values and selections presented in a pick list.** Upon activating the ENTER key, the value is *immediately saved* to non-volatile memory and applied to the operation of the instrument unless otherwise noted.

NOTE: The <Enter> prompt indicates that the ENTER key should be activated to display more information for the selection or select the next display screen.

MEASUREMENT MODE

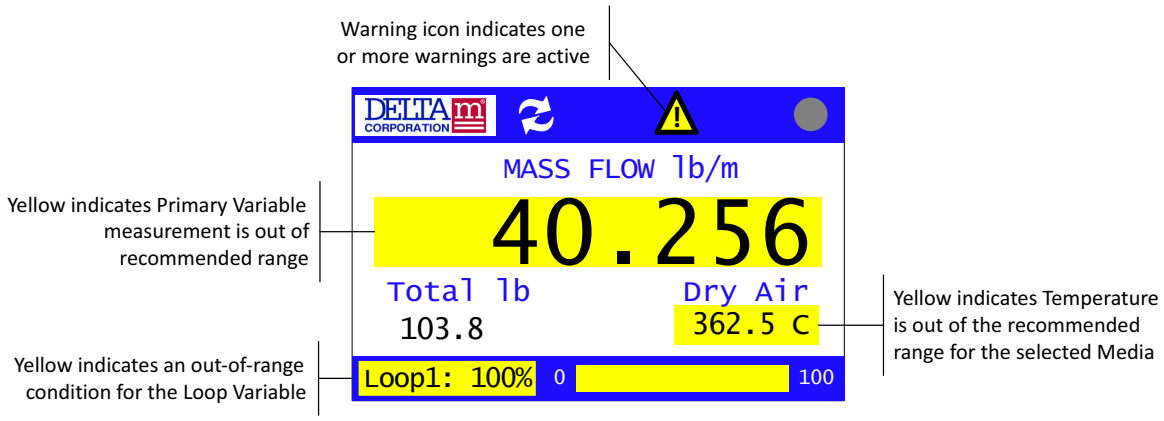
When in Measurement mode, which is the default display, the instrument displays the Primary Variable value along with the Temperature measurement, Totalizer value, Loop Output bar graph, and Switch state indication as shown in the figure below. This is the “normal operation” display.



WARNING INDICATION

The Measurement mode also displays a warning icon and yellow color to indicate warnings. This warnings are illustrated in the figure below. Further details regarding the warnings can be obtained by reading the Status registers as described on page 40.

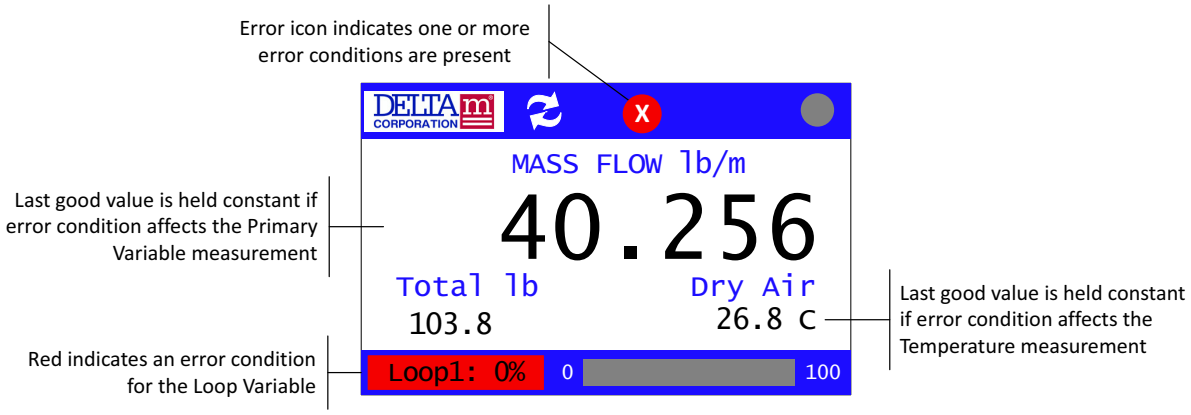
NOTE: If only a warning is active, all measurements will continue without interruption.



ERROR INDICATION

The Measurement mode displays an error icon and red color to indicate error modes as illustrated in the figure below. Further details regarding the error states can be obtained by reading the Status registers as described on page 40. The last valid value or output before the error is held constant until the error clears, with the exception of the 4-20mA loop outputs which can optionally output a fault current level as selected by the user.

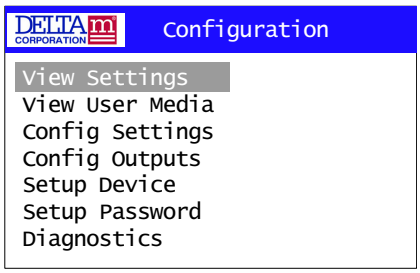
NOTE: If an error is active for a given variable or output using that variable, then measurements for that variable and updates to any output which has selected that variable, are suspended while the error is active.



CONFIGURATION MODE

The Configuration mode is used for configuring the instrument or performing diagnostics. After configuring the settings, the user should exit to the Measurement mode to resume local display of flow, temperature, and Totalizer measurements.

To *enter* the Configuration mode, the user must activate the ENTER key for at least 2 seconds. To *exit* the Configuration mode, the user must exit all submenus using the BACK key to the home Configuration screen as shown at right, and then activate the BACK key for at least 2 seconds.



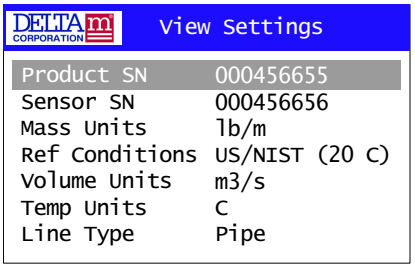
NOTE: The display will revert automatically to the Measurement display mode after 60 seconds of inactivity at the local interface, with the exception of active Diagnostics tests.

Mass flow, Volume flow, Temperature, Hot Current and Totalizer measurements continue while in the Configuration mode, with the exception of some Diagnostics settings. For example, the Test Ihot diagnostic interrupts flow measurements while active. Diagnostics on a specific output such as the Loop1, Loop2, Pulse, or Switch outputs obviously interrupt the normal state of the selected output.

The Configuration mode includes several sub-categories of viewable screens, settings, and diagnostics. The complete menu tree is shown in Figure 3-1 on page 22 for quick reference. The UP/DOWN keys cycle through the selections. The present selection is highlighted. Activate the ENTER key to enter the highlighted menu.

VIEW SETTINGS MENU

The View Settings menu displays several of the most critical settings of the instrument. The primary use of the View Settings is quick viewing of a summary of settings without requiring entry of the User Password. Viewing the entire menu requires scrolling the display using the UP and DOWN keys. The topmost portion of the submenu is illustrated at right.



NOTE: All information in the View Settings menu is READ ONLY.

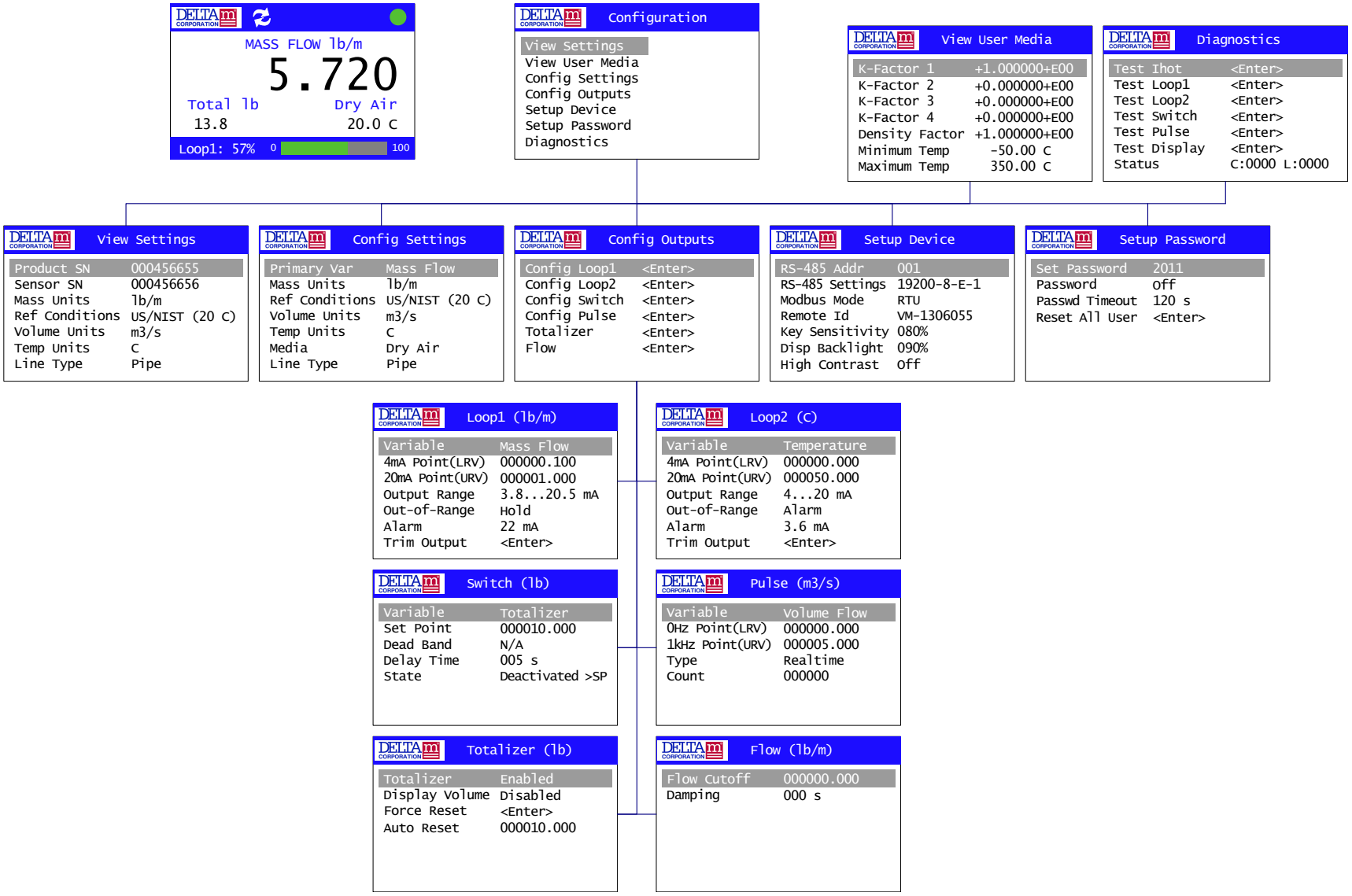
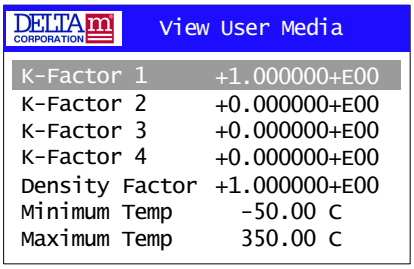


FIGURE 3-1. Configuration Mode menu tree

Settings that involve more than one parameter, such as the Loop, Pulse, and Switch configurations, require the user to activate the ENTER key to display a multi-line summary as indicated by the <Enter> prompt for a given setting.

VIEW USER MEDIA MENU

The View User Media menu is a READ ONLY display of the four K-factors, Density factor, and valid temperature range for the "User Media" media type.

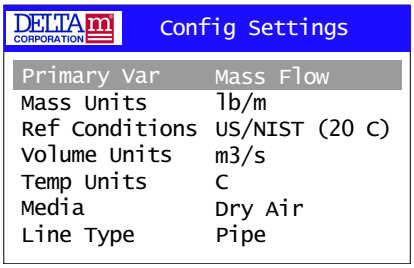


Please consult with the factory for assistance in defining User Media data. The default User Media settings are compatible with Dry Air media at International Standard Metric Conditions (15.00 °C, 101.325 kPa).

NOTE: All information in the View User Media menu is READ ONLY via the local interface. The values may only be changed by using the Modbus-compatible remote interface registers (see page 53).

CONFIG SETTINGS MENU

The Config Settings menu provides the interface for selection of the Primary Variable, units for Mass Flow, preferred Reference Conditions, units for Volumetric Flow, units for Temperature, Media selection, Line Type and Size, and the source for the Gauge display. The topmost portion of the menu is illustrated at right. Use the UP/DOWN keys to access all the settings.



The Primary Var selects the measurement that will be displayed in the largest text in the Measurement mode screen. Note that values for all measured variables are continuously updated in the 30000-block of the Modbus-compatible remote interface registers (see page 54).

The Line Type can be selected as either a round pipe or a rectangular duct. The inside diameter (ID) in inches is required for round pipes. The internal width and height in inches is required for a duct. The available Line Type selections are illustrated in Figure 3-2 below.

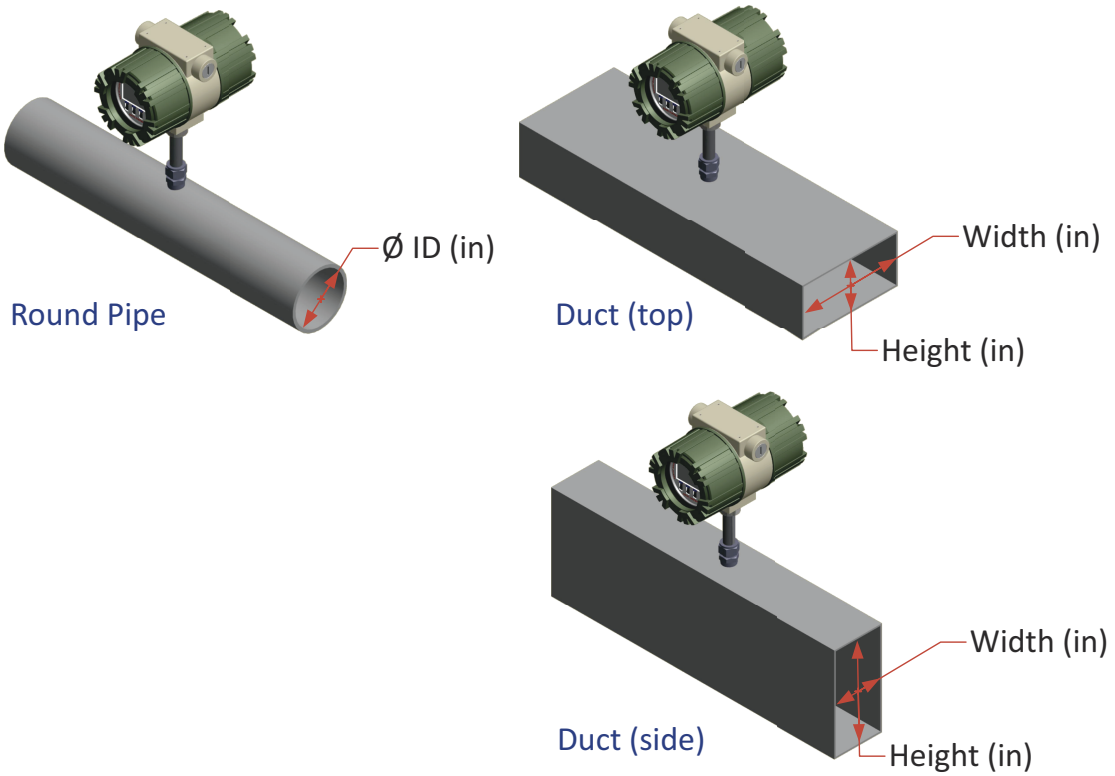


FIGURE 3-2. Line Types and required flow area dimensions

NOTE: The Width dimension of the duct should always be the dimension of the side where the sensor is mounted. This convention should be observed for correct internal calculation of the hydraulic flow area.

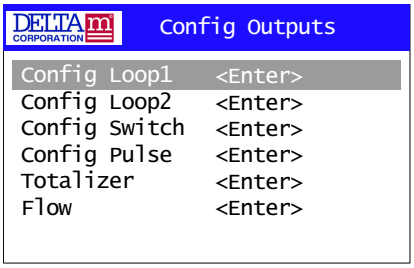
The following Config Settings Parameters table summarizes all the parameters available in the Config Settings menu and provides a cross-reference to the associated Modbus registers.

Config Settings Parameters			
Setting	**Description**	**Pick Values or Range**	**Modbus Register**
Primary Var	Selects the Primary Variable that is displayed in the largest characters in Measurement mode	Mass Flow Volume Flow Hot Current	40001

Config Settings Parameters			
Setting	**Description**	**Pick Values or Range**	**Modbus Register**
Mass Units	Selects the units used for displaying the Mass Flow rate	lb/s = pounds mass per second lb/m = pounds mass per minute lb/h = pounds mass per hour kg/s = kilograms per second kg/m = kilograms per minute kg/h = kilograms per hour g/s = grams per second g/m = grams per minute g/h = grams per hour	40002
Ref Conditions	Selects the preferred Reference Temperature and Pressure used to normalize all volumetric values	Normal: 0° C and 101.325 kPa Metric: 15° C and 101.325 kPa US/NIST: 20° C and 101.325 kPa US/STP: 70° F and 14.7 psia IUPAC STP: 0° C and 100 kPa	40003
Volume Units	Selects the units used for displaying the Volumetric Flow rate normalized to the selected Reference Conditions	l/m = liters per minute l/h = liters per hour l/d = liters per day m3/s = cubic meters per second m3/m = cubic meters per minute m3/h = cubic meters per hour cc/s = cubic centimeters per second cc/m = cubic centimeters per minute cc/h = cubic centimeters per hour CFM = cubic feet per minute	40004
Temp Units	Selects the units used for display of the flowstream temperature	C = degrees Centigrade F = degrees Fahrenheit	40005
Media	Selects the gas media and the built-in K-factors for named gases, or the User Media for a set of custom K-factors	Dry Air Ammonia Argon Carbon Dioxide Carbon Monoxide Helium Methane Nitrogen Oxygen Propane User Media (custom)	40006
Line Type	Line Type Selection	Pipe (round) Duct (rectangular) LFB (low flow block)	40007
Line Size	Line Size Entry	For Pipe: ID in inches For Duct: Internal Width x Height in inches For Low Flow Block: No entry (fixed size)	40101 40103-5
Gauge Display	Selects the 4-20 mA Loop output that is source for the Measurement mode display and bar graph	Loop1 Loop2	40008

CONFIG OUTPUTS MENU

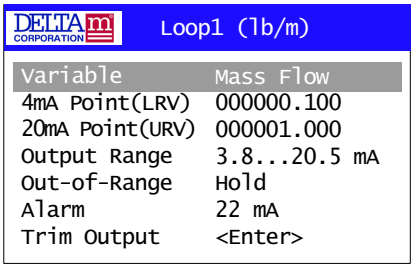
The Config Outputs menu illustrated at right provides the interface for configuring the various outputs such as the 4-20 mA Loops 1 & 2, the Switch output, and the 0-1kHz Pulse output. It also provides configuration screens for the Totalizer function and functions related to the Flow measurement.



Activate the ENTER key to gain access to the configuration submenu for each output type and then edit the detailed settings for each as presented in the following submenu sections.

CONFIG LOOP1 SUBMENU

The Config Loop1 submenu provides the interface for configuring the 4-20 mA output for Loop1 as shown at right. Note that the active units for the presently selected Variable are shown in the title bar at the top of the screen. The units can be changed only in the Config Settings screen or by remote Modbus command.



The 4mA Point (LRV[1]) and 20mA Point (URV[2]) values are not constrained and may be set to any value (except the same value), including reversing the range.

The Output Range can be set to the default extended range of 3.8 to 20.5 mA, which allows for some under- and over-ranging output with respect to the LRV/URV values (per the NAMUR NE43 standard), or the range can be limited strictly to 4 to 20 mA. The ranging is illustrated in Figure 3-3 below. A loop output in the Fault range indicates an active Alarm condition to a remote system.

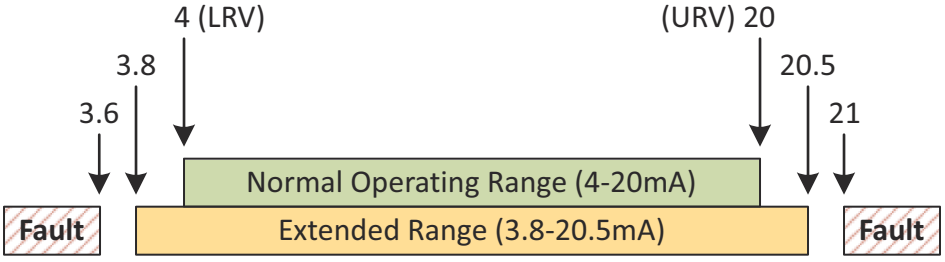


FIGURE 3-3. Loop output ranging

1. LRV = Lower Range Value
2. URV = Upper Range Value

The Out-of-Range behavior can be set to Hold, meaning the last Variable measurement within the output range is held if the selected Variable value is not presently within the output range, or it can be set to Alarm which will generate an alarm output for Loop1 when the Variable measurement goes out of range.

The Alarm (or Fault) selection allows for selection of 3.6 or 22 mA as the alarm output level indication for Loop1. If the Out-of-Range behavior is set to Hold, then the Alarm output level is only activated for an instrument fault condition.

The Trim Output selection, when entered, displays a trim interface for the 4 and 20 mA analog output to allow adjustments needed for installation-specific loop hardware configurations. When the 4 or 20 mA trim is active, the UP and DOWN keys will increase or decrease the output current for Loop1. Continue the adjustment for the 4 and 20 mA levels until your loop measurement device reads exactly 4 and 20mA, respectively. Activate ENTER to save the trim values which are restored on power cycles.

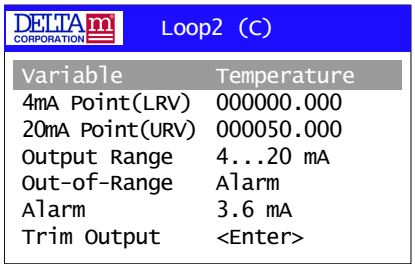
NOTE: A fully remote trim of the 4-20 mA output can also be performed by alternately remotely enabling the diagnostic level for Loop1 to 4 mA or 20 mA (see Modbus Register 40052) and remotely adjusting the trim settings for each level (see Modbus Registers 40013 and 40014) while observing the remote Loop1 current measurement.

The Config Loop1 Parameters table below summarizes the settings for Loop1 and cross-references the applicable Modbus registers.

Config Loop1 Parameters			
Setting	**Description**	**Pick Values or Range**	**Modbus Register**
Variable	Selects the Variable that is tracked by the Loop1 4-20mA output	Mass Flow Volume Flow Temperature Hot Current	40009
4mA Point (LRV)	The value of the selected Variable that will correspond to 4mA output (Lower Range Value)	Any value except the value of the 20mA Point. Negative flowrates or current are not allowed; minus temperatures are valid.	40121
20mA Point (URV)	The value of the selected Variable that will correspond to 20mA output (Upper Range Value)	Any value except the value of the 4mA Point. Negative flowrates or current are not allowed; minus temperatures are valid.	40123
Output Range	Selects the desired output range of Loop1	3.8 to 20.5 mA (allows under/overrange) 4 to 20 mA (no under/overrange)	40010

Config Loop1 Parameters			
Setting	**Description**	**Pick Values or Range**	**Modbus Register**
Out-of-Range	Selects the desired behavior of the Loop1 output in the event the selected Variable is out of range	*Hold:* The last output within range is held *Alarm:* Loop1 outputs the Alarm value in the event the Variable is out of range	40011
Alarm	Selects the desired Alarm level for Loop1	3.6mA 22mA	40012
Trim Output	Trim values for installation-specific calibration of 4 and 20mA output	Adjustable using the UP/DOWN keys. Activate ENTER after adjustment to save value	40013-40014

CONFIG LOOP2 SUBMENU



The Config Loop2 submenu provides the interface for configuring the 4-20 mA output for Loop2 as shown at right. The interface is identical to that for Loop1. Note that the active units for the presently selected Variable are shown in the title bar at the top of the screen. The units can be changed only in the Config Settings screen or by remote Modbus command.

The 4mA Point (LRV) and 20mA Point (URV) values are not constrained and may be set to any value (except the same value), including reversing the range.

The Output Range can be set to the default extended range of 3.8 to 20.5 mA, which allows for some under- and over-ranging output with respect to the LRV/URV values, or the range can be limited strictly to 4 to 20 mA. The ranging is identical to that of Loop1 as illustrated in Figure 3-3 on page 26.

The Out-of-Range behavior can be set to Hold, meaning the last Variable measurement within the output range is held if the selected Variable value is not presently within the output range, or it can be set to Alarm which will generate an alarm output for Loop1 when the Variable measurement goes out of range.

The Alarm selection allows for selection of 3.6 or 22 mA as the alarm output level indication for Loop2. If the Out-of-Range behavior is set to Hold, then the Alarm output level is only activated for an instrument fault condition.

The Trim Output selection, when entered, displays a trim interface for the 4 and 20 mA analog output to allow adjustments needed for installation-specific loop hardware configurations. When the 4 or 20 mA trim is

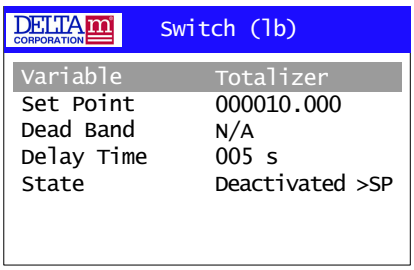
active, the UP and DOWN keys will increase or decrease the output current for Loop2. Continue the adjustment for the 4 and 20 mA levels until your loop measurement device reads exactly 4 and 20mA, respectively. Activate ENTER to save the trim values which are restored on power cycles.

NOTE: A fully remote trim of the 4-20 mA output can also be performed by alternately remotely enabling the diagnostic level for Loop2 to 4 mA or 20 mA (see Modbus Register 40053) and remotely adjusting the trim settings for each level (see Modbus Registers 40019 and 40020) while observing the remote Loop2 current measurement.

The Config Loop2 Parameters table below summarizes the settings for Loop2 and cross-references the applicable Modbus registers.

Config Loop2 Parameters			
Setting	**Description**	**Pick Values or Range**	**Modbus Register**
Variable	Selects the Variable that is tracked by the Loop2 4-20mA output	Mass Flow Volume Flow Temperature Hot Current	40015
4mA Point (LRV)	The value of the selected Variable that will correspond to 4mA output (Lower Range Value)	Any value except the value of the 20mA Point. Negative flowrates or current are not allowed; minus temperatures are valid.	40125
20mA Point (URV)	The value of the selected Variable that will correspond to 20mA output (Upper Range Value)	Any value except the value of the 4mA Point. Negative flowrates or current are not allowed; minus temperatures are valid.	40127
Output Range	Selects the desired output range of Loop2	3.8 to 20.5 mA (allows under/overrange) 4 to 20 mA (no under/overrange)	40016
Out-of-Range	Selects the desired behavior of the Loop2 output in the event the selected Variable is out of range	*Hold:* The last output within range is held *Alarm:* Loop2 outputs the Alarm value in the event the Variable is out of range	40017
Alarm	Selects the desired Alarm level for Loop2	3.6mA 22mA	40018
Trim Output	Trim values for installation-specific calibration of 4 and 20mA output	Adjustable using the UP/DOWN keys. Activate ENTER after adjustment to save value	40019-40020

CONFIG SWITCH SUBMENU



The Config Switch submenu displays the settings associated with the Switch (relay) output as illustrated at right. The settings include the Variable selection, Set Point, Dead Band, Delay Time, and State control. The active units for the presently selected Variable are shown in the title bar at the top of the screen. The units can be changed only in the Config Settings screen or by remote Modbus command.

The Switch terminals on the field side of the device include labeled terminals for both the normally-open (NO) and normally-closed (NC) states. The normal outputs correspond to the deactivated (i.e. de-energized coil) Switch state.

Figure 3-4 below provides an example illustrating how the Set Point, Dead Band, and Delay Time function together for a time-varying Variable measurement. In the example, the Switch State is set to "*Activated > SP*". Therefore, the relay does not activate until the measurement exceeds the Set Point. Once activated, the relay will remain activated until the Delay Time expires, *regardless of the measurement*. Once the Delay Time expires, if the measurement falls below the Dead Band limit, the relay will then be deactivated.

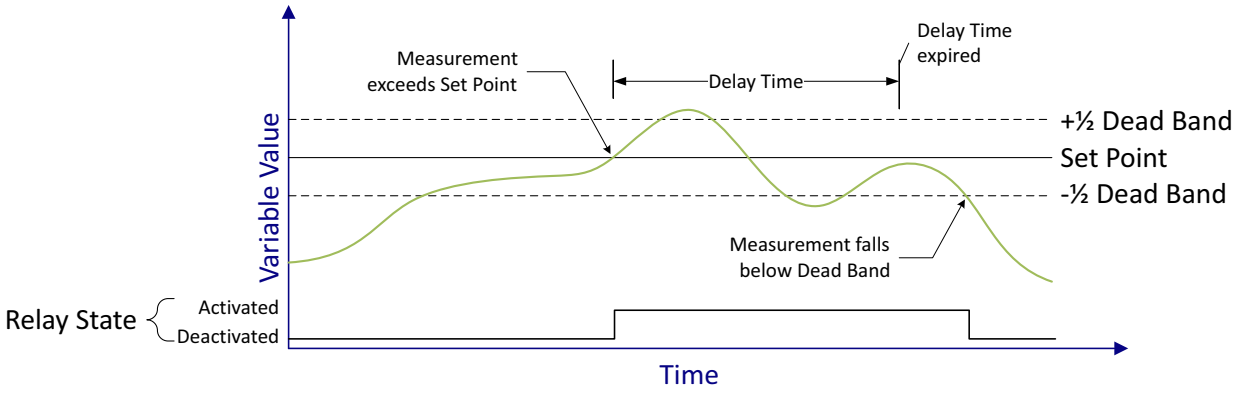


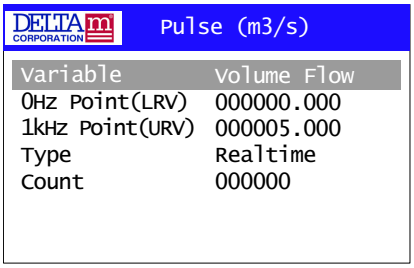
FIGURE 3-4. Example Switch state for *"Activated > SP" setting*

The Config Switch Parameters table below summarizes the settings for the Switch and cross-references the applicable Modbus registers.

Config Switch Parameters			
Setting	**Description**	**Pick Values or Range**	**Modbus Register**
Variable	Selects the Variable that is tracked by the Switch output	Mass Flow Volume Flow Temperature Hot Current Totalizer	40021
Set Point	The value of the selected Variable that specifies the switching point	Negative flowrates, current, or totalizer values are not allowed; minus temperatures are valid.	40129
Dead Band	Specifies the magnitude of the Dead Band that is centered on the Set Point	Negative values are not allowed. The Dead Band is not applicable (N/A) for the Totalizer Variable selection.	40131
Delay Time	Specifies the minimum time required between changes of State	0 to 999 seconds	40022
State	Selects the desired behavior of the Switch when the set point is reached	*Deactivated >SP*: The Switch output is deactivated (coil is de-energized, output is at normal state) when the Variable is greater than the Switch Set Point *Activated > SP*: The Switch output is activated (coil is energized) when the Variable is greater than the Switch Set Point	40023

CONFIG PULSE SUBMENU

The Config Pulse submenu provides the settings for the 0 to 1 kHz pulse output feature. The pulse output requires external power to function (see Figure 2-5 on page 11).



The settings include the Variable selection, 0 Hz Point (no pulse), 1 kHz Point, function Type, and Count.

If the Type is set to function as Realtime, then the pulse output tracks the present Variable value by scaling the pulse output frequency between the 0 Hz and 1kHz Points. For example, if the selected Variable is Mass Flow, the 0 Hz Point is 0 lb/m, and the 1 kHz Point is 10 lb/m, then a mass flowrate of 5 lb/m will result in 500 Hz continuous pulse output.

If the Type is set to function as Cumulative, then the pulse output only occurs when the Totalizer automatically resets. In this functional mode,

the pulse output is a single pulse with a fixed 500ms in duration when the Totalizer auto reset occurs. *The Variable selection, 0 Hz and 1 kHz Points have no function and are ignored.*

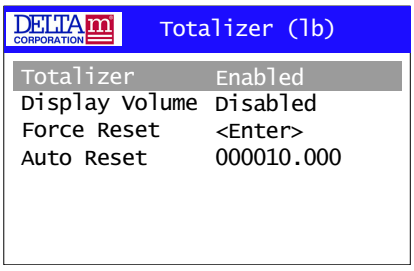
The Count value is incremented by one each time the Totalizer automatically resets regardless of the Type of function. The Count value is saved between power cycles of the instrument and can be reset by selecting it with the ENTER key and confirming the reset.

The Config Pulse Parameters table below summarizes the settings for the Pulse output and cross-references the applicable Modbus registers.

Config Pulse Parameters			
Setting	**Description**	**Pick Values or Range**	**Modbus Register**
Variable	Selects the Variable that is tracked by the pulse output in Realtime mode	Mass Flow Volume Flow Temperature Hot Current	40024
0Hz Point(LRV)	The value of the selected Variable that will correspond to 0 Hz output (Lower Range Value)	Any value except the value of the 1 kHz Point. Negative flowrates or current are not allowed; minus temperatures are valid.	40133
1kHz Point(URV)	The value of the selected Variable that will correspond to 1 kHz output (Upper Range Value)	Any value except the value of the 0 Hz Point. Negative flowrates or current are not allowed; minus temperatures are valid.	40135
Type	Specifies the function of the Pulse output	*Realtime*: The Pulse output is continuous and is scaled from 0 to 1 kHz according to the present value of the Variable and the LRV and URV values. *Cumulative*: Outputs a single 500ms duration pulse each time the Totalizer automatically resets. The LRV and URV values are ignored.	40025
Count	Cumulative count of Totalizer automatic resets	Read only. Can be cleared by selecting the line, activating the ENTER key, and confirming the action.	30021

TOTALIZER SUBMENU

The Totalizer submenu provides settings for the Totalizer function of the instrument. The Totalizer function can be enabled/disabled, forced to manually reset, and provides an Auto Reset value for automatic clearing of the Totalizer when the specified total value is reached.



The title bar indicates the Totalizer configuration screen is selected and indicates the units for the Auto Reset value.

The first line of the Totalizer configuration screen allows the feature to be Enabled or Disabled. When Disabled, the totalizing halts, however the present Totalizer value is still retained and displayed. When Enabled, the totalizing resumes.

Display Volume, when enabled, will display the Totalizer value in the current selected volumetric units normalized to the selected Reference Conditions.

Force Reset allows manual intervention to force the Totalizer to reset to zero. This is not counted as an automatic reset (see the Count function of the Pulse output).

Auto Reset is a value that specifies the total mass or volume that, when reached, triggers the Totalizer to reset to zero. Auto Resets are cumulative in the Count function of the Pulse output. Each Count increment reflects one Totalizer reset at the Auto Reset value.

NOTE: The Totalizer resets to zero on a power cycle, but the Count value of the Pulse screen (which counts the Totalizer auto-resets) is retained and restored from non-volatile memory.

The units of the Auto Reset value are indicated in the title bar and follow the selected mass or volume units of the Primary Variable. If the Primary Variable is any setting except Volume Flow, then the units will be in mass. If the Primary Variable is selected as Volume Flow, the Auto Reset units will be in the preferred volume units.

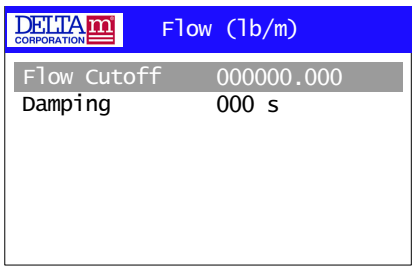
The following Totalizer Parameters table summarizes the settings for the Totalizer configuration and cross-references the applicable Modbus registers.

Totalizer Parameters

Setting	Description	Pick Values or Range	Modbus Register
Totalizer	Enables or disables the totalizing function	Enabled Disabled	40026
Display Volume	Enables display of the Totalizer value in Volumetric units	Enabled Disabled	40027
Force Reset	Activate ENTER to confirm a manual forced reset of the Totalizer to zero	N/A	40028
Auto Reset	The total value in mass or volume units at which the Totalizer will automatically reset to zero	Any positive value in the selected mass or (normalized) volume units	40137

FLOW SUBMENU

The Flow submenu configures general settings related to the flow measurement function. The settings include the Flow Cutoff and Damping features.



The title bar indicates the Flow configuration screen is selected and indicates the units for the Flow Cutoff value.

The Flow Cutoff feature allows specification of a value below which the reported flow will be zero. The units of the Flow Cutoff value are indicated in the title bar and follow the selected mass flow or volumetric flow units of the Primary Variable. If the Primary Variable is any setting except Volume Flow, then the units will be in mass per unit time. If the Primary Variable is selected as Volume Flow, the Flow Cutoff units will be in the preferred volume per unit time units.

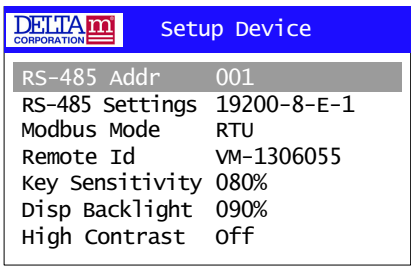
The Damping function specifies a filtering time constant that can be used to reduce unwanted variations in the reported flow rate. The higher the Damping value, the more filtering that is applied. Specifically, the Damping time specifies the amount of time necessary for the reported flow value to be within 99% of its steady-state value. The underlying technical implementation is a first-order low pass filter (or exponential filter) with the Damping value corresponding to the 5τ (5 time constants) time. A Damping time of zero results in no filtering.

The following Flow Parameters table summarizes the settings for the Flow configuration and cross-references the applicable Modbus registers.

Flow Parameters			
Setting	**Description**	**Pick Values or Range**	**Modbus Register**
Flow Cutoff	The value in mass flow or volumetric flow units below which the reported flow rate will be zero	Zero (no cutoff), or any positive value	40139
Damping	Filtering function based on first-order low pass	0 to 600 seconds in 1 sec increments	40029

SETUP DEVICE MENU

The Setup Device menu provides the interface for selection of the RS-485 Address (Slave address), RS-485 Communication Settings, Modbus Mode, Remote Id, Key Sensitivity, Display Backlight level, and activation of an alternative High Contrast color scheme. The menu is illustrated at right.



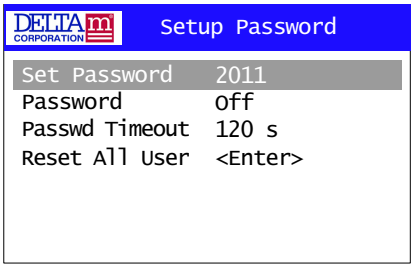
The following Setup Device Parameters table summarizes all the parameters available in the Setup Device menu and provides a cross-reference to the associated Modbus registers.

Setup Device Parameters

Setting	Description	Pick Values or Range	Modbus Register
RS-485 Addr	The slave address of the device for RS-485 based communications	1 to 247, 1 is the default. A unique address is required for multidrop comm configurations.	40033 30034
RS-485 Settings	Settings for the RS-485 and Bluetooth-based serial communications	Available selections follow the Modbus Mode. The shorthand format of each selection is: **Baudrate-DataBits-Parity-StopBits** *Example*: 19200-8-E-1 is 19200 baud, 8 data bits, even parity, and 1 stop bit Instrument supports 9600, 19200, and 38400 baud rates with none or even parity for both ASCII (7 data bits) and RTU (8 data bits) Modbus Modes.	40035
Modbus Mode	Selects the Modbus communication mode	ASCII RTU	40034
Remote Id	Specifies the label for the wireless comm function	7 adjustable numerical digits with fixed VM- prefix	N/A
Key Sensitivity	Adjusts the light sensitivity of the optical-based key switches	50 to 100% in 1% increments	40036
Disp Backlight	Adjusts the display backlight level	10 to 100% in 1% increments	40037
High Contrast	Enables alternative color scheme (bright letters on black background)	Off On	40038

SETUP PASSWORD MENU

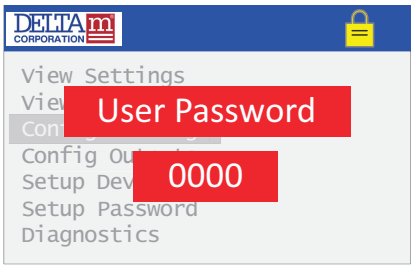
The Setup Password menu provides the interface for setting the Password, turning the Password function on or off, specifying the Timeout, and optionally resetting all User configuration parameters to factory defaults. The menu is illustrated at right.



The Password feature is a single 4-digit password that can optionally protect the configuration of the instrument if enabled.

NOTE: The 4-digit password also functions as the wireless pairing code and is required when first making a wireless remote connection regardless of the whether the Password function is enabled/disabled for the local interface.

If the Password is enabled, then the instrument will require entry of the 4-digit password to access any configuration menu (view-only menus are still accessible by all). The display will appear as shown at right (the first password digit will be blinking as a prompt for entry) if the Password feature is enabled and the operator attempts to enter a configuration menu.



The Password Timeout feature allows adjustment of how long a successfully entered password remains valid at the local interface without any interaction with the instrument. This allows the operator time to refer to references or make external adjustments without the instrument requiring constant reentry of the password.

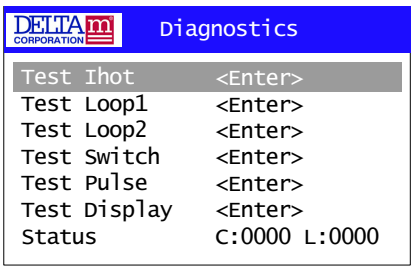
The Reset All User feature when chosen and verified will reset all user-adjustable settings to the factory defaults. This feature should be activated with care as it will permanently erase all previous user settings.

The following Setup Password Parameters table summarizes all the parameters available in the Setup Device menu and provides a cross-reference to the associated Modbus registers.

Setup Password Parameters			
Setting	**Description**	**Pick Values or Range**	**Modbus Register**
Set Password	The 4-digit password code required for changes at the local interface. Also acts as the wireless pairing code.	0000 to 9999	40030
Password	Enables or disables the Password function for the local interface. (Wireless pairing still requires pairing code at all times.)	Off On	40031
Passwd Timeout	The allowed amount of time without user interaction at the local interface before a previous valid password entry expires	60 to 999 seconds in 1 sec increments	40032
Reset All User	Resets all User configuration to factory defaults	Use ENTER to activate and then verify the reset (BACK key will cancel action). Use with care!	N/A

NOTE: The password protection feature restricts access only if the password protection is enabled. The instrument is shipped with password protection disabled. If you have misplaced your password please call the factory for assistance (800-922-0083). Once enabled, password protection can be disabled from the Setup Password menu.

DIAGNOSTICS MENU



The Diagnostics menu, illustrated at right, provides an interface for controlling the various outputs of the device for field setup and fault diagnosis. The Diagnostics menu provides manual control of the Hot Current (Test Ihot), the Loop1 output (Test Loop1), the Loop2 output (Test Loop2), the Switch output (Test Switch), and the Pulse output (Test Pulse). The menu also provides a 3-color Display test and an interface for summarizing and clearing the current (C:xxxx) and latched (L:xxxx) Status of the instrument (see page 40 for more description of the Status system).

Each Test requires the operator to select the line and activate the ENTER key. The selected test becomes active when the ENTER key is first activated, and the normal function of the selected output is interrupted. The test selection can be changed via the UP and DOWN keys. Use the BACK key to exit a test and return to normal operation for a given output.

NOTE: Activating the Test Ihot selection interrupts flow measurements. The last valid flow measurement is held until Test Ihot is exited using the BACK key. Upon test exit, the instrument re-enters the start-up mode for flow measurements which is indicated by the "Start-up" Status bit and then resumes measurements if the start-up sequence is successful.

The following Diagnostic Parameters table summarizes all the parameters available in the Diagnostics menu and provides a cross-reference to the associated Modbus registers.

Diagnostic Parameters			
Setting	**Description**	**Pick Values or Range**	**Modbus Register**
Test Ihot	Tests the Hot (Sensor) Current	100mA 150mA 200mA 250mA 300mA	40051 40141
Test Loop1	Tests the Loop1 4-20 mA output	3.6mA (Low Alarm Level) 4mA 8mA 12mA 16mA 20mA 22mA (High Alarm Level)	40052

Diagnostic Parameters			
Setting	**Description**	**Pick Values or Range**	**Modbus Register**
Test Loop2	Tests the Loop2 4-20 mA output	3.6mA (Low Alarm Level) 4mA 8mA 12mA 16mA 20mA 22mA (High Alarm Level)	40053
Test Switch	Tests the Switch function	Activated (coil energized) Deactivated (coil de-energized, normal state)	40054
Test Pulse	Tests the Pulse 0-1kHz output	0 Hz 500 Hz 1 kHz	40055
Test Display	Tests the Display for 2 seconds with a full screen display of the selected color	White Black Blue	N/A
Status	Summarizes the current and latched Status	Read only. All status can be cleared by selecting the line and activating the ENTER key twice.	20001-16

STATUS DESCRIPTION

The status system for the VersaMassTer is designed to provide both a current status register that displays the *present* condition of the instrument and a *latched* register that provides historical data.

The latched register sets a particular state and *holds that state* until it is cleared by the user or power is cycled. A latched register bit indicates if the condition has ever occurred since power-up or the last status clear command, regardless of the current condition of the instrument.

The status can be accessed via the local interface through the Diagnostics menu (see page 38) of the Configuration Mode. The Current (C) and Latched (L) Status registers are first summarized as *hexidecimal* values in the Diagnostics menu (hexidecimal values 1000 and 9000 in the example Figure 3-5 below).

The example Figure 3-5 below illustrates how the display changes as the ENTER key is activated with the Status line selected in the Diagnostics menu. The *first* activation of ENTER breaks the hexidecimal display (i.e. C:1000 L:9000) into individual status bits that are either ON=1 or OFF=0. The *second* activation of the ENTER key clears the status registers. The BACK key may also be used to exit the detailed bit Status display without clearing the registers.

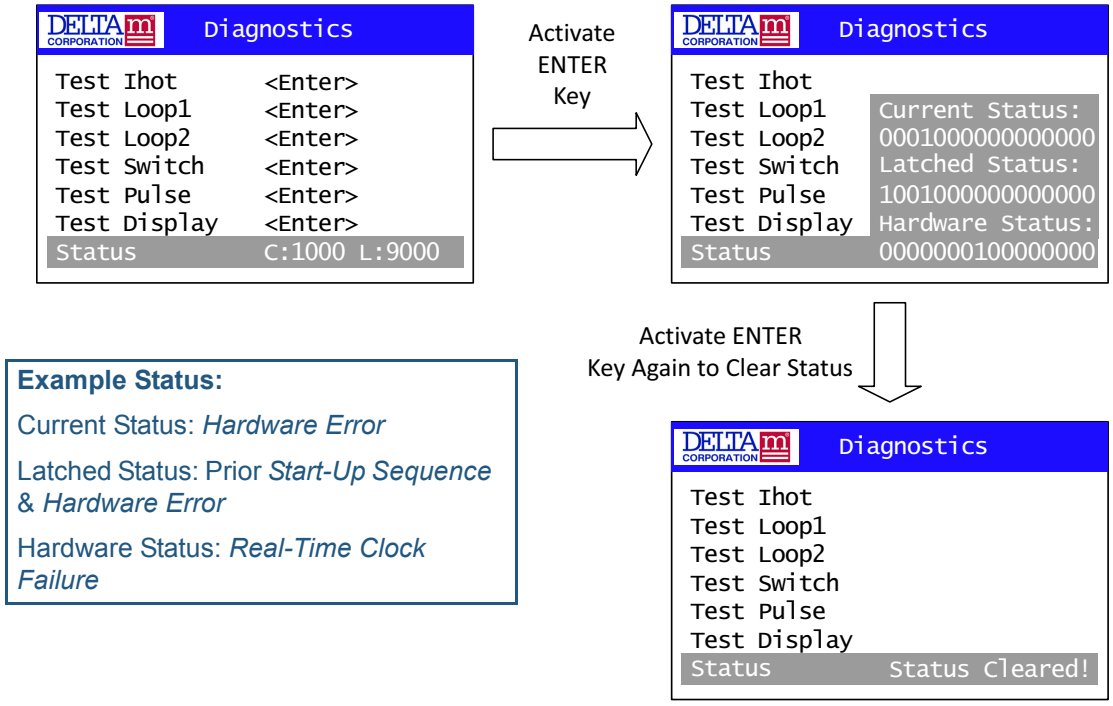


FIGURE 3-5. Example status display

The following tables provide the bit mapping for the Current, Latched, and Hardware Status registers as well as cross-referencing the applicable Modbus-compatible register(s). The bits are numbered starting with bit 1 which is the Least Significant Bit (LSB) — the rightmost bit in the Status display as illustrated in Figure 3-5.

Current (C) and Latched (L) Status Registers Bit Map			
Bit	**Value**	**Description**	**Modbus Register**
1	Sensor Current Error	ON = Sensor current fault condition	**Current:** 20001-20016 **Latched:** 40056
2	Sensor Current Diagnostic Mode	ON = Device is in Ihot test mode *(flow measurements are suspended)*	
3	Output in Diagnostic Mode	ON = Any combination of Loop, Pulse, or Switch outputs is in a test mode	
4	Sensor Board Fault	ON = Fault in sensor board (see Hardware Status Register Bit Map for fault detail)	
5	Loop1 Alarm	ON = Loop 1 alarm condition	
6	Loop1 Variable Out-of-Range	ON = Out-of-range measurement for present Loop1 configuration	
7	Loop2 Alarm	ON = Loop2 alarm condition	
8	Loop2 Variable Out-of-Range	ON = Out-of-range measurement for present Loop2 configuration	
9	Pulse Output Variable Out-of-Range	ON = Out-of-range measurement for present Pulse Output configuration	
10		Reserved	
11		Reserved	
12	NVRAM Error	ON = Non-volatile storage of settings failed (see Hardware Status Register Bit Map for fault detail)	
13	Hardware Error	ON = Internal hardware failure (see Hardware Status Register Bit Map for fault detail)	
14	Temperature Range Warning	ON = Present gas temperature outside of recommended operational range	
15	Gas Velocity Warning	ON = Present bulk gas velocity exceeds the recommended operation range and flow measurement may be inaccurate	
16	Flow Measurement Start-Up Sequence	ON = Device is presently in a sensor current warm-up phase from a power-cycle, or is restarting after a Diagnostic session	

Hardware Status Register Bit Map			
Bit	**Value**	**Description**	**Modbus Register**
1	Sensor NVRAM Checksum Error	ON = Non-volatile sensor calibration memory failed consistency check	40057
2	Sensor NVRAM Communication Error	ON = Non-volatile sensor calibration memory failed to communicate with internal microprocessor	
3	Sensor NVRAM Address Error	ON = Non-volatile sensor calibration memory addressed outside of valid range	
4	User NVRAM Checksum Error	ON = Non-volatile user settings memory failed consistency check	
5	User NVRAM Communication Failure	ON = Non-volatile user settings memory failed to communicate with internal microprocessor	
6	User NVRAM Address Error	ON = Non-volatile user settings memory addressed outside of valid range	
7	ADC Data Timeout	ON = Analog-to-digital converter did not return data to internal microprocessor	
8	ADC Range Error	ON = Analog-to-digital converter returned a value outside of the valid range	
9	Real-Time Clock Failure	ON = Real-time internal clock failed, fall-back to microprocessor clock with up to ±20% error (will generate a warning for the Totalizer display value since it may be inaccurate)	
10-16		Reserved	

REMOTE INTERFACE

The VM7000 implements a *comprehensive* Modbus-compatible remote interface available via the RS-485 and short-range wireless connections. The Modbus implementation conforms to the standards of the **Modbus Application Protocol Specification v1.1b3** available from the Modbus Organization.

A primer on Modbus is beyond the scope of this manual. In addition to the protocol specification noted above, there are numerous resources available on-line including, but not limited to:

- A brief **protocol description** available at ModbusTools.com.
- Excellent **Modbus Tutorial** published by Control Solutions, Inc.
- **Modbus page** at Wikipedia.com.

Conformance to the standard Modbus protocol ensures compatiblity with various off-the-shelff protocol translation products that support Modbus RTU devices.

IMPLEMENTATION NOTES

The VM7000 Modbus implementation does have the following limitation or exceptions to the Modbus protocol specification:

- Multiple register write, via function code 16 (0x10), is not supported except for purposes of writing a single floating point or single 32-bit integer parameter (i.e. limited to two contiguous 16-bit Modbus registers).[1]
- Exception code 3 (ILLEGAL DATA VALUE) *is used to indicate a data value that is out-of-range*, as well as a fault in the structure of a message per the protocol.

1. This limitation is primarily to offset the fact that there is no standard Modbus method of validating multiple register writes. By limiting the multiple register write to a single “parameter” in the VM7000, the response from the VM7000 can *unambiguously* indicate whether a value was accepted. If the value is accepted, the VM7000 returns the standard response. If a parameter value is not acceptable in an otherwise correct message, the VM7000 returns exception code 3 (ILLEGAL DATA VALUE) which indicates write failure to the Modbus master for that single parameter.

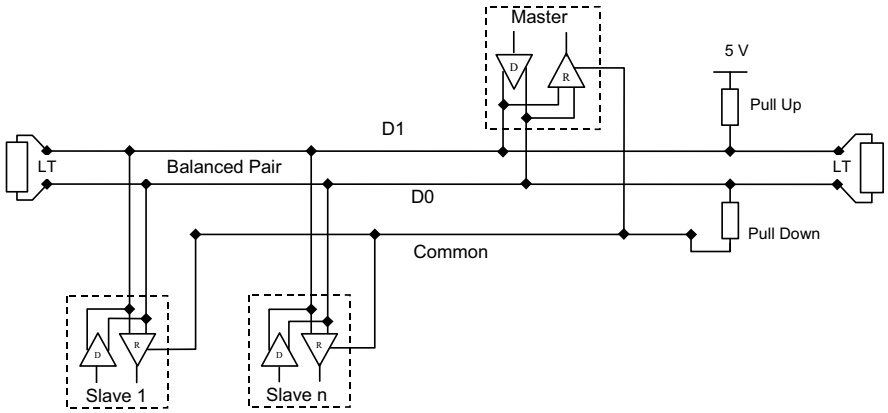
Also, only a subset of the Modbus function codes are implemented:

- Function code 3 (0x03) for read and function codes 6 (0x06) or 16 (0x10) for write of Holding Registers.
- Function code 4 (0x04) for read-only Input Register values.
- Function code 2 (0x02) for discrete (single-bit) read-only status values.

PHYSICAL LAYER

An RS-485 two-wire port is provided for the remote interface connection. The RS-485 wiring is designed to conform to the recommendations in the **Modbus Serial Line Protocol and Implementation Guide v1.02** for the Two-Wire topology available from the Modbus Organization.

The general 2-wire topology is illustrated in Figure 4-1 below. The line termination (LT) and Pull-up/Pull-down bias resistors are provided externally. *There are no internal termination or bias resistors installed in the VersaMassTer.* Please note that the Common is not exposed for connection on the VersaMassTer. The line drive voltage for the VersaMassTer is 5 V.



2W-MODBUS Circuits Definition

Required Circuits		For device	Required on device	EIA/TIA-485 name	Description
on ITr	on IDv				
D1	D1	I/O	**X**	B/B'	**Transceiver terminal 1, V1 Voltage** (V1 > V0 for binary 1 [OFF] state)
D0	D0	I/O	**X**	A/A'	**Transceiver terminal 0, V0 Voltage** (V0 > V1 for binary 0 [ON] state)
Common	Common	--	**X**	C/C'	Signal and optional Power Supply Common

FIGURE 4-1. General 2-wire RS-485 topology[1]

1. From "Modbus Serial Line Protocol and Implementation Guide v1.02", page 22.

MODBUS POLL APPLICATION

A special license is included for the ModbusPoll Windows application, developed by ModbusTools.com, that allows unlimited use of pre-defined VM7000 Workspaces for reading and writing via the Modbus interface.

Download and install the 32-bit Modbus Poll application trial version from the ModbusTools.com website via the following URL:

http://www.modbustools.com/download.asp

Once the Modbus Poll application is downloaded and installed, launch it and open the Workspace file: **VersaMassTer.mbw**. This Workspace file, and all associated panes, can be obtained by downloading a ZIP archive from the Delta M Corporation server at the following URL:

http://www.deltamcorp.com/modbus/vm7000.zip

Be sure to unzip all the files in the archive and place them all in the same folder. After the application is installed and the VersaMassTer Workspace is open, the screen should appear as illustrated in Figure 4-2 on page 46.

As can be observed in Figure 4-2, the *entire* Modbus register map is displayed in a convenient spreadsheet-like format. The color coding defines the data type of the each parameter as provided in Figure 4-3. Once a connection is made to the instrument, it is possible to double-click each parameter to gain access to a dialog that allows you to specify a value to write for that parameter.

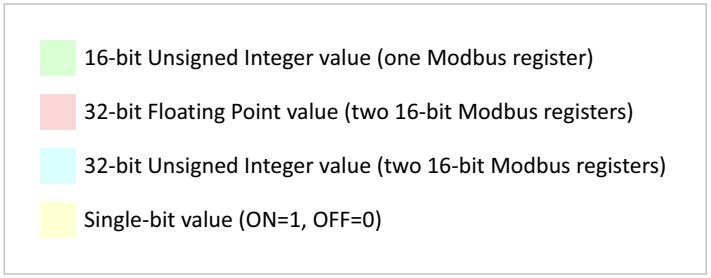


FIGURE 4-3. Color map definition for VersaMassTer Workspace

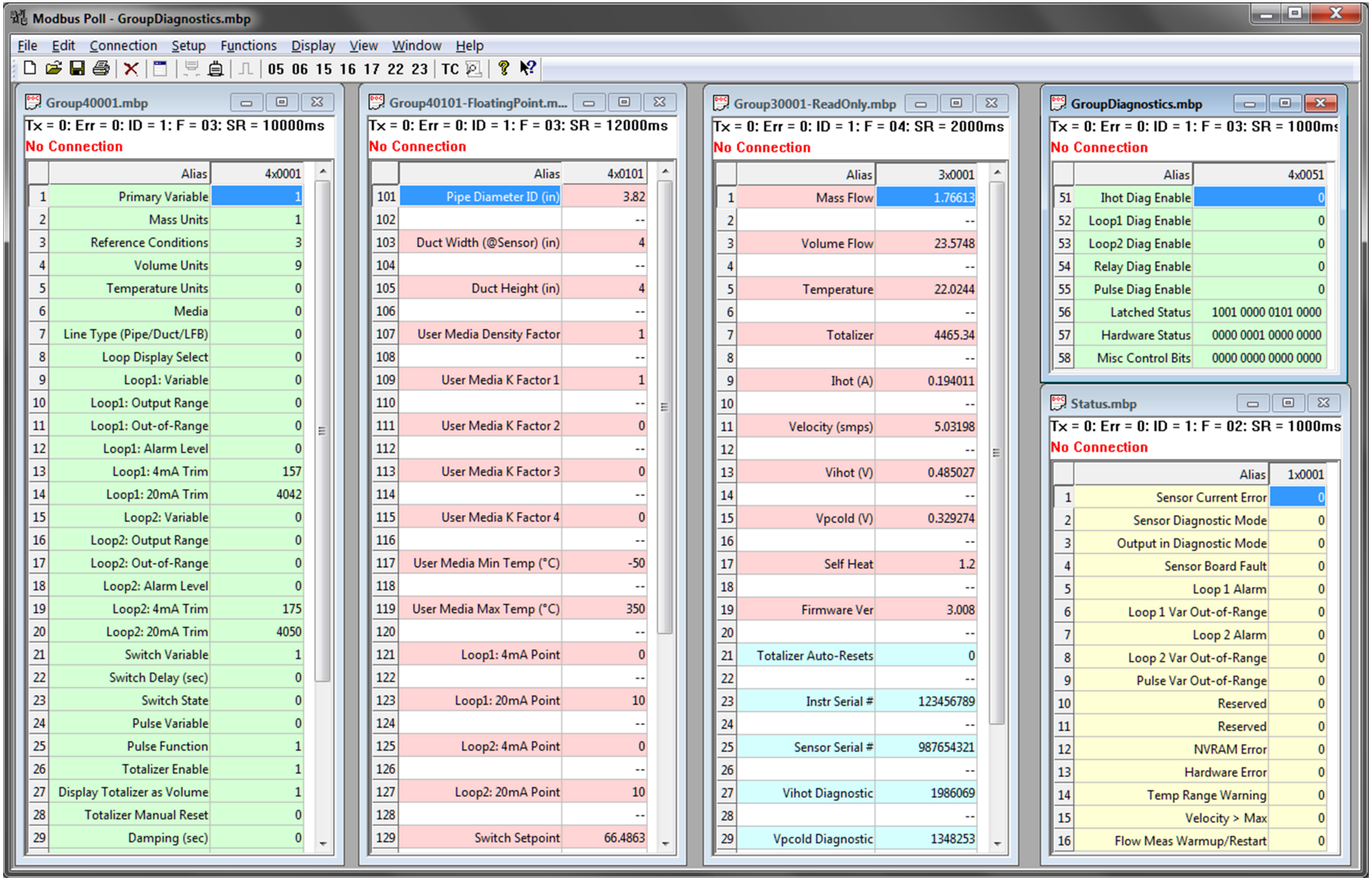
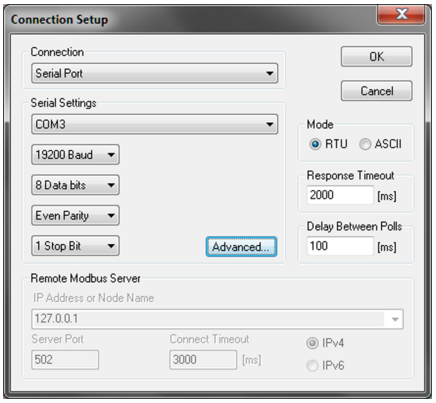


FIGURE 4-2. VersaMassTer Workspace in Modbus Poll application

CONNECT TO THE INSTRUMENT

The *Connection* ► *Connect...* dialog of the Modbus Poll application is used to establish communication with the target VersaMassTer. The Connect dialog is illustrated at right. Be sure to specify the correct COM port for the installation and Serial Settings. Both RTU and ASCII modes are supported by the VM7000 (RTU is recommended for bandwidth efficiency). A minimum value of 100 ms is recommended for the *Delay Between Polls* setting for the VM7000 RS-485 interface.



Once the connection is established, the Modbus Poll application will display a licensing notice panel. Enter the license code “DELTA M” (without the quotes but *including the space* between DELTA and M). This will enable unlimited use of the VersaMassTer Workspace provided. Please note that you cannot create a new Workspace or modify the existing Workspace without the full Modbus Poll license.

The Modbus Poll application has several useful features. Please use the Help provided in the Modbus Poll application (*Help* ► *Help Topics*) as well as the on-line resources at ModbusTools.com for further details on how to operate the Modbus Poll application. A PDF-formatted User Manual is also available for the Modbus Poll application at:

http://www.modbustools.com/PI_MBUS_300.pdf

MODBUS REGISTER MAP REFERENCE

The following sections detail the Modbus-compatible register map for the VM7000. The register map is designed to group similar data types in contiguous register space. This grouping is also reflected in the individual Modbus Poll files (*.mbp* file extension) that are part of the VersaMassTer Workspace. The grouping is intended to simplify the formatting of multiple register reads during coding for a programmer.

The Register ID follows the “plus 1” convention of identifying the register address. The Function Code and Protocol Address provide the function code and numerical address used to format an actual Modbus message. The Type heading includes UINT16 (unsigned 16-bit integer), UINT32 (unsigned 32-bit integer), and FLOAT (single-precision, 32-bit floating point) designations.

GROUP 40001

The following table documents Holding Registers 40001 through 40038.

Modbus Poll file: Group 40001.mpb					
Register ID	**Function Code**	**Protocol Address**	**Description**	**Type**	**Value**
40001	Read: 3 Write: 6	0	Primary Variable	UINT16	0 = Mass flow rate 1 = Volumetric flow rate 2 = Hot current
40002	Read: 3 Write: 6	1	Mass Flow Units	UINT16	0 = lb/s 1 = lb/m 2 = lb/h 3 = kg/s 4 = kg/m 5 = kg/h 6 = g/s 7 = g/m 8 = g/h
40003	Read: 3 Write: 6	2	Reference Conditions	UINT16	0 = Normal (0°C, 101.325 kPa) 1 = Metric (15°C, 101.325 kPa) 2 = US/NIST (20°C, 101.325 kPa) 3 = US/STP (70°F, 14.7 psia) 4 = IUPAC STP (0°C, 100 kPa)
40004	Read: 3 Write: 6	3	Volume Units	UINT16	0 = l/m 1 = l/h 2 = l/d 3 = m3/s 4 = m3/m 5 = m3/h 6 = cc/s 7 = cc/m 8 = cc/h 9 = CFM
40005	Read: 3 Write: 6	4	Temperature Units	UINT16	0 = Celsius 1 = Fahrenheit
40006	Read: 3 Write: 6	5	Media Selection	UINT16	0 = Dry Air 1 = Ammonia 2 = Argon 3 = Carbon Dioxide 4 = Carbon Monoxide 5 = Helium 6 = Methane 7 = Nitrogen 8 = Oxygen 9 = Propane 10 = User Media
40007	Read: 3 Write: 6	6	Line Type Selection	UINT16	0 = Pipe 1 = Duct 2 = Low Flow Block (read only)
40008	Read: 3 Write: 6	7	Gauge Display Selection	UINT16	0 = Loop 1 1 = Loop 2

Modbus Poll file: Group 40001.mpb					
Register ID	**Function Code**	**Protocol Address**	**Description**	**Type**	**Value**
40009	Read: 3 Write: 6	8	Loop 1: Variable Selection	UINT16	0 = Mass flow rate 1 = Volumetric flow rate 2 = Temperature 3 = Hot Current
40010	Read: 3 Write: 6	9	Loop 1: Output Range	UINT16	0 = 3.8 to 20.5 mA (NAMUR NE-43 Std) 1 = 4 to 20 mA
40011	Read: 3 Write: 6	10	Loop 1: Out-of-Range Behavior	UINT16	0 = Hold 1 = Alarm
40012	Read: 3 Write: 6	11	Loop 1: Alarm (Fault)	UINT16	0 = 3.6 mA 1 = 22 mA
40013	Read: 3 Write: 6	12	Loop 1: 4 mA Trim	UINT16	Trim value corresponding to 4 mA output
40014	Read: 3 Write: 6	13	Loop 1: 20 mA Trim	UINT16	Trim value corresponding to 20 mA output
40015	Read: 3 Write: 6	14	Loop 2: Variable Selection	UINT16	0 = Mass flow rate 1 = Volumetric flow rate 2 = Temperature 3 = Hot Current
40016	Read: 3 Write: 6	15	Loop 2: Output Range	UINT16	0 = 3.8 to 20.5 mA (NAMUR NE-43 Std) 1 = 4 to 20 mA
40017	Read: 3 Write: 6	16	Loop 2: Out-of-Range Behavior	UINT16	0 = Hold 1 = Alarm
40018	Read: 3 Write: 6	17	Loop 2: Alarm (Fault)	UINT16	0 = 3.6 mA 1 = 22 mA
40019	Read: 3 Write: 6	18	Loop 2: 4 mA Trim	UINT16	Trim value corresponding to 4 mA output
40020	Read: 3 Write: 6	19	Loop 2: 20 mA Trim	UINT16	Trim value corresponding to 20 mA output
40021	Read: 3 Write: 6	20	Switch (Relay) Variable Selection	UINT16	0 = Mass flow rate 1 = Volumetric flow rate 2 = Temperature 3 = Hot Current 4 = Totalizer
40022	Read: 3 Write: 6	21	Switch (Relay) Delay	UINT16	Delay in seconds
40023	Read: 3 Write: 6	22	Switch (Relay) State	UINT16	0 = Activated when Variable is greater than Set Point 1 = Deactivated when Variable is greater than Set Point
40024	Read: 3 Write: 6	23	Pulse Output Variable Selection	UINT16	0 = Mass flow rate 1 = Volumetric flow rate 2 = Temperature 3 = Hot Current
40025	Read: 3 Write: 6	24	Pulse Output Function	UINT16	0 = Cumulative 1 = Real-Time Proportional

Modbus Poll file: Group 40001.mpb					
Register ID	**Function Code**	**Protocol Address**	**Description**	**Type**	**Value**
40026	Read: 3 Write: 6	25	Totalizer Enable	UINT16	0 = Disabled 1 = Enabled
40027	Read: 3 Write: 6	26	Display Totalizer as Volume	UINT16	0 = Disabled 1 = Enabled
40028	Read: 3 Write: 6	27	Totalizer Manual Reset	UINT16	Any value write to the register resets the Totalizer to zero. Read always returns zero.
40029	Read: 3 Write: 6	28	Flow Damping	UINT16	Flow rate damping factor in seconds
40030	Read: 3 Write: 6	29	User Password	UINT16	4-digit User Password value (0000 to 9999)
40031	Read: 3 Write: 6	30	User Password Enable	UINT16	0 = Disabled 1 = Enabled
40032	Read: 3 Write: 6	31	User Password Timeout	UINT16	Timeout in seconds (60 to 999), default = 120 sec
40033	Read: 3 Write: 6	32	RS-485 (Slave) Address	UINT16	Slave address (1 - 247), default = 1
40034	Read: 3 Write: 6	33	Modbus Mode	UINT16	0 = ASCII 1 = RTU (default)
40035	Read: 3 Write: 6	34	RS-485 Serial Settings	UINT16	In RTU Modbus Mode: 0 = 9600-8-E-1 1 = 9600-8-N-2 2 = 19200-8-E-1 (default) 3 = 19200-8-N-2 4 = 38400-8-E-1 5 = 38400-8-N-2 In ASCII Modbus Mode the data bits are reduced to 7, otherwise identical to RTU.
40036	Read: 3 Write: 6	35	Key Sensitivity %	UINT16	50 to 100 in integer increments
40037	Read: 3 Write: 6	36	Display Backlight %	UINT16	10 to 100 in integer increments
40038	Read: 3 Write: 6	37	High Contrast Mode	UINT16	0 = Disabled 1 = Enabled

GROUP DIAGNOSTICS

The following table documents Holding Registers 40051 through 40058 that are allocated to diagnostic and status functions.

Modbus Poll file: GroupDiagnostics.mpb					
Register ID	**Function Code**	**Protocol Address**	**Description**	**Type**	**Value**
40051	Read: 3 Write: 6	50	Ihot Diagnostic Enable	UINT16	0 = Diagnostic Inactive 1 = Enabled When enabled, test DAC output is set to value of Register 40141. All flow rate measurements are suspended when enabled.
40052	Read: 3 Write: 6	51	Loop 1 Diagnostics	UINT16	0 = Diagnostic Inactive 1 = 3.6 mA 2 = 4.0 mA 3 = 8.0 mA 4 = 12.0 mA 5 = 16.0 mA 6 = 20.0 mA 7 = 22.0 mA
40053	Read: 3 Write: 6	52	Loop 2 Diagnostics	UINT16	0 = Diagnostic Inactive 1 = 3.6 mA 2 = 4.0 mA 3 = 8.0 mA 4 = 12.0 mA 5 = 16.0 mA 6 = 20.0 mA 7 = 22.0 mA
40054	Read: 3 Write: 6	53	Switch (Relay) Diagnostics	UINT16	0 = Diagnostic Inactive 1 = Relay Activated 2 = Relay Deactivated
40055	Read: 3 Write: 6	54	Pulse Output Diagnostics	UINT16	0 = Diagnostic Inactive 1 = 0 Hz 2 = 500 Hz 3 = 1 kHz
40056	Read: 3 Write: 6	55	Latched Status Register Summary	UINT16	Register bits are equivalent to the Status Registers (20001-16). This register saves (i.e. "latches") the ON status of any flag until cleared by the operator. It indicates a latched history of the Status register. Register is cleared by a power cycle.

Modbus Poll file: GroupDiagnostics.mpb					
Register ID	**Function Code**	**Protocol Address**	**Description**	**Type**	**Value**
40057	Read: 3 Write: 6	56	Hardware Fault Summary	UINT16	Register bits[a] remain set until cleared by a power cycle and correspond to the following faults: **Bit 1 ON:** Sensor non-volatile memory failed checksum. **Bit 2 ON:** Sensor non-volatile memory failed to communicate. **Bit 3 ON:** Sensor non-volatile memory addressed outside of valid range. **Bit 4 ON:** User settings non-volatile memory failed checksum. **Bit 5 ON:** User settings non-volatile memory failed to communicate. **Bit 6 ON:** User non-volatile memory addressed outside of valid range.. **Bit 7 ON:** ADC data timeout. **Bit 8 ON:** ADC range error. **Bit 9 ON:** Real-Time Clock failure.
40058	Read: 3 Write: 6	57	Miscellaneous Control Bits	UINT16	Register bits[a] are persistent between power cycles (unless otherwise noted) and correspond to: **Bit 1 ON:** Reset and reinitialize the ADC. This bit clears when the reinitialization is complete. **Bit 2 ON:** Disables the automatic sensor current recovery function. **Bit 5 ON:** Disables Loop 1 output. **Bit 6 ON:** Disables Loop 2 output. **Bit 7 ON:** Disables the Pulse output.

a. Bits are referenced starting at Bit 1 as the LSB (Least Significant Bit).

GROUP 40101 FLOATING POINT

The following table documents Holding Registers 40101 through 40141. All registers in this group are 32-bit floating point values.

Modbus Poll file: Group 40101-FloatingPoint.mpb					
Register ID	**Function Code**	**Protocol Address**	**Description**	**Type**	**Value**
40101	Read: 3 Write: 16	100-101	Pipe Diameter[a]	FLOAT	Pipe diameter (ID) in inches
40103	Read: 3 Write: 16	102-103	Duct Width	FLOAT	Internal width of duct side where sensor is inserted in inches
40105	Read: 3 Write: 16	104-105	Duct Height	FLOAT	Internal height of duct in inches
40107	Read: 3 Write: 16	106-107	User Media Density Factor	FLOAT	User media density factor relative to Dry Air @ 15° C, 1 atm
40109	Read: 3 Write: 16	108-109	User Media K Factor 1	FLOAT	User media K factor
40111	Read: 3 Write: 16	110-111	User Media K Factor 2	FLOAT	User media K factor
40113	Read: 3 Write: 16	112-113	User Media K Factor 3	FLOAT	User media K factor
40115	Read: 3 Write: 16	114-115	User Media K Factor 4	FLOAT	User media K factor
40117	Read: 3 Write: 16	116-117	User Media Minimum Temperature	FLOAT	Minimum valid temperature in °C for User Media factors
40119	Read: 3 Write: 16	118-119	User Media Maximum Temperature	FLOAT	Maximum valid temperature in °C for User Media factors
40121	Read: 3 Write: 16	120-121	Loop 1: 4 mA Point (LRV)	FLOAT	Selected Loop 1 variable value in present units corresponding to 4 mA output
40123	Read: 3 Write: 16	122-123	Loop 1: 20 mA Point (URV)	FLOAT	Selected Loop 1 variable value in present units corresponding to 20 mA output
40125	Read: 3 Write: 16	124-125	Loop 2: 4 mA Point (LRV)	FLOAT	Selected Loop 2 variable value in present units corresponding to 4 mA output
40127	Read: 3 Write: 16	126-127	Loop 2: 20 mA Point (URV)	FLOAT	Selected Loop 2 variable value in present units corresponding to 20 mA output
40129	Read: 3 Write: 16	128-129	Switch (Relay) Set Point	FLOAT	Switch Set Point for selected variable in present units
40131	Read: 3 Write: 16	130-131	Switch (Relay) Dead-band	FLOAT	Dead-band for selected Switch variable in present units (±½ Dead-band centered on Set Point)
40133	Read: 3 Write: 16	132-133	Pulse Output: 0 Hz Point (LRV)	FLOAT	Selected Pulse variable value in present units corresponding to 0 Hz output
40135	Read: 3 Write: 16	134-135	Pulse Output: 1 kHz Point (URV)	FLOAT	Selected Pulse variable value in present units corresponding to 1 kHz output
40137	Read: 3 Write: 16	136-137	Totalizer Auto Reset Value	FLOAT	Automatic reset value for Totalizer in present Totalizer Units (e.g. total lb for lb/s, see Register 30033)

Modbus Poll file: Group 40101-FloatingPoint.mpb					
Register ID	Function Code	Protocol Address	Description	Type	Value
40139	Read: 3 Write: 16	138-139	Flow Minimum Value	FLOAT	Low flow cutoff value in units of Mass or Volume Flow primary variable (see Register 30035)
40141	Read: 3 Write: 16	140-141	Ihot Diagnostic DAC Output Level (V)	FLOAT	Ihot diagnostic output level, default value = 0.8 V, ~ 150mA (not saved between power cycles)

a. Pipe Diameter is read-only for Low Flow Block sensor configuration.

GROUP 30001 READ ONLY

The following table documents read-only Input Registers 30001 through 30035. Various types are mixed in this group. This group contains the measurement values for all variables.

Modbus Poll file: Group 30001-ReadOnly.mpb					
Register ID	Function Code	Protocol Address	Description	Type	Value
30001	4	0-1	Mass Flow Rate	FLOAT	Present Mass Flow Rate in selected Mass Units
30003	4	2-3	Volumetric Flow Rate	FLOAT	Present Volumetric Flow Rate in selected Volume Units
30005	4	4-5	Temperature	FLOAT	Present Temperature in selected Temperature Units
30007	4	6-7	Totalizer	FLOAT	Present Totalizer value in Totalizer Units (30033)
30009	4	8-9	Hot Current (A)	FLOAT	Present Ihot (Hot Current) value in amperes
30011	4	10-11	Velocity (smps)	FLOAT	Present bulk gas velocity in pipe/duct, always in units of standard m/s (smps)
30013	4	12-13	Vihot (V)	FLOAT	Hot sensor measurement in volts
30015	4	14-15	Vpcold (V)	FLOAT	Cold sensor (V´or ‘V-prime’) measurement in volts
30017	4	16-17	Sensor Self-Heating Ratio	FLOAT	Default value = 1.146
30019	4	18-19	Firmware Version	FLOAT	Example: 3.009
30021	4	20-21	Totalizer Auto Reset Count	UINT32	Cumulative number of Totalizer Auto Resets
30023	4	22-23	Instrument Serial #	UINT32	
30025	4	24-25	Sensor Serial #	UINT32	
30027	4	26-27	Vihot Diagnostic	UINT32	Raw Ihot ADC measurement in ADC counts
30029	4	28-29	Vcold Diagnostic	UINT32	Raw Vcold ADC measurement in ADC counts
30031	4	30-31	ADC Temp Diagnostic	FLOAT	Internal Temperature of ADC in °C

Modbus Poll file: Group 30001-ReadOnly.mpb					
Register ID	**Function Code**	**Protocol Address**	**Description**	**Type**	**Value**
30033	4	32	Totalizer Units	UINT16	Present Totalizer Units: 0 = lb 1 = kg 2 = g 3 = l 4 = m3 5 = cc 6 = CF
30034	4	33	Slave Address	UINT16	Read-only RS-485 Slave Address (1-247)
30035	4	34	Flow Minimum Value Units	UINT16	Low flow cutoff value units (see Register 40139) 0 = lb/s 1 = lb/m 2 = lb/h 3 = kg/s 4 = kg/m 5 = kg/h 6 = g/s 7 = g/m 8 = g/h 9 = l/m 10 = l/h 11 = l/d 12 = m3/s 13 = m3/m 14 = m3/h 15 = cc/s 16 = cc/m 17 = cc/h 18 = CFM

DISCRETE STATUS

The following table documents the read-only Status Bits 20001 through 20016. The returned bits are packed according to the Modbus protocol specification into one or more bytes depending on the message request. This group is also summarized in the Latched Status register 40056.

Modbus Poll file: Status.mpb					
Register ID	**Function Code**	**Protocol Address**	**Description**	**Type**	**Value**
20001	2	0	Sensor Current Error	1 BIT	ON = Sensor current fault condition
20002	2	1	Sensor Current Diagnostic Mode	1 BIT	ON = Device is in Ihot test mode. *Flow measurements are suspended.*
20003	2	2	Output in Diagnostic Mode	1 BIT	ON = Loop, Pulse, or Switch output is in a test mode
20004	2	3	Sensor Board Fault	1 BIT	ON = Fault in sensor board (see Register 40057 for fault detail)
20005	2	4	Loop 1 Alarm	1 BIT	ON = Loop 1 Alarm condition
20006	2	5	Loop 1 Out-of-Range	1 BIT	ON = Out-of-range measurement for present Loop 1 configuration
20007	2	6	Loop 2 Alarm	1 BIT	ON = Loop 2 Alarm condition
20008	2	7	Loop 2 Out-of-Range	1 BIT	ON = Out-of-range measurement for present Loop 2 configuration
20009	2	8	Pulse Output Variable Out-of-Range	1 BIT	ON = Out-of-range measurement for present Pulse Output configuration
20010	2	9	Reserved	1 BIT	Reserved for future use
20011	2	10	Reserved	1 BIT	Reserved for future use
20012	2	11	NVRAM Error	1 BIT	ON = Non-volatile storage of settings failed (see Register 40057 for more fault detail)
20013	2	12	Hardware Error	1 BIT	ON = Internal hardware failure (see Register 40057 for more fault detail)
20014	2	13	Temperature Range Warning	1 BIT	ON = Present temperature outside of recommended operational range
20015	2	14	Gas Velocity Exceeds Recommended Maximum	1 BIT	ON = Present bulk gas velocity exceeds the recommended operational range. Flow measurement may be inaccurate.
20016	2	15	Flow Measurement Warm-up/Restart	1 BIT	ON = Device is presently in a sensor current warm-up phase from a power cycle, or is restarting after a Diagnostic session.

MAINTENANCE, TROUBLESHOOTING, AND REPAIR

SENSOR MAINTENANCE

The sensor probe can be cleaned by soaking, spraying solvents or detergent-and-water on the sensor or by ultrasonic cleaning.

Lime deposits can be safely removed by soaking in 20% hydrochloric acid. Warming to 65°C (150°F) is permissible to speed this process.

For unusual cleaning problems, contact Delta M to determine the exact materials of construction and chemical compatibility before using strong acids or unusual cleansers.

— IMPORTANT —

DO NOT SANDBLAST OR ABRASIVELY CLEAN THE SENSING PROBES. THE SENSING PROBES CAN BE DAMAGED BY ABRASIVES.

TROUBLESHOOTING AND REPAIR

INSTALLATION VERIFICATION

Before troubleshooting the instrument verify that power, mechanical, and electrical configurations are correct. Operation of the instrument can be affected by any of the following:

1. Verify that power supplied to the unit is of the correct voltage and polarity (see Figure 2-4 on page 10).
2. Verify the mechanical installation is correct (see page 6).
3. Verify the electrical installation is correct (see page 8).

POWER VERIFICATION

To verify the power supply to the instrument:

1. Remove the field-side (i.e. the side opposite the display window) enclosure cover by unscrewing it counter-clockwise.
2. Check the label below the power terminals (see Figure 2-4 on page 10) to ascertain whether the instrument is AC or DC.
3. Apply power and measure the voltage between power terminals (see Figure 2-4 on page 10) using a DVM, verifying that the type (AC or DC), voltage, and polarity are correct.

INSTRUMENT DIAGNOSTICS RESOLUTION

If the flow meter display is indicating a non-zero value for the Current Status (see page 40), decode the Status register and use the DIAGNOSTIC WARNING and DIAGNOSTIC ERROR tables below as a guide for determining and correcting the problem.

NOTE: The instrument enclosure does not allow for convective ventilation of the internal components. The unit is rated for operation to +60 °C (+140 °F) maximum external ambient temperature. Operation beyond that ambient temperature, or in an environment with significant radiant heat sources, can result in overheating of the internal components. Isolate the electronics from excessive heat sources using the Remote Electronics mount option if necessary.

DIAGNOSTIC WARNING	POSSIBLE CAUSE	POSSIBLE FIX
Loop1 Variable Out-of-Range	Selected Variable is out-of-range of the URV and LRV values for Loop1	Check the process for expected Variable range and increase URV or decrease LRV if necessary (see page 27)
Loop2 Variable Out-of-Range	Selected Variable is out-of-range of the URV and LRV values for Loop2	Check the process for expected Variable range and increase URV or decrease LRV if necessary (see page 29)
Pulse Output Variable Out-of-Range	Selected Variable is out-of-range of the URV and LRV values for the Pulse Output	Check the process for expected Variable range and increase URV or decrease LRV if necessary (see page 32)
Temperature Range Warning	The measured flow stream temperature exceeds the recommended maximum	Check the process for expected temperature range and adjust to maintain within the specified probe range (see page 66). Measurements beyond the recommended range may not be within specifications.
Gas Velocity Warning	The measured bulk gas velocity exceeds the recommended maximum	Check the process for expected flow rate range and adjust to maintain within the specified range (see page 63). Measurements beyond the recommended maximum velocity may not be within specifications.

DIAGNOSTIC ERROR	POSSIBLE CAUSE	POSSIBLE FIX
Sensor Current Error[a]	Bad probe connection	Check remote probe wiring (see Figure 2-7 on page 15)[b]
	Ground loop	Check outputs wiring (see Figure 2-5 on page 11) and ensure the outputs remain isolated
Sensor Board Fault	Bad internal power or signal cabling interconnect	Contact an Authorized Delta M Representative for more assistance
NVRAM Error or Hardware Error	Unstable power supply	Check facility power for proper ratings. Cycle power and observe if error repeats.
	Excessive EMI	Relocate electronics away from EMI source using Remote Electronics option. Cycle power and observe if error repeats.
	Internal overheating	Relocate electronics away from heat source using Remote Electronics option. Cycle power and observe if error repeats.

a. The instrument is setup by default to detect sensor current errors and will continually attempt to reset the hardware and restart flow measurements until the error clears.

b. Contact an Authorized Delta M Representative for assistance with an integrally-mounted probe.

If the error remains after verifying the facilities, mechanical components, and diagnostics, contact an Authorized Delta M Representative for additional assistance.

PROCESS OR APPLICATION ISSUES

Most problems should have been determined by the procedures outlined previously. If not, additional scenarios are listed below. If the instrument needs to be returned, please see page 72 for a Return Authorization Form.

PROBLEM	POSSIBLE CAUSE	POSSIBLE FIX
Mass Flow Indication is Erratic	Sensor is in wrong position	Check sensor depth and orientation (see page 6). Probe tip should be approximately centered in the pipe or duct.
	Flow is non-uniform or fluctuating	Add flow conditioner, longer straight run before sensors, or select another location for instrumentation (see page 5)
	Ground loop	Check outputs wiring (see Figure 2-5 on page 11) and ensure the outputs remain isolated
Mass Flow Indication is in Known Error	Incorrect line type (pipe or duct) and size	Enter correct line type and size (see page 24)
	Incorrect media selection	Select correct media (see page 24)

PROBE VERIFICATION

Probe verification can only be performed for a Remote Electronics configuration as shown in Figure 2-7 on page 15. There is no ready access provided for the wiring of a probe integrally-mounted to the instrument enclosure. Please contact an Authorized Delta M Representative for assistance with troubleshooting an integrally-mounted probe.

With the power off, remove the field-side cover and measure resistance between the pins of the connector labeled 1 through 7 (see Figure 2-7 on page 15) as shown in the table below.

Pin-to-Pin	Expected Resistance[a] (Ω)	Comments
1-to-3	0 to1 Ω	Sensing
2-to-4	0 to 1 Ω	Sensing
5-to-6	0 to1 Ω	Sensing
3-to-5	10.7 to 11.0 Ω minus $\overline{\text{Sensing}}$	Hot sensor

Pin-to-Pin	Expected Resistance[a] (Ω)	Comments
4-to-5	1070 to 1100 Ω minus $\overline{\text{Sensing}}$	Cold (reference) sensor

a. Expected values for room temperature (20-25°C or 68-77°F)

For the Remote Probe there is an added resistance approximately 1Ω per 50 feet of cable to the table values. The cable resistance will be measured by the first three measurements in the above table (measurements between pins 1-3, 2-4, and 5-6). To obtain an accurate resistance of the hot and cold sensors, subtract the average cable resistance of the three sensing measurements ($\overline{\text{Sensing}}$) from the total resistance obtained for the hot and cold sensors.

If the sensors are at a process temperature, T_a, other than room temperature, calculate the expected resistances by the following equation:

$$R_T = R_0(1 + \alpha T_a)$$

where:

R_T = Resistance (Ω) of the sensor at temperature T_a.

R_0 = Sensor characteristic resistance (see calibration certificate for values; typically 10Ω for hot sensor and 1000Ω for cold sensor).

α = Sensor temperature coefficient of resistance in Ω/Ω/°C (typically 0.00385).

T_a = Sensor actual temperature in °C, should be accurate to ~ ± 1°C.

Example cold sensor calculation:

$$R_T = 1000(1 + 0.00385 \times 25.0) = 1096.25\Omega$$

If the *measured* and *expected/calculated* resistances of each sensor differs by more than a few percent, then there is either a sensor wiring problem or the sensor probe itself is faulty.

SPECIFICATIONS

INSTRUMENT SPECIFICATIONS

DESCRIPTION	SPECIFICATIONS
FLOW MEDIA	AIR ONLY, OTHER SELECTED GASES USING POLYNOMIAL K-FACTOR
LINE SIZES	1/2, 3/4, 1, 1.5, 2, 3, 4, 6, 8, 10, 12 INCH OPTIONALLY GREATER THAN 12 INCHES
FLOW RANGE	0 TO 100 SMPS[1] FOR AIR
FLOW ACCURACY	± 1% OF READING PLUS ± 0.2% FULL SCALE
TURNDOWN	100:1 STANDARD, OPTIONALLY UP TO 1000:1
REPEATABILITY	± 0.5% OF READING FOR GASES
TEMPERATURE ACCURACY	± 1°C (± 1.8°F) ACROSS RANGE OF -50 TO 350°C (-58 TO 650°F)
TEMPERATURE EFFECT	IN SPEC WITHIN ± 30°C (± 54°F) OF CALIBRATION TEMPERATURE FOR 100:1 TURNDOWN

1. SMPS = standard meters/second

TIME RESPONSE	0.5 TO 10 SECONDS (MEDIA DEPENDENT)
CALIBRATION	NIST TRACEABLE OR EQUIVALENT
POWER REQUIREMENT	**DC:** 18–30 VDC, 0.7 A MAX **AC:** 90–260 VAC, 47–63 HZ, 15 W
ELECTRONICS TEMPERATURE RATING	-20 TO +60°C (-4 TO +140°F)
MEASURED VARIABLES	MASS FLOW VOLUMETRIC FLOW TEMPERATURE HOT CURRENT TOTAL FLOW
OUTPUT TYPES	**ANALOG:** DUAL 4-20 mA, ISOLATED, WITH EXTERNAL LOOP POWER **PULSE:** 0-1 kHz, ISOLATED, WITH EXTERNAL POWER **DIGITAL:** ISOLATED RS-485 AND SHORT-RANGE WIRELESS **SWITCH:** SPDT RELAY, 6A/250VAC/ 1500VA MAXIMUM **DISPLAY:** 400x240 PIXEL COLOR TFT
USER INTERFACE	REMOTE WINDOWS®-BASED INTERFACE VIA MODBUS COMPATIBLE PROTOCOL AND INCLUDED MODBUS POLL LICENSE OR LOCAL DISPLAY/KEYPAD
REMOTE COMM CABLE LENGTH	2000 FEET MAX, CONSULT FACTORY FOR LONGER LENGTHS

DIAGNOSTICS	SENSOR AND ELECTRONICS ARE MONITORED AT ONE SECOND INTERVALS USER SELECTABLE 3.6mA OR 22mA FAULT SIGNALS ARE AVAILABLE FOR LOOP OUTPUTS
ENCLOSURE	**STANDARD:** DOUBLE-SIDED, NON-EXPLOSION PROOF, CAST Al.
OTHER OPTIONS	REMOTE ELECTRONICS LINE SIZES GREATER THAN 12 INCHES
MECHANICAL CONFIGURATION	ROTATION OF DISPLAY TO PROVIDE DISPLAY ORIENTATION IN 90 DEGREE INCREMENTS

PROBE SPECIFICATIONS

DESCRIPTION	SPECIFICATIONS
SENSOR TYPE	STAINLESS STEEL PROBE WITH HASTELLOY C TWIN TIPS
REMOTE SENSOR CABLE LENGTH	100 FEET MAX, CONSULT FACTORY FOR LONGER LENGTHS
MATERIALS	HASTELLOY C SENSOR TIPS WITH 316L SS PROBE BODY STANDARD CONSULT FACTORY FOR ADDITIONAL MATERIAL OPTIONS
PROCESS CONNECTION	MNPT FITTING STANDARD OPTIONAL SWAGELOK OR 150 TO 300 LB FLANGES SPOOL-PIECES AVAILABLE FOR ½ TO 4 INCH LINE SIZES SENSOR FOR LOW FLOW APPLICATIONS AVAILABLE
TEMPERATURE RATING	**GAS STANDARD:** -50° TO +150°C (-58° TO +300°F) **MEDIUM TEMP:** TO +250°C (+480°F) **HIGH TEMP:** TO +350°C (+650°F)
PRESSURE RATING	TO 3000 PSIG

WARRANTY AND SERVICE

WARRANTY

For a period of one year from the date of shipment DELTA M Corporation will repair or replace this product in the event of a defect in materials or workmanship. To have a product repaired it should be returned at customer's expense, after obtaining a return authorization as provided on page 72, to a repair facility designated by Delta M. After repair, Delta M will prepay transportation for the return of the product to the customer. This limited warranty only covers failures due to defects in materials or workmanship which occur during normal use.

LIMITS AND EXCLUSIONS

DELTA M CORPORATION SHALL NOT BE LIABLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, LOSS OF USE, LOSS OF SALES, OR INCONVENIENCE) RESULTING FROM THE USE OF THESE PRODUCTS, OR ARISING OUT OF ANY BREACH OF THIS WARRANTY. EXCEPT AS SET FORTH ABOVE, THERE ARE NO EXPRESSED OR IMPLIED WARRANTIES OR WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

SERVICE

To receive prompt service call DELTA M's Customer Service Department at (865) 483-1569 or toll free 1-800-922-0083. A representative will assist you in determining if the unit must be returned to the factory. A Return Authorization Number (RAN) will be given and should be clearly visible on the outside of the returning package. **Prior to calling, be sure to have the model number and serial number information for quick identification and service response.**

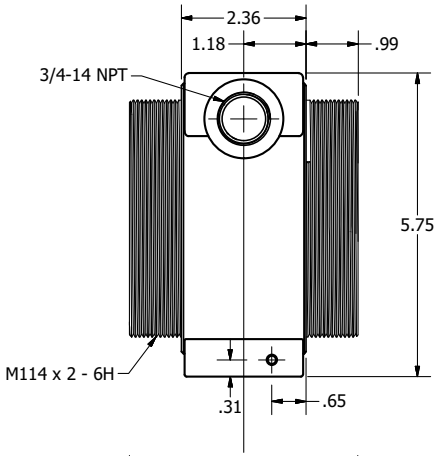
In addition to the RAN, the Return Shipment Form should be attached to the packing list. This form is available at Delta M's website (www.deltamcorp.com), from the Customer Service Representative, or on page 72 of this manual. **The package will be returned unopened to the customer at the customer's expense if the Return Shipment Form and RAN are not present on the outside of the package.**

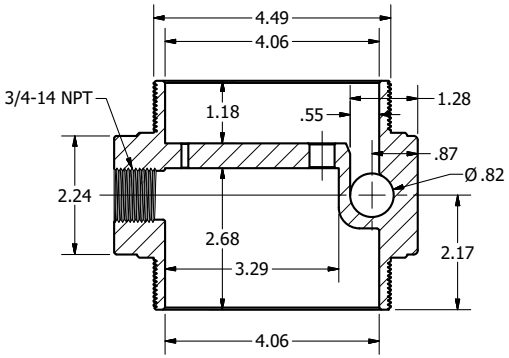
Because we serve a diverse customer base, there is a risk of receiving contaminated returned material from our customers. **When uncleaned material is received at Delta M, the item will be returned to the customer for cleaning at the customer's expense.**

NOTE: TO ENSURE THE SAFETY OF SHIPPING CARRIERS AND DELTA M PERSONNEL, ANY PACKAGE THAT DOES NOT HAVE THE RETURN SHIPMENT FORM AND RETURN AUTHORIZATION NUMBER PRESENT ON THE OUTSIDE OF THE PACKAGE WILL BE RETURNED TO THE CUSTOMER AT THE CUSTOMER'S EXPENSE.

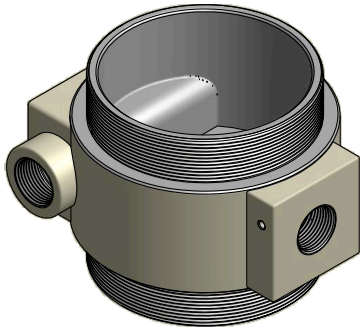
APPENDIX

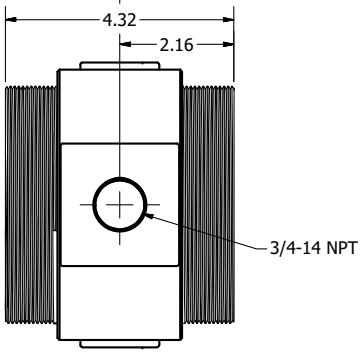
The Appendix contains the following drawings, tables, or forms that the user may find informative:

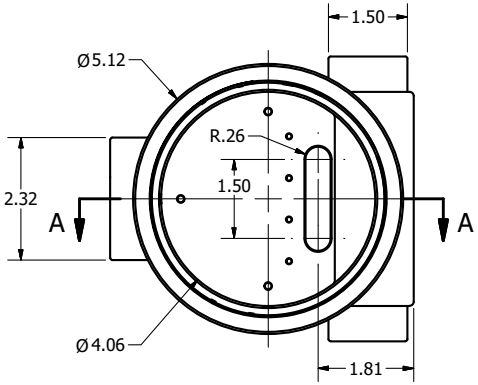


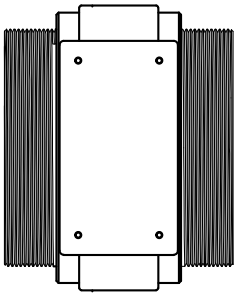


SECTION A-A









REVISION	REVISED BY	ECO NUMBER	DATE	APPROVED	

NEXT ASSY:

DIR: ELECT DWG | FOLDER: DESIGN

ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

TOLERANCES

DECIMALS: .X +/- 0.030, .XX +/- 0.020, .XXX +/- 0.010

FRACTIONS: +/- 1/32

ANGULAR: +/- 0' 0.30"

FINISH: ✓

DO NOT SCALE THIS DRAWING

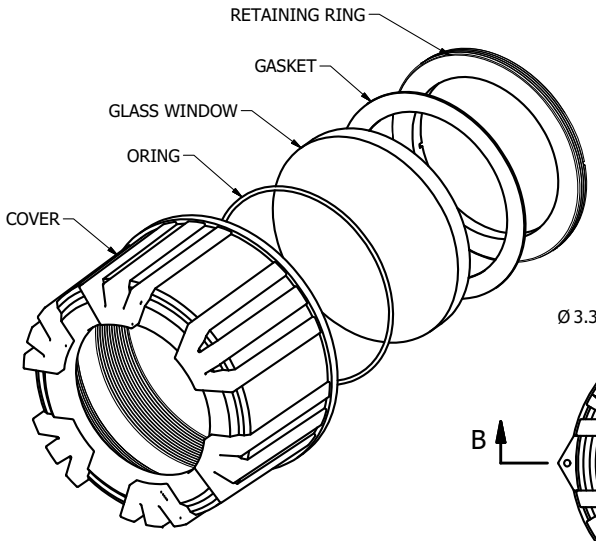
APPROVALS		
DESIGNED BY:		DATE:
DRAWN BY:		DATE:
ENGINEERING:		DATE:
VERIFICATION:	NOT REQ'D	DATE:
DEPT. MANAGER:		DATE:
DOCUMENT CONTROL:		DATE:

DELTA CORPORATION

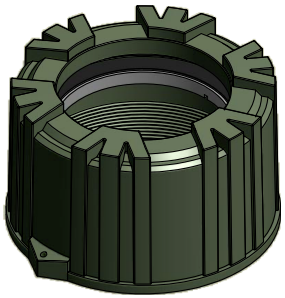
1003 LARSEN DRIVE
OAK RIDGE, TN 37830

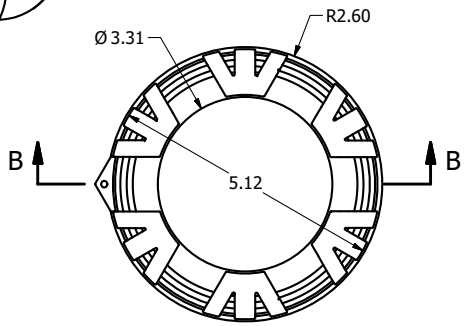
VersaMassTer ENCLOSURE

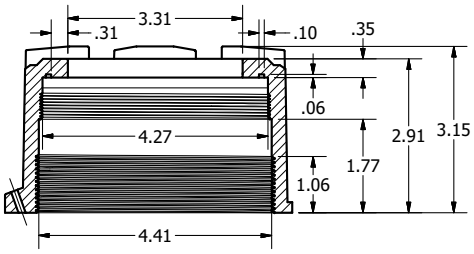
SCALE: 1:2	SIZE: B	DWG. No.: MM14072401	REV.: 00
SHEET: 1 OF: 2			



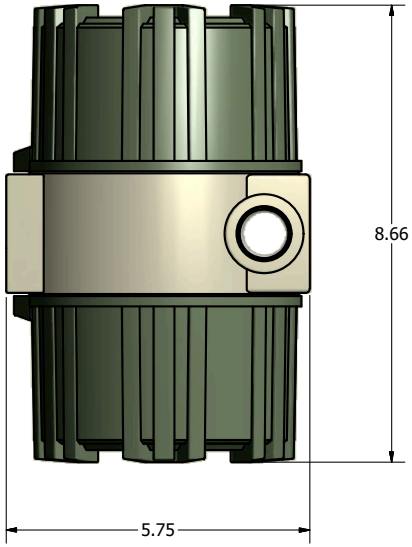
COVER ASSY







SECTION B-B



REVISION	REVISED BY	ECO NUMBER	DATE	APPROVED	

NEXT ASSY:

DIR: ELECT DWG | FOLDER: DESIGN

ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

TOLERANCES

DECIMALS: .X +/- 0.030, .XX +/- 0.020, .XXX +/- 0.010

FRACTIONS: +/- 1/32

ANGULAR: +/- 0' 0.30"

FINISH: ✓

DO NOT SCALE THIS DRAWING

APPROVALS		
DESIGNED BY:		DATE:
DRAWN BY:		DATE:
ENGINEERING:		DATE:
VERIFICATION:	NOT REQ'D	DATE:
DEPT. MANAGER:		DATE:
DOCUMENT CONTROL:		DATE:

DELTA CORPORATION 1003 LARSEN DRIVE OAK RIDGE, TN 37830

VersaMassTer ENCLOSURE

SCALE: 1:2	SIZE:	DWG. No.:	REV.:
SHEET: 2 OF: 2	B	MM14072401	00

RETURN SHIPMENT

Ship to: Delta M Corporation
1003 Larsen Drive
Oak Ridge, TN 37830
Phone: (800) 922-0083
Fax: (865) 483-1142

If you believe your unit is not working properly, contact the Delta M Customer Service Department. Please have the following information ready to give to the Delta M Customer Service Representative:

*Defective Unit's Model Number: *Date:

*Defective Unit's Serial Number:

*Description of Application Unit was used in:

*Description of Type of Environment Unit was used in:

Description of Perceived Problem:

Special QA Requirements (nuclear or military application, oxygen service, special calibration or certification, etc.):

*Technical Contact's Name:

*Technical Contact's Phone Number:

*Complete Shipping Address:

*Complete Billing Address:

You will then be issued a RAN number. **Delta M personnel will refuse to accept return material shipments if a RAN number is not visible on the outside surface of the shipping container.**

*RAN (Return Authorization Number)

Cleaning of Material to be Returned

Thoroughly clean all material to be returned to Delta M. Because we serve a diverse customer base, there is a risk of receiving contaminated returned material from our customers. **When uncleaned material is received at Delta M, the item will be returned to the customer for cleaning at the customer's expense.**

Shipping Material to be Returned

Securely package cleaned material. **(When uncleaned material is received at Delta M the material will be returned.)** A packing list referencing the RAN number, model number and serial number should be in the sturdy shipping container with the return address and RAN number clearly marked on the outside surface of the container. **Delta M personnel will refuse to accept returns if a RAN number is not visible on the outside surface of the shipping container.**

*Required Fields

QSP-7.2-3

P

R

S

T

U

V

W