

User's manual

Sentinel™ LCT8

High accuracy ultrasonic liquid flow meter



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Services



Panametrics provides customers with an experienced staff of customer support personnel ready to respond to technical inquiries, as well as other remote and on-site support needs. To complement our broad portfolio of industry-leading solutions, we offer several types of flexible and scalable support services including: Training, Product Repairs, Service Agreements and more.

Please visit <https://panametrics.com/services> for more details.

Typographical Conventions

Note: These paragraphs provide information that provides a deeper understanding of the situation, but is not essential to the proper completion of the instructions.

IMPORTANT: These paragraphs provide information that emphasizes instructions that are essential to proper setup of the equipment. Failure to follow these instructions carefully may cause unreliable performance.



CAUTION! This symbol indicates a risk of minor personal injury and/or damage to the equipment unless these instructions are followed carefully.



WARNING! This symbol indicates a risk of serious personal injury unless these instructions are followed carefully.

Safety Issues



WARNING! It is the responsibility of the user to follow all site rules and applicable regulatory requirements.



IMPORTANT Any instructions on grounding and cable termination in this manual are necessary for compliance with global EMC / RFI standards. Such compliance may be required by National EMC / RFI legislation.

Local Safety Standards

The user shall ensure that he operates the equipment in accordance with the applicable local codes, standards, regulations, or laws.

Qualification of Personnel

Ensure that all personnel have applicable training to use the equipment.

Personal Safety Equipment

Ensure that operators and maintenance personnel have all safety equipment applicable.

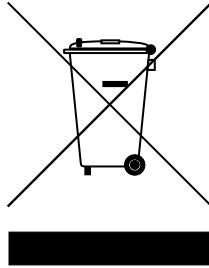
Unauthorized Operation

Ensure that unauthorized personnel cannot gain access to the operation of the equipment.

Environmental Compliance

Waste Electrical and Electronic Equipment

This apparatus required the extraction and use of natural resources for its production. It may contain hazardous substances that could impact health and the environment. To avoid the dispersal of these substances into our environment and to reduce the pressure on natural resources, we encourage you to use an appropriate “take-back” resource recovery scheme. These schemes will reuse or recycle most of the materials of your end-of-life equipment in an environmentally responsible way. The crossed-out wheeled bin symbol marked on the product invites you to use such a scheme.



If you need more information on the collection, reuse and recycling systems, please contact your local waste management administration.

As part of its commitment to the environment and the EU's WEEE Directive 2012/19/EU, Panametrics participates in a take-back scheme.

Please visit <https://panametrics.com/health-safety-and-environment-hse> for take-back instructions and more information about this initiative.

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Appendix C. Modbus register map

Chapter 1. General information

1.1 Theory of operation

The **Sentinel LCT8** measurement system uses ultrasonic transit-time technology. A brief description of transit-time theory follows. For more information about the theory, and the use of Panametrics ultrasonic flow meters for measuring flow, please refer to *Ultrasonic measurements for process control* by L.C. Lynnnworth (Academic Press, 1989).

1.1.1 Transit-time method

The transit time technique uses a pair of transducers, with each transducer alternately sending and receiving coded ultrasonic signals through the fluid. When the fluid is flowing, signal transit time in the downstream direction is shorter than in the upstream direction. The difference between these transit times is proportional to the flow velocity. The **Sentinel LCT8** measures this very small time difference and, using various digital signal processing techniques combined with programmed pipe parameters, determines the flow rate and direction.

1.1.2 Transducers

When in a transmit cycle, transducers convert electrical energy into ultrasonic pulses and then convert the ultrasonic pulses back to electrical energy when in a receive cycle. In other words, they act like loudspeakers when transmitting the signal and like microphones when receiving it. They perform the actual data transmission and collection, thus interrogating the flow.

The transducers in the **Sentinel LCT8** measurement system were specifically designed to be replaced under normal operating conditions. A damaged or non-functional transducer, can be replaced without shutting down the pipeline. Recalibration of the replacement is not necessary.

1.2 Multi-path design

Multi-path ultrasonic flow meters are designed with more than one pair of transducers to interrogate the flow field in different locations and more accurately determine the actual flow rate. The **Sentinel LCT8** measurement system uses eight measurement locations. These measurement paths are located across the meter body and tilted at an angle. The eight measurement paths are orthogonal to each other. The sensor path placements provide the best swirl and disturbance immunity.

1.3 Flow profile

One of the main factors that can adversely affect the performance of an ultrasonic flow measurement is a disturbed and unsymmetrical flow profile. Maintaining a desired flow-profile shape across all flow velocities, pipe sizes and upstream flow disturbances is difficult. For this reason, Panametrics has tested the **Sentinel LCT8** under various pipe configurations in an effort to determine its operational specifications and immunity against cross flow and swirl. Panametrics also completes calibrations based on the specific customer application needs to ensure the best meter performance. Owing to the design of our Eight-path flowmeter, we are able to meet performance specifications across a range of disturbances. Use of flow conditioners is normally unnecessary due to calibration methods and meter design. If the need of a flow conditioner is concluded, the meter calibration will be performed with the flow conditioner in place.

1.4 Unpacking

The **Sentinel LCT8** is typically packaged in a wooden crate, the size of which will depend on the size of product ordered. It will be secured by several 2x4 wood blocks to prevent shifting during transit. Simply remove these 2x4 braces to unpack the system. For local-mount systems the transmitter will be installed directly on top of the pressure vessel. For remote-mount systems the transmitter and remote cable may ship in a separate package.

1.5 Inspection

Prior to installation, inspect all materials to be used in the installation:

- **Gaskets** – check for cracks, tears and over compression (not included in **Sentinel LCT8** package)
- **Nuts and bolts** – check for damaged threads and for debris (not included in **Sentinel LCT8** package)
- **RF flange faces** – check for damage to serrations that may cause gaskets to not seal properly.
- **Flow conditioners** – check for blockages or damage to the flow conditioner

In general, check for anything that may prevent safe operation of the equipment.

IMPORTANT: If pipes are shipped pre-assembled as a single section, care should be taken to inspect and check the bolts and gaskets.

1.6 Meter components

Figure 1 on page 3 shows a **Sentinel LCT8** system, with items 1–8 as described in Table 1 below.

Table 1: Sentinel LCT8 system components

No	Component	Material (ASTM)	Qty
1	Meter body with flanges	SA216 Gr. WCB (carbon steel) SA352 Gr. LCB (low temp carbon steel) SA351 Gr. CF8 (304 SS) SA351 Gr. CF8M (316 SS)	1
2	Model tag plate		1
3	Transmitter tag plate		1
4	Part string and serial number tag plate		1
5	Transducer insert/buffer	316 SS	16
6	Transducer	316 SS	16
7	SEN898 electronics		1
8	External conduit connections, 3/4" cable glands		3
9	Upstream meter run (not supplied by Panametrics)		N/A
10	Flow conditioner (optional)		A/R
11	Downstream meter run (not supplied by Panametrics)	See Figure 11 on page 11	N/A
12	Temperature probe (optional, not supplied by Panametrics)		N/A
13	Pressure probe (optional, not supplied by Panametrics)		N/A

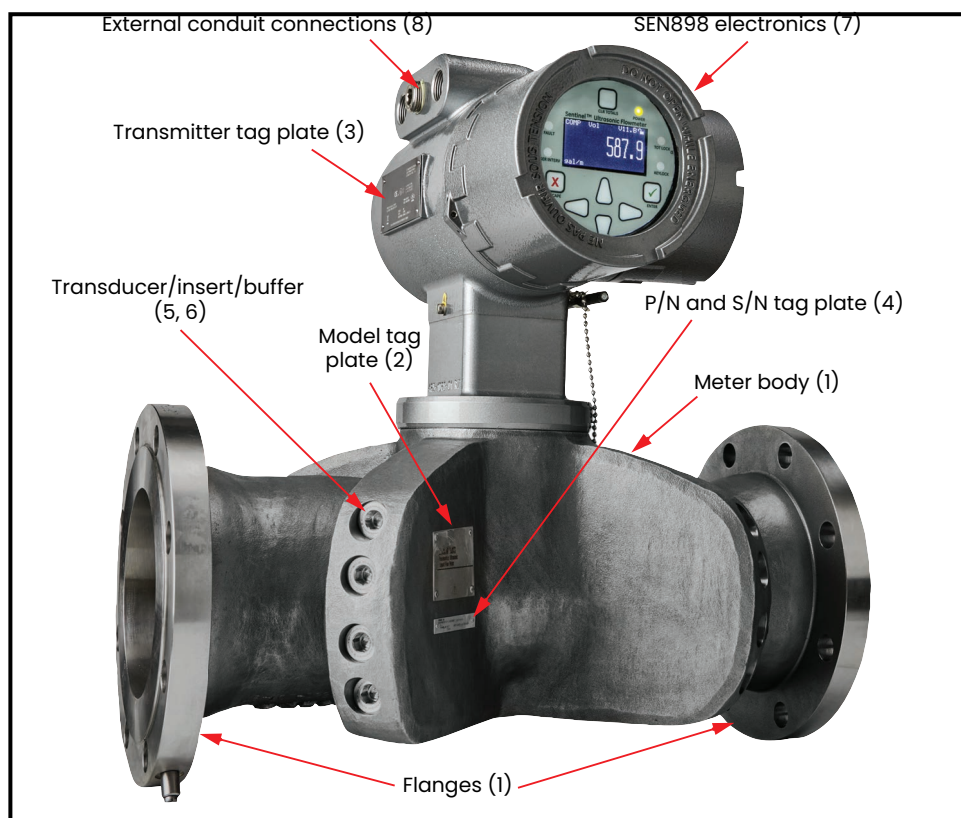


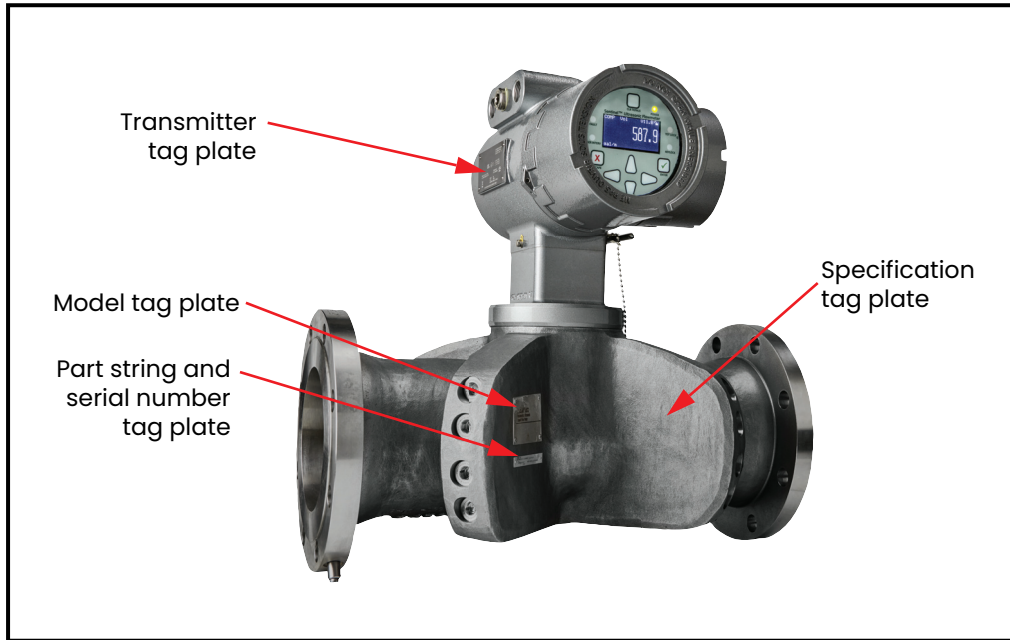
Figure 1: Typical Sentinel LCT8 assembly

Note: Design details changes slightly with pipe size.

1.7 Marking and Labeling

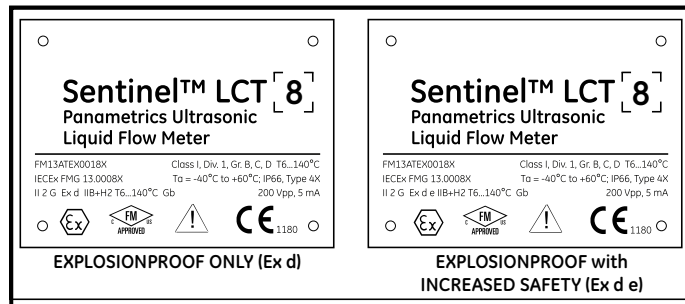
1.7.1 Tag plates

There are four tag plates affixed to the **Sentinel LCT8** which provide details about the system. Three are located on the vessel and one is located on the transmitter. Their locations are shown in *Figure 2* below.

Figure 2: *Sentinel LCT8* tag plate locations

1.7.2 Model tag plate

The *model tag plate* (see Figure 3 below) contains the model name and certification markings for the pressure vessel and its hazardous area usage.

Figure 3: *Sentinel LCT8* model tag plate (ref. 442-1402)

1.7.3 Specification tag plate

The *specification tag plate* (see Figure 4 below) contains information pertaining to the build and test of the pressure vessel. It contains the following information:

- Vessel nominal size, flange rating, wall thickness, material
- Dry weight (including transmitter)
- Vessel manufacturer serial number
- Ambient and fluid temperature ranges
- Operating pressures
- Hydro test pressure and date

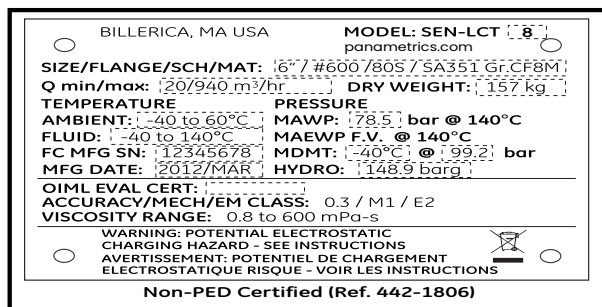


Figure 4: Specification tag plate

Note: Information in dashed boxes above is shown only as an example.

1.7.4 Part string and serial number tag plate

The *part string and serial number tag* (see Figure 5 below) contains the specific configuration of the pressure vessel as well as the final assembly date, Panametrics serial number and customer tag information.

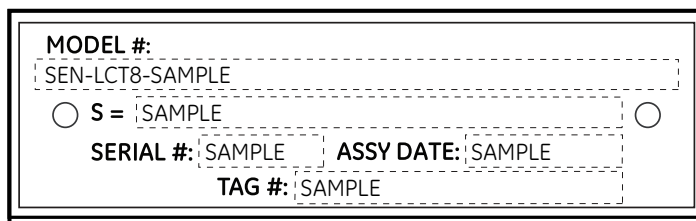


Figure 5: Part string and S/N tag plate (ref. 442-1445)

Note: Information in dashed boxes is shown only as an example.

1.7.5 Transmitter tag plate

The *SEN898 transmitter tag plate* (see Figure 6 below) is affixed to the transmitter and includes the configuration per the model information detailed on the model tag plate. This tag plate also contains the hazardous area certification information for the transmitter.

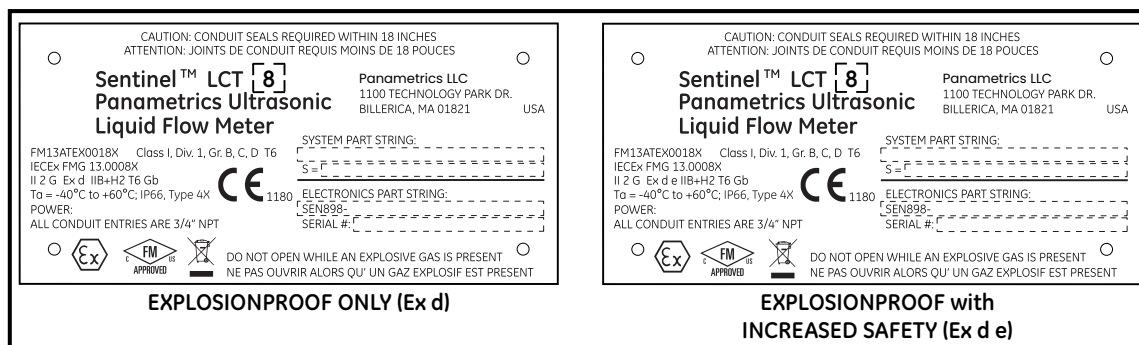


Figure 6: SEN898 transmitter tag plate (ref. 442-1521)

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Chapter 2. Installation

2.1 Installation guidelines

This section provides general information with respect to the mechanical and electrical installation, and should be thoroughly reviewed before the system is installed. To ensure safe and reliable operation of the **Sentinel LCT8**, the system must be installed in accordance with the guidelines established by Panametrics, as explained in this chapter.



WARNING! The *Sentinel LCT8* flow measurement system can measure the flow rate of many fluids, some of which are potentially hazardous. Strict observance of proper safety practices is essential.



WARNING! Be sure to follow all applicable local safety codes and regulations for installing electrical equipment and working with hazardous gases or flow conditions. Consult company safety personnel or local safety authorities to verify the safety of any procedure or practice.



Attention European Customers! To meet CE Mark requirements, all cables must be installed as described in *Appendix A, "CE Mark compliance and high noise environments"*, on page 133.



Attention European Customers! This manual fulfills the requirements of the Pressure Equipment Directive 97/23/EC. Please read it carefully in order to guarantee safe operation of this pressure equipment. Follow all warnings and instructions marked on the product.

2.2 Bill of materials

The following items should have been included in the shipment:

- **Sentinel LCT8** flow meter
- Magnetic wand
- User's manual
- CD with PanaView SEN898 software (optional)

2.3 Preparing for Installation

2.3.1 Installation precautions

Any questions with respect to the installation should be addressed prior to beginning the installation. Failure to install the **Sentinel LCT8** correctly can increase measurement uncertainty.

All the mechanical and electronic components are shipped fully assembled, however the following precautions should be observed:

- Only authorized personnel should perform the installation. The proper personal protection equipment (PPE) should always be used when working with this equipment.
- The vessel shall be installed in such a way that it can be safely operated, maintained and inspected. Please refer to specific outline and installation drawings for proper clearances and specific distances for each system size. In general, allow for a minimum of 12" of space on all sides of pressure vessel and transmitter, with an ideal clearance of 24" on all sides.
- You must provide suitable over-pressure protection at or in the main piping to the flowcell in order to prevent damage to the flowcell and injury to personnel. The utilized over-pressure protection device shall be supplied with all declarations of conformity and EC-type design certificates.

- Make sure the difference between the inside diameter of the pipe and that of the **Sentinel LCT8** meter does not exceed 0.5%, as changes in internal diameters will cause flow profile disturbances.
- Make sure any non-symmetrical offset does not exceed 1%, as misalignment between the piping and the meter may cause flow profile disturbances.
- Make sure the gasket is centered on the flange faces and does not protrude into the pipe, as protrusion of the gasket into the pipe may cause flow profile disturbances.
- Make sure the **Sentinel LCT8** is oriented with the flow transmitter in a vertical position at the top, as shown in *Figure 7* below.

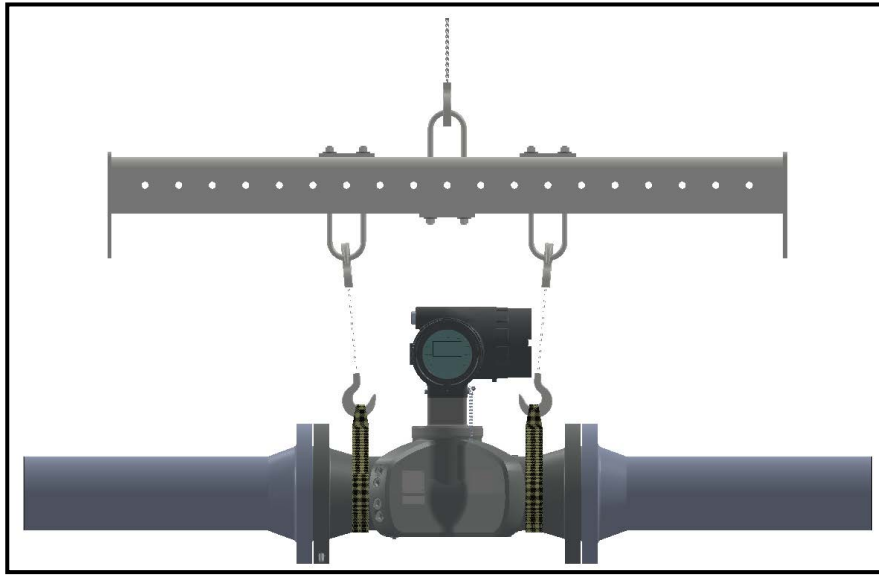


Figure 7: Lifting strap locations 6

2.3.2 Lifting Instructions



WARNING! To avoid possible strain, refer to the *Sentinel LCT8* label for the assembly weight, use a properly-rated lifting assembly, and place the lifting straps in the indicated locations (see *Figure 7*). Never stand below any object being lifted!

Use proper lifting techniques when moving the **Sentinel LCT8** (see *Figure 8* below). No lifting hooks or eyelets are provided. The recommended method for lifting the **Sentinel LCT8** is by using lifting straps on each side of the pressure vessel with a stabilizer bar between them, located above the transmitter enclosure. Additional care may need to be taken to prevent the transmitter from rotating, especially on smaller systems where the transmitter weight is a larger percentage of the total system weight.



Figure 8: Proper lifting method



WARNING! Do not use the transmitter to support the weight of the flowcell, as shown in *Figure 9* below. The transmitter cannot support the weight of the pressure vessel.



Figure 9: Improper lifting method

2.4 Mechanical installation

Being mindful of the *Installation precautions* on Section 2.3.1, complete the following steps:

1. Make sure the gaskets are in place on the flanges.
2. Support the **Sentinel LCT8** between the flanges on the pipe.
3. Align the flange mounting holes as shown in *Figure 10* below.
4. Secure the meter to the pipe by using the appropriate hardware.

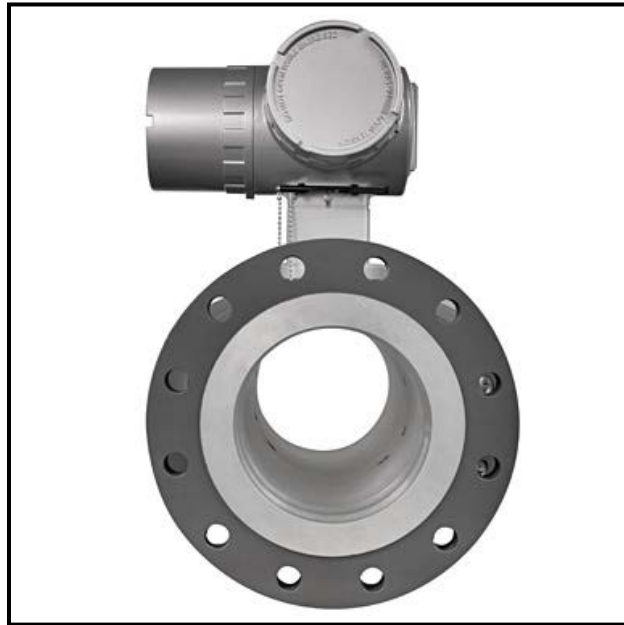


Figure 10: *Sentinel LCT8* mounting flange

2.4.1 Standard installation recommendations

2.4.1.1 Installation location

Proper installation of the **Sentinel LCT8** is important to achieve maximum performance from the system. The following installation recommendations provide general guidelines of how this system should be installed. If the following recommendations cannot be met, please consult the factory for a more detailed review of the application to see what performance may be achievable. Following these recommendations may not be the solution for all situations, since every installation is different.

2.4.1.2 Straight pipe run requirements

The **Sentinel LCT8** should be installed to meet one of the following condition:

- A minimum of 5 nominal pipe diameters upstream of the metering section (pressure vessel) and a minimum of 3 nominal pipe diameters downstream.

For any other straight run configurations, consult Panametrics for an application assessment.

2.4.1.3 Flow direction - straight pipe run differences

For both uni-directional and bi-directional flow, the user must provide the minimum straight pipe runs upstream and downstream from the flowcell, as shown in *Figure 11* below. Any additional length of straight pipe run will help produce a more symmetrical flow profile, thus further reducing measurement uncertainty.

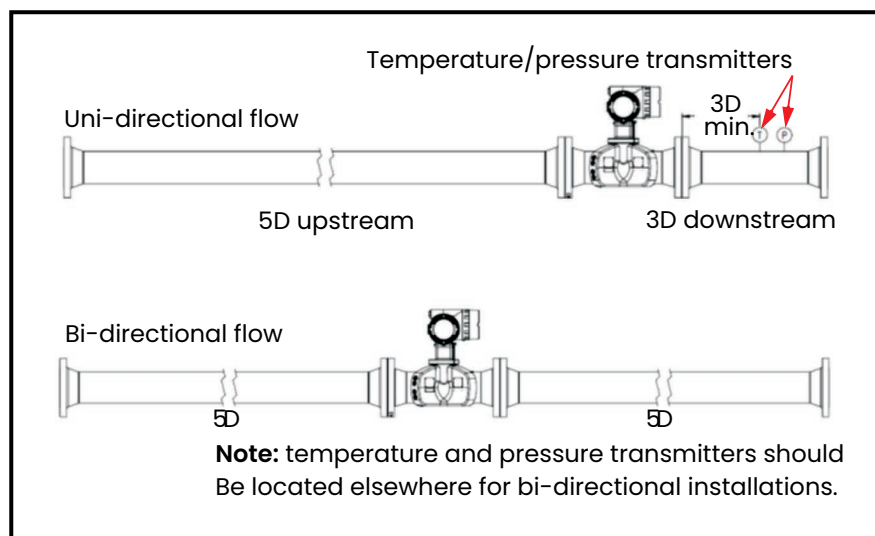


Figure 11: Minimum straight pipe runs for *Sentinel LCT8* installations

2.4.1.4 Inner diameter matching

To maintain optimal product performance, the inner diameter of the upstream sections should be within 0.5% of the metering section inner diameter at the flange. The downstream matching is not as critical but should be of the same schedule and matched as closely as possible.

In addition, gaskets should not protrude past the inner diameter to disrupt the flow profile.

2.4.1.5 Location of temperature and pressure measurements

Temperature and pressure measurements should always be made downstream of the *Sentinel LCT8* and be located a minimum of 3D downstream of the pressure vessel, with a preferred distance of 5D downstream. For any other locations for temperature and pressure measurement consult Panametrics for an application assessment.

2.4.1.6 Calibration recommendations

In general, the best practice is to calibrate as much of the measuring section as possible. This would include upstream and downstream straight pipe runs and the *Sentinel LCT8*. While this is not always possible or cost effective, it will provide the best transferability from calibration to field usage. This methodology is highly recommended for *custody transfer master meter and duty* systems to maintain the lowest possible system uncertainty. Each application is different and requires a customized calibration plan. For calibration recommendations, consult the factory for an application assessment.

2.4.2 Fluid requirements

Gas – To avoid measurement errors, suitable measures should be taken to make sure the line is full and the gas in the line is kept below 1%. While the system may still be able to measure with larger amounts, it has the potential to affect accuracy. When gas is present, keep flow rates as high as possible to help push the gas through the metering section.

Particulate – To avoid measurement errors, suitable measures should be taken to minimize solid particulate in the line. Particulate should ideally be less than 1% for accurate measurement.

Water in oil – Water and oil mixtures under 5% should not affect accuracy as long as they are well mixed. Keep flow rates high enough to ensure a well-mixed solution. Higher percentages of water may be present, but this could affect the accuracy of measurements.

Please consult Panametrics for any applications where conditions are outside the above recommendations for a more comprehensive application review.

2.4.3 Guidelines for installing pipe insulation

If pipe insulation is required:

- Install all insulation materials and accessories in accordance with the manufacturer's instructions and the recognized industry practices. Adhere to the local code where applicable to ensure that the safe and proper installation will serve its intended purpose.
- Install the insulation material in layers, with smooth and even surfaces. Allow adequate space (air pockets) around all extended transducer buffer rods, conduit fittings, junction boxes, and cables, for proper ventilation. Avoid using cut pieces or scrap insulation when abutting the sections being installed. Butt insulation joints firmly to ensure a complete, tight fit over and around all piping surfaces.
- Maintain the integrity of any factory-applied vapor barrier jacketing on all pipe insulation, if applicable. Seal all joints and seams, protecting the insulation against puncture, tears or other damage.

2.5 Making the electrical connections

This section contains instructions for making the necessary electrical connections to the flow transmitter (see *Figure 12* below). The wiring between the transmitter and the transducers has been installed at the factory, and no further connections are required on this portion of the wiring.

IMPORTANT: When wires are connected to terminal blocks, use wire ties routed through the blocks, to secure them.



Attention European Customers!

To meet CE Mark requirements, all cables must be installed as described in *Appendix A, "CE Mark compliance and high noise environments"*, on page 133.

IMPORTANT: The meter is grounded to the electronics. This configuration must be considered when applying cathodic protection to the pipe line. The power ground applied to the instrument should be at the cathodic protection voltage level.

2.5.1 Removing the enclosure covers



WARNING! Always disconnect the line power from the meter before removing either the front display cover or the wiring access cover.

This is especially important in a hazardous environment.

1. Disconnect any previously wired power line from the flow transmitter.
2. Loosen the set screw on the side cover using a 2.5 mm hex wrench.
3. Place a rod or long screwdriver across the cover in the slots provided, and rotate the cover counterclockwise until it comes free from the enclosure.
4. Note the text printed on the terminal board (see *Figure 13* on page 13) to assist in wiring the power and option card connections.

Proceed to the appropriate section of this chapter to make the desired wiring connections.

2.5.2 Cable tie-down posts

There are two cable tie-down posts provided in the **Sentinel LCT8** transmitter (see *Figure 14* below). These posts enable the user to insert a cable tie through them, and secure the wiring coming into or out of the instrument. The posts rotate on the printed circuit board to provide ease-of-use.

- **Power cable tie-down post** - use this tie-down post to secure the power cable.
- **Optional I/O cable tie-down post** - use this tie-down post to secure all I/O cables.

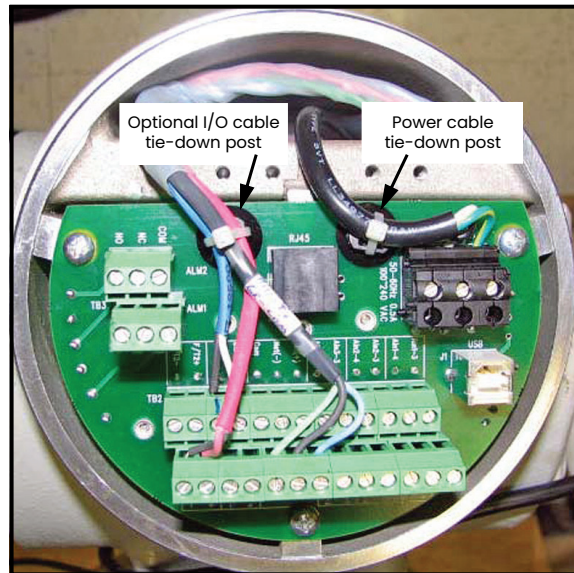


Figure 14: Cable tie-down posts locations

2.5.3 Wiring the line power

The **Sentinel LCT8** may be ordered for operation with a power input of either 100–240 VAC or 12–32 VDC. The label on the side of the electronics enclosure lists the required line voltage and power rating for your unit. Be sure to connect the **Sentinel LCT8** to the specified line voltage only.

Note: For compliance with the North American and European low voltage directive, this unit requires an external power disconnect device such as a switch or circuit breaker. The disconnect device must be marked as such, clearly visible, directly accessible, and located within 1.8 m (6 ft) of the unit.

Note: Use one conduit inlet for the power cable, and use the two remaining conduit inlets for any I/O cables as needed. All unused conduit inlets should be sealed with suitable blank plugs (see *Figure 15* below).



Figure 15: Conduit inlet ports

See Figure 16 or Figure 17 to locate terminal block TB1 and to connect the line power as follows:



WARNING! Improper connection of the line power leads, or connecting a *Sentinel LCT8* to the incorrect line voltage, may damage the unit. It may also result in hazardous voltages at the meter body and associated piping as well as within the electronics enclosure.

1. Prepare the line power leads by trimming the line and neutral AC power leads (or the positive and negative DC power leads) to a length 0.5 in. (1 cm) shorter than the ground lead. This ensures that the ground lead is the last to detach if the power cable is forcibly disconnected from the meter.
2. Route the cable through one of three conduit inlet ports (see Figure 15 above) and connect the line power leads to terminal block **TB1**, using the pin number assignments shown in Figure 30 on page 26 and Figure 16 on page 15 or Figure 17 on page 15.



Attention European Customers! To meet CE Mark requirements, all cables must be installed as described in Appendix A, “CE Mark compliance and high noise environments”, on page 133.

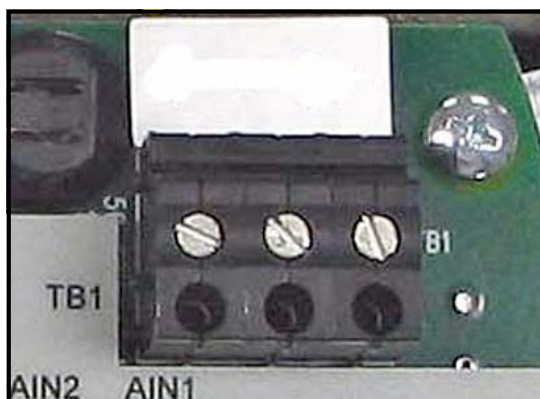


Figure 16: Wiring the AC line power

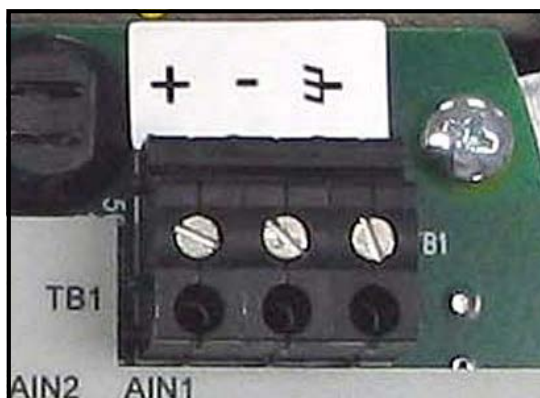


Figure 17: Wiring the DC line power

Note: All wires shall have a temperature/type rating 10K above the maximum service temperature of 85°C, be stripped back 5/16 in. (8 mm) and torqued to a minimum of 4.4 in.-lb (0.5 N-m).

3. Run the power connections to the *power terminal block* shown in *Figure 16* (AC power) or *Figure 17* (DC power) above. The use of 12-18 AWG (3.3 - 0.82 mm²) wire is recommended for the power connections.
4. Strip 1/4-in. of insulation from the end of each of the three line power leads.
5. Route the cable through the chosen conduit hole and connect the line power leads to terminal block **TB1**, using the pin number assignments shown in *Figure 31* on page 27 and *Figure 16* on page 15 or *Figure 17* on page 15.
6. Leaving a bit of slack, secure the power line with the cable clamp.



WARNING! Make sure both covers, with their o-ring seals, are installed, and the set screws tightened, before applying power in a hazardous environment.

7. After the line power has been connected to the flow transmitter, replace the side cover, tighten the set screw using a 2.5 mm hex wrench and proceed to the next section.

2.5.4 Wiring the serial port

The flow transmitter is equipped with a built-in serial communications port. This port is user-selectable to be either an RS232 or RS485 port. For more information on serial communications refer to Panametrics document *EIA serial communications* (916-054), which is included on the *flow manuals CD* included with your order. The use of 12-24 AWG (3.3 - 0.2 mm²) twisted pair wiring is recommended for single conductors, and a minimum 18 AWG (1.5 mm²) is recommended for two conductors per terminal.

2.5.4.1 Wiring the serial interface

To wire the serial port, refer to *Figure 31* on page 27 and complete the following steps:

1. Disconnect the main power to the meter and remove the wiring access cover.
2. Install the required cable gland in the chosen conduit hole of the electronics enclosure.
3. Feed one end of the cable through the cable gland, wire it to terminal block **TB2**, and secure it.

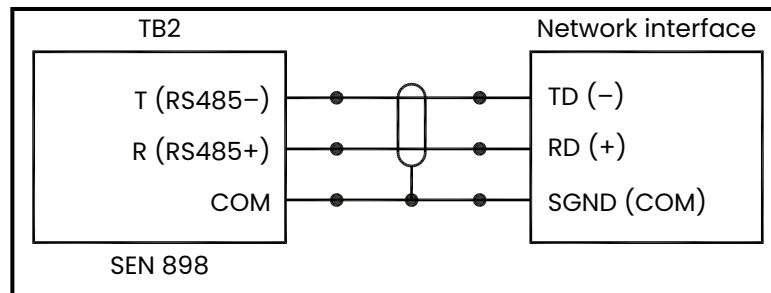


Figure 18: Serial connections



Attention European Customers! To meet CE Mark requirements, all cables must be installed as described in *Appendix A, "CE Mark compliance and high noise environments"*, on page 133.

4. If the wiring of the unit has been completed, reinstall the wiring access cover and tighten the set screw.

2.5.5 Wiring the modbus communications line (optional)

The **Sentinel LCT8** uses the RS485 interface with *modbus* communications protocol for a maximum line distance of up to 4000 ft (1200 m). Panametrics recommends using shielded 18-24 AWG (0.82 - 0.2 mm²) cable having a characteristic impedance of 120 ohms, with 120-ohm termination at each end of the communications line. This interface is also user-configurable as an RS232 interface.

Connect the two leads and the shield of the modbus line to the **NET** section of terminal block **TB2** in the flow meter. See *Figure 13* on page 13, *Table 2* on page 22 and *Figure 31* on page 27.

2.5.6 Wiring the alarm relay

Note: The alarm relay can be wired as either normally open (NO) or normally closed (NC).

An alarm relay should be wired for *fail-safe* operation. In fail-safe mode, the alarm relay is constantly energized, except when it is triggered, or a power failure or other interruption occurs. See *Figure 19* below for the operation of a normally open alarm relay in *fail-safe* mode.

Connect the alarm relay in accordance with the wiring instructions shown on the terminal board label (see *Figure 13* on page 13 and *Figure 29* on page 25). For a wiring diagram see *Figure 31* on page 27.

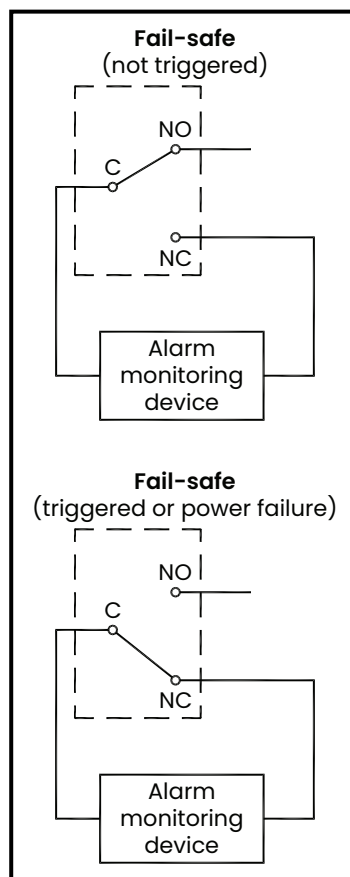


Figure 19: Fail-safe operation

The use of 12-24 AWG (3.3 - 0.2 mm²) is recommended for single conductor wiring, and 16-24 AWG (1.5 - 0.2 mm²) is recommended for two conductors per terminal.

2.5.7 Wiring the 4-20mA analog input (optional)

1. Disconnect the main power to the flow meter and remove the wiring access cover.
2. Install a cable gland in the chosen conduit hole of the electronics enclosure and feed a standard twisted-pair cable through this conduit hole.
3. Locate the 26-pin terminal block (**TB2**) in *Figure 29 on page 25* and wire the I/O terminal as indicated on the label inside the wiring access cover (see *Figure 13 on page 13* and *Figure 29 on page 25*). For a wiring diagram, see *Figure 31 on page 27*.
4. Secure the cable clamp.



Attention European Customers!

To meet CE Mark requirements, all cables must be installed as described in *Appendix A, "CE Mark compliance and high noise environments", on page 133*.

5. If wiring of the unit has been completed, reinstall the side cover on the enclosure and tighten the set screw.

The analog input option provides either three isolated 4-20mA analog inputs (designated as Ain1, Ain2 and Ain3) or two isolated 4-20mA analog inputs and one RTD input (designated as Ain1, Ain2 and RTD1). Each of the 4-20mA inputs includes a 24 VDC power supply for loop- powered transmitters. The inputs may be used to process temperature, density and pressure signals.

Note: To enter programming data during operation of the **Sentinel LCT8**, it will be necessary to know which input is assigned to which process parameter. This information should be entered in *Appendix C, "Modbus register map," on page 139*.

The analog inputs, which have an impedance of 118 ohms, should be connected with standard twisted-pair wiring. Power to the transmitters may be supplied either by the internal 24 VDC power supply on the analog input terminal or by an external power supply. *Figure 20 on page 19* shows typical wiring diagrams, with and without an external power supply, for one of the analog inputs. *Figure 21 on page 19* shows 4-wire RTD 100 Ω input wiring. Wire the analog inputs as shown on the label in the enclosure side cover (see *Figure 13 on page 13* and *Figure 29 on page 25*).

Terminal locations are shown in *Figure 22 on page 20* through *Figure 25 on page 21*.

The use of 12-24 AWG (3.3 - 0.2 mm²) is recommended for single conductor wiring, and 16-24 AWG (1.5 - 0.2 mm²) is recommended for two conductors per terminal.

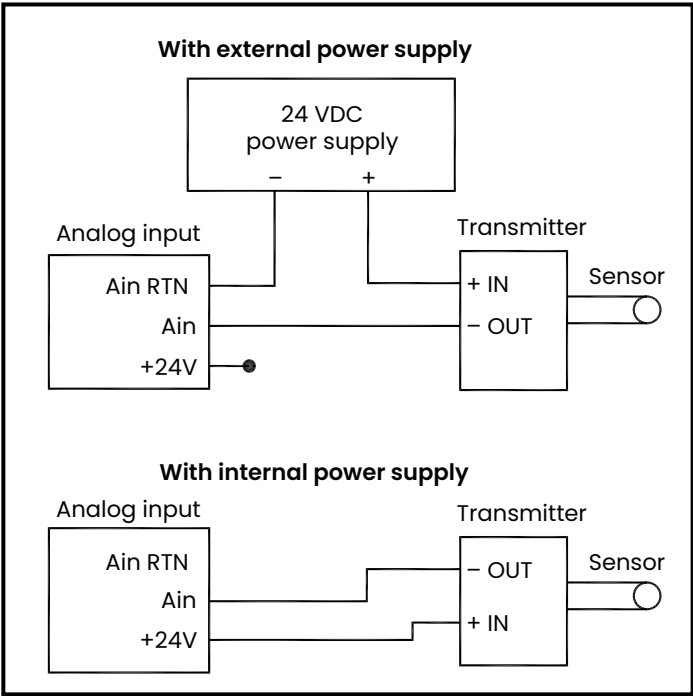


Figure 20: Analog input wiring diagram

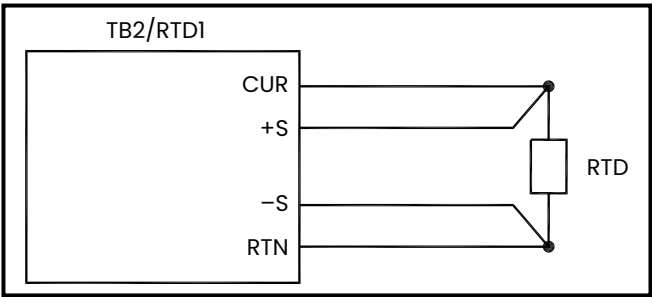


Figure 21: 4-Wire RTD input wiring diagram

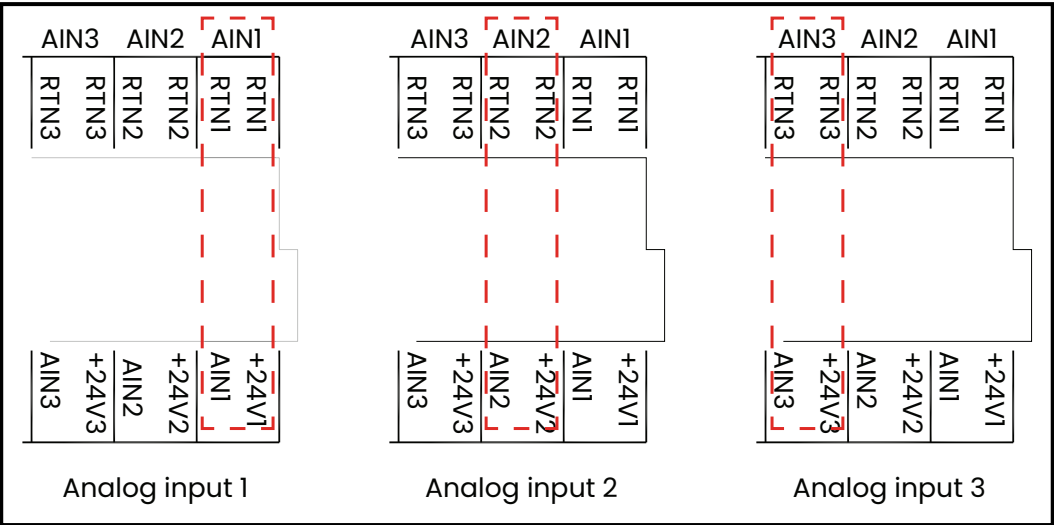


Figure 22: Terminal locations for 3 analog input option

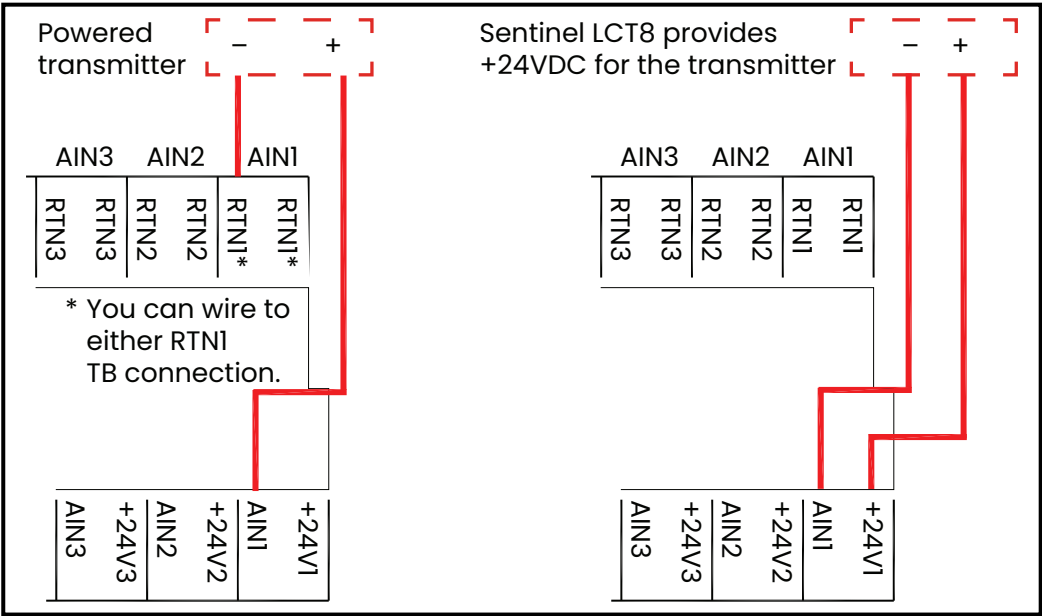


Figure 23: Terminal locations for analog transmitter use

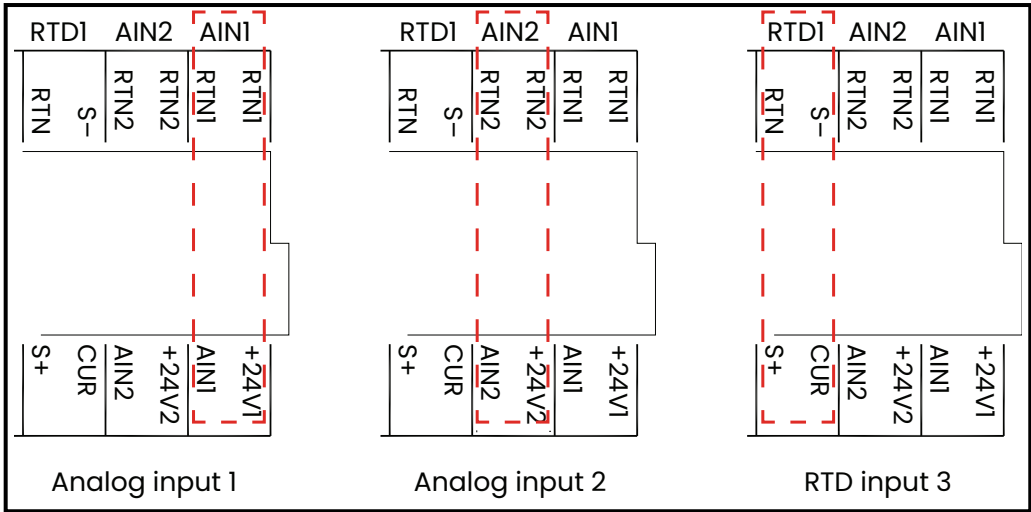


Figure 24: Terminal locations for 2 analog input and 1 RTD input option

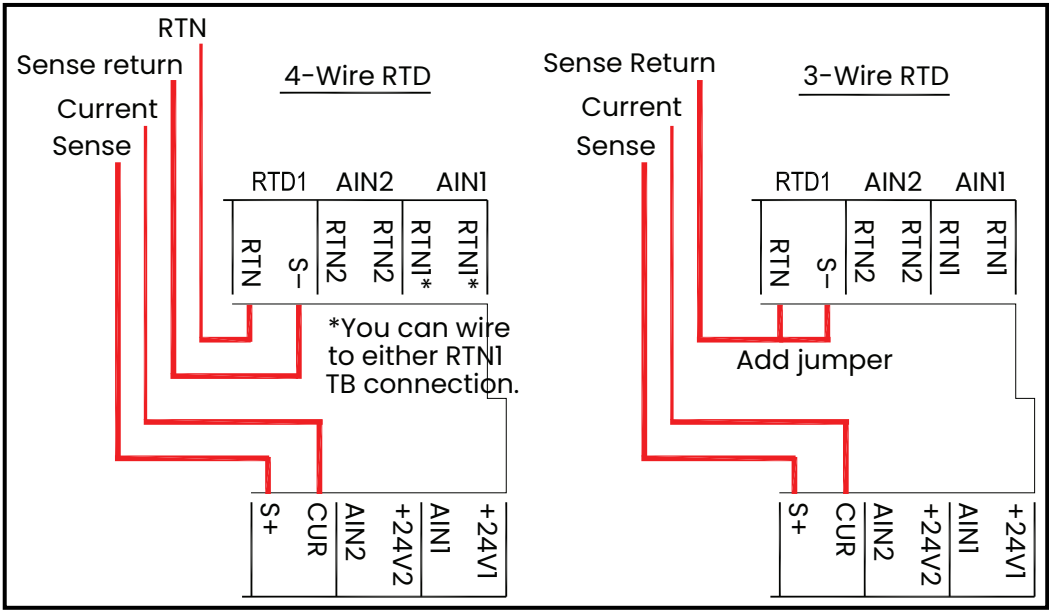


Figure 25: Terminal locations for 4-wire and 3-wire RTD use

2.5.8 Wiring the frequency/totalizer output

Figure 26 below shows sample wiring diagrams of the frequency/totalizer output circuit for open drain and pushpull configurations. The use of 12-24 AWG (3.3 - 0.2 mm²) is recommended for single conductor wiring, and 16-24 AWG (1.5 - 0.2 mm²) is recommended for two conductors per terminal.

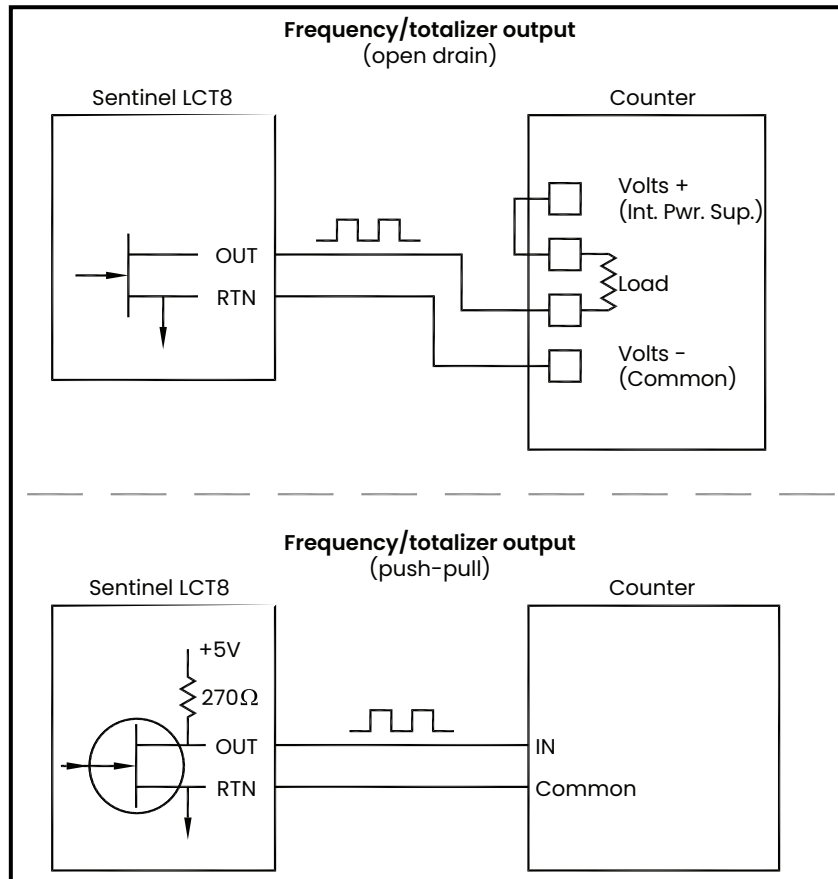


Figure 26: Totalizer and frequency output wiring

Table 2: Wiring the TB2 I/O terminal block

I/O Pin #	Function
F/T1+	Freq 1/totalizer 1 OUT
F/T1-	Freq 1/totalizer 1 RTN
F/T2+	Freq 2/totalizer 2 OUT
F/T2-	Freq 2/totalizer 2 RTN
NET R (+)	MODBUS-RTU RS232 (R)/RS485 (+)
NET T (-)	MODBUS-RTU RS232 (T)/RS485 (-)
NET COM	MODBUS-RTU common

2.5.9 Wiring the 4–20 mA analog output

The standard configuration of the flow transmitter includes an isolated 4–20 mA analog output. Connections to this output may be made with standard 12–24 AWG (3.3 – 0.2 mm²) twisted-pair wire for a single conductor, and 16–24 AWG (1.5 – 0.2 mm²) wire for a two-conductor connection, but the current loop impedance for these circuits must not exceed 1000 ohms. To wire the analog outputs, complete the following steps:

1. Disconnect the main power to the flow meter and remove the enclosure side cover.
2. Install the required cable clamp in the chosen conduit hole on the side of the electronics enclosure.
3. Locate the 26-pin terminal block (**TB2**) shown in *Figure 30 on page 26*, and wire the I/O terminal as indicated on the label inside the wiring access cover (see *Figure 31 on page 27* and *Figure 29 on page 25*). For a wiring diagram see *Figure 27 on page 23* or *Figure 28 below*.

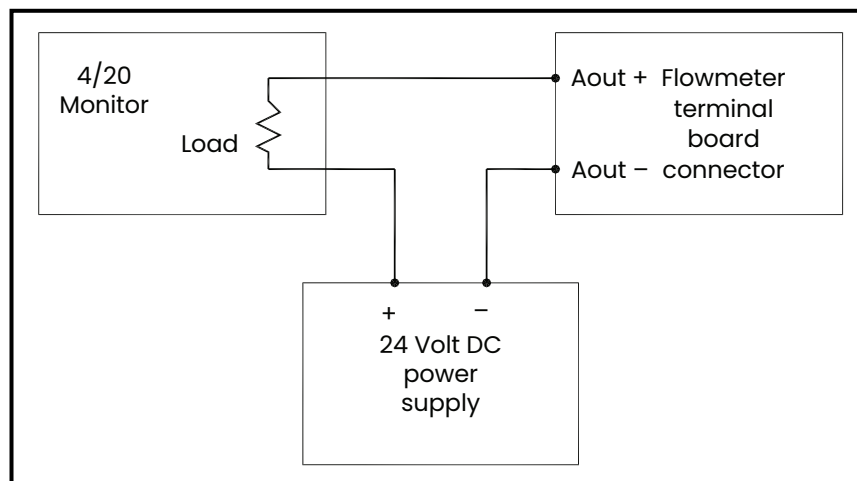


Figure 27: Analog output passive wiring

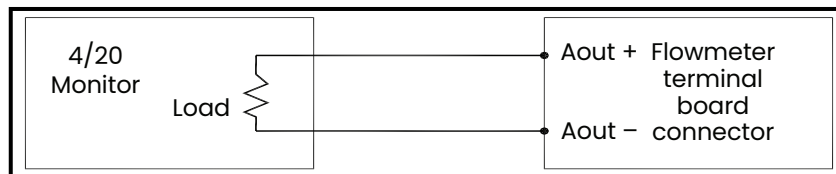


Figure 28: Analog output active wiring

4. Secure the cable clamp.



WARNING! To meet CE Mark requirements, all cables must be installed as described in *Appendix A, "CE Mark compliance and high noise environments", on page 133.*

5. If wiring of the unit has been completed, reinstall the wiring access cover on the enclosure and tighten the set screw.

2.6 Operation

After the **Sentinel LCT8** has been completely installed and wired, proceed to *Chapter 3, "Programming", on page 29*, to configure the flow meter.



WARNING! Make sure both covers, with their o-ring seals, are installed, and the set screws tightened, before applying power in a hazardous environment.

Only properly trained personnel are allowed to operate this vessel at the following conditions:

2.6.1 Startup

The **Sentinel LCT8** does not have any specific startup requirements after it has been properly installed into the piping system. Power should be supplied in accordance with local and national electrical codes. The pipeline does not need to be full of fluid for the system to be powered on.

2.6.2 Normal operation

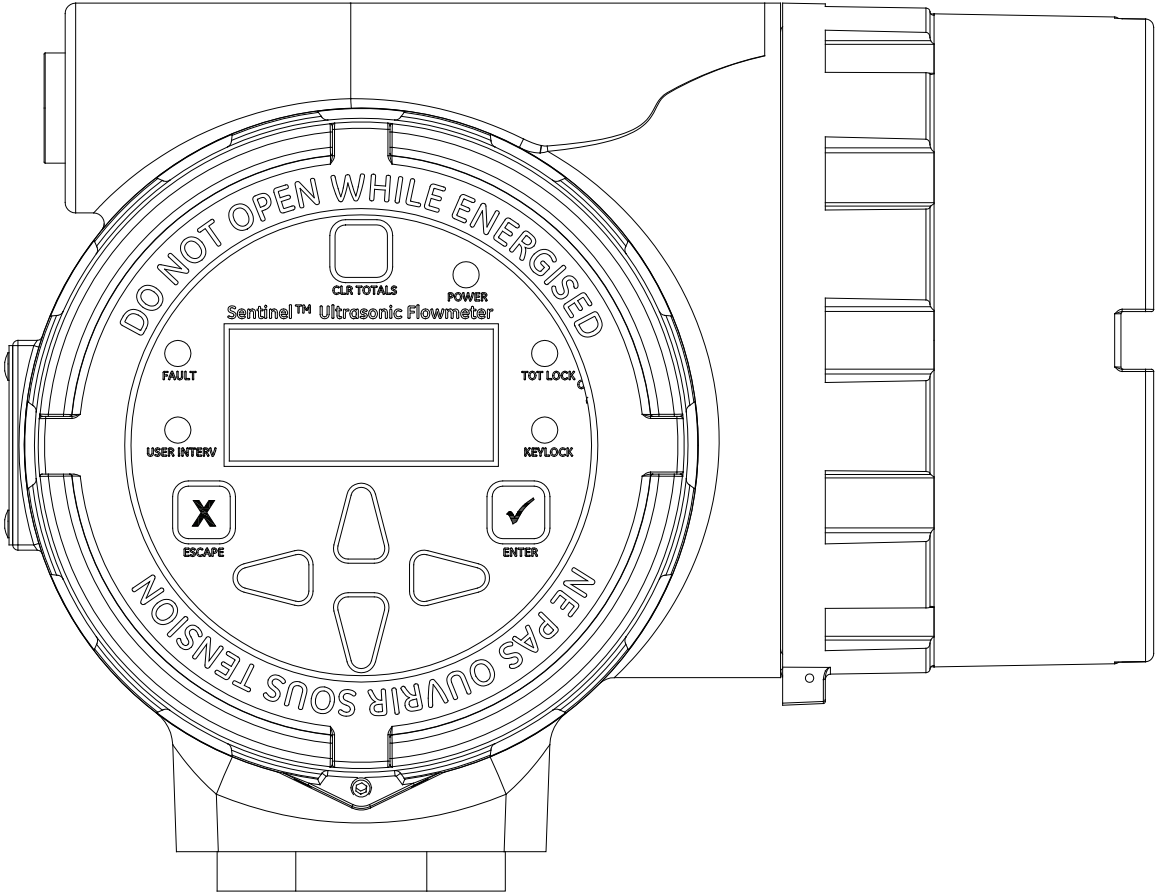
This pressure vessel is intended to measure fluid flow under normal operation. There are no moving parts. The transmitter will make continuous measurements of the flow along with ancillary inputs of temperature and pressure for density compensation. The transmitter will output readings through any of several available output options (4-20mA, pulse out, modbus, etc.). If any errors occur they will be reported out as well.

2.6.3 Shutdown

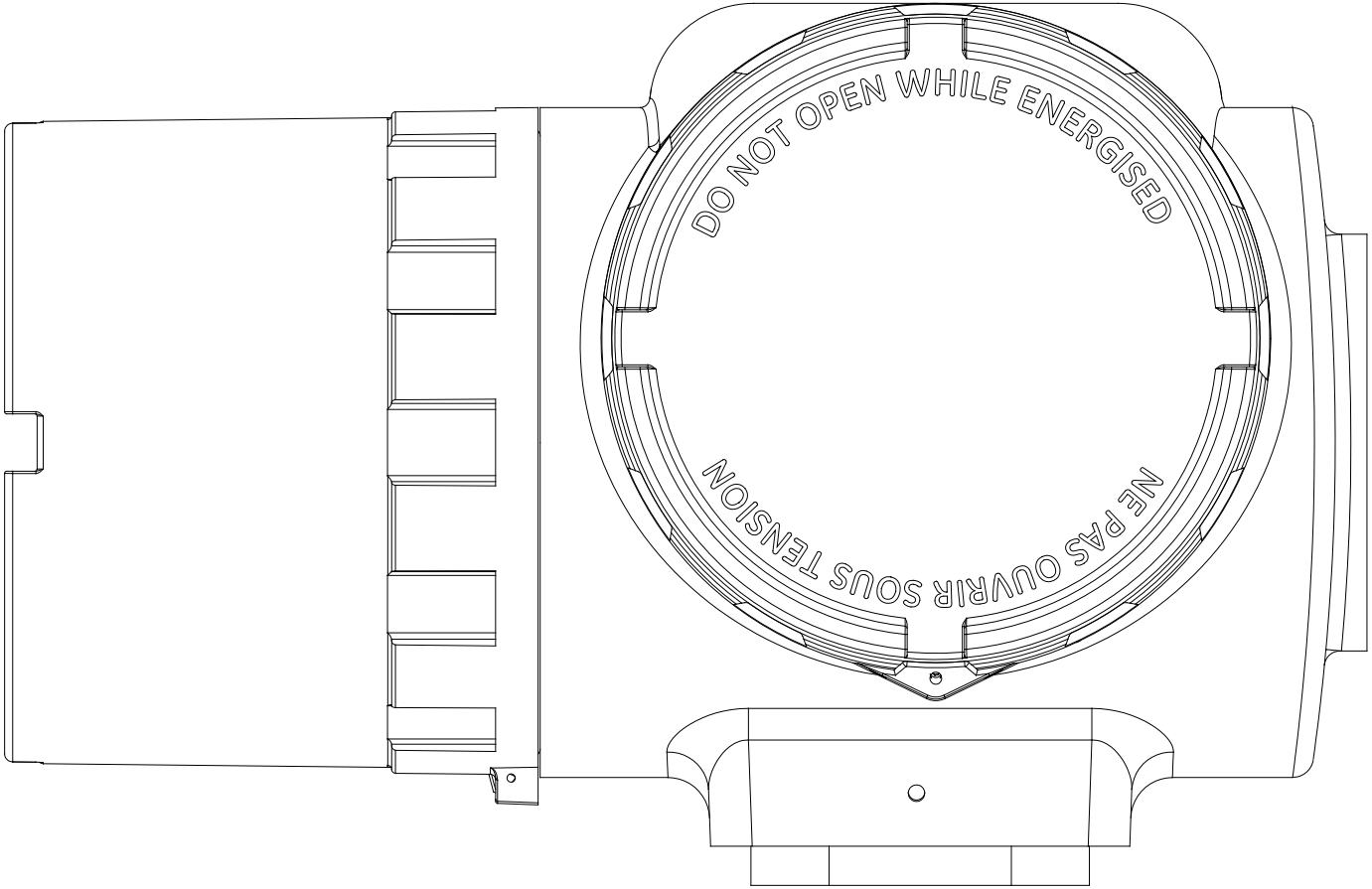
While the **Sentinel LCT8** is intended for continuous service there are occasions where shutdown is required. There are no special requirements specifically for shutdown. The system should be de-energized prior to troubleshooting and any pressure build-up should be relieved.

2.6.4 Troubleshooting

Refer to *Chapter 5, "Troubleshooting", on page 103*, for a list of error codes and troubleshooting steps. For any other inquiries or assistance with troubleshooting the **Sentinel LCT8**, please consult Panametrics.



Front Display



Wiring Access Cover

Figure 29: SEN898 Electronics enclosure - front display and wiring access cover

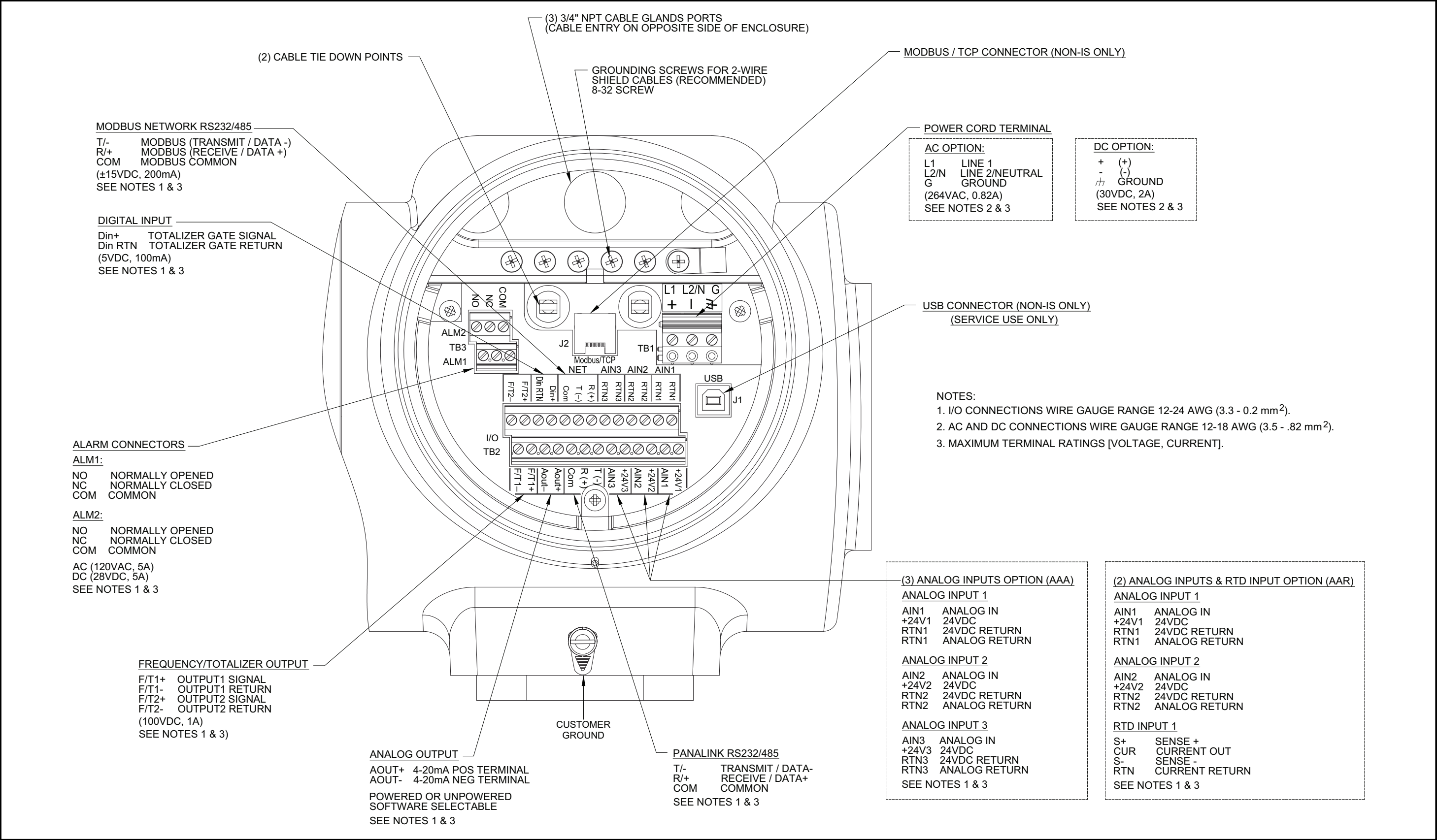


Figure 31: SEN898 electronics – wiring diagram (ref. dwg #702-884)

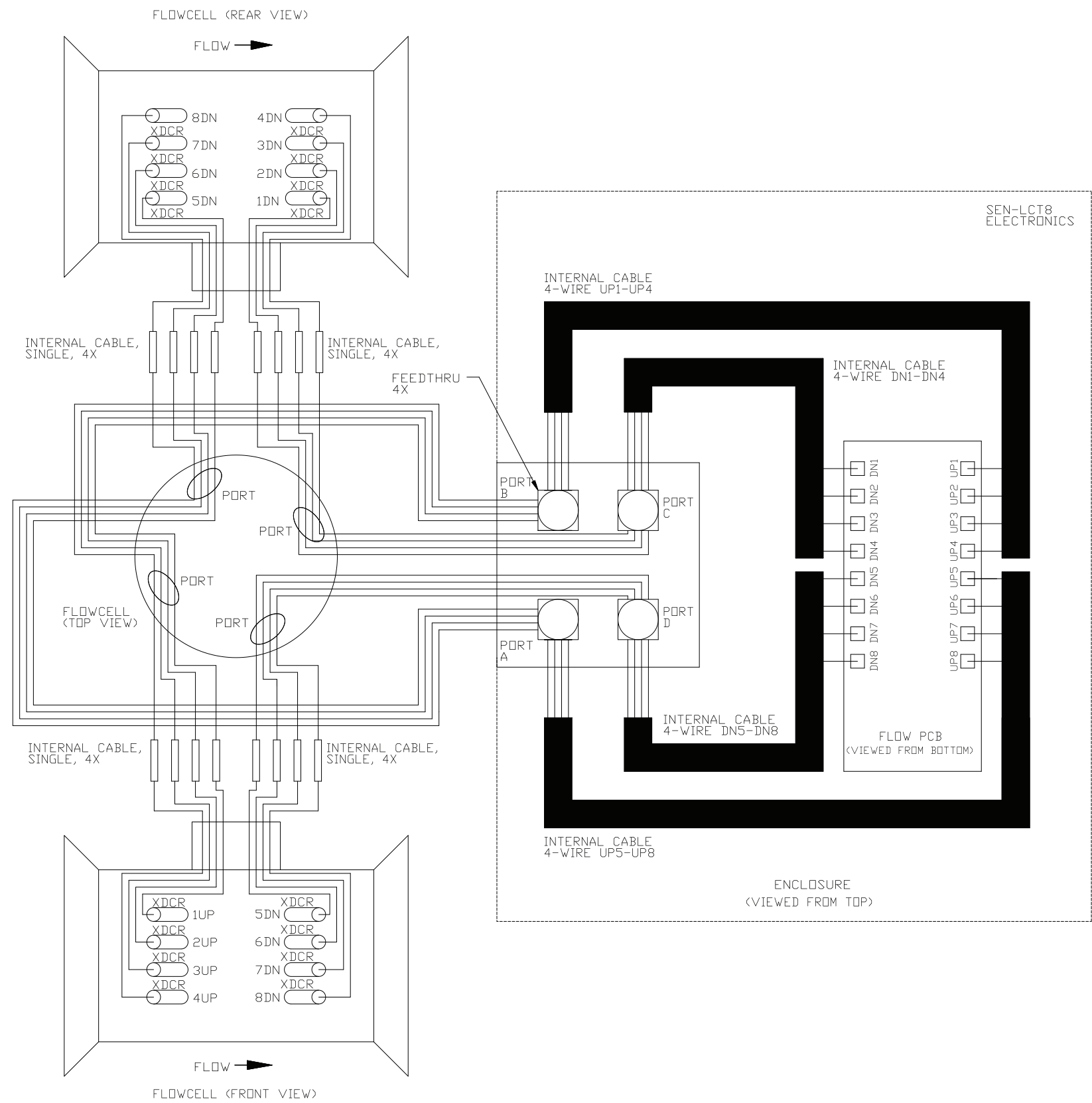


Figure 32: Wiring LCT8 to SEN898 electronics - cross plane (6" - 24" flowcell), local mount (ref. dwg #702-2041)

Chapter 3. Programming

3.1 Introduction

The **Sentinel LCT8** flow transmitter includes a user program that provides access to the various programmable features of the instrument. This chapter describes step-by-step configuring instructions using the internal keypad shown in *Figure 33* below.

3.1.1 HMI features

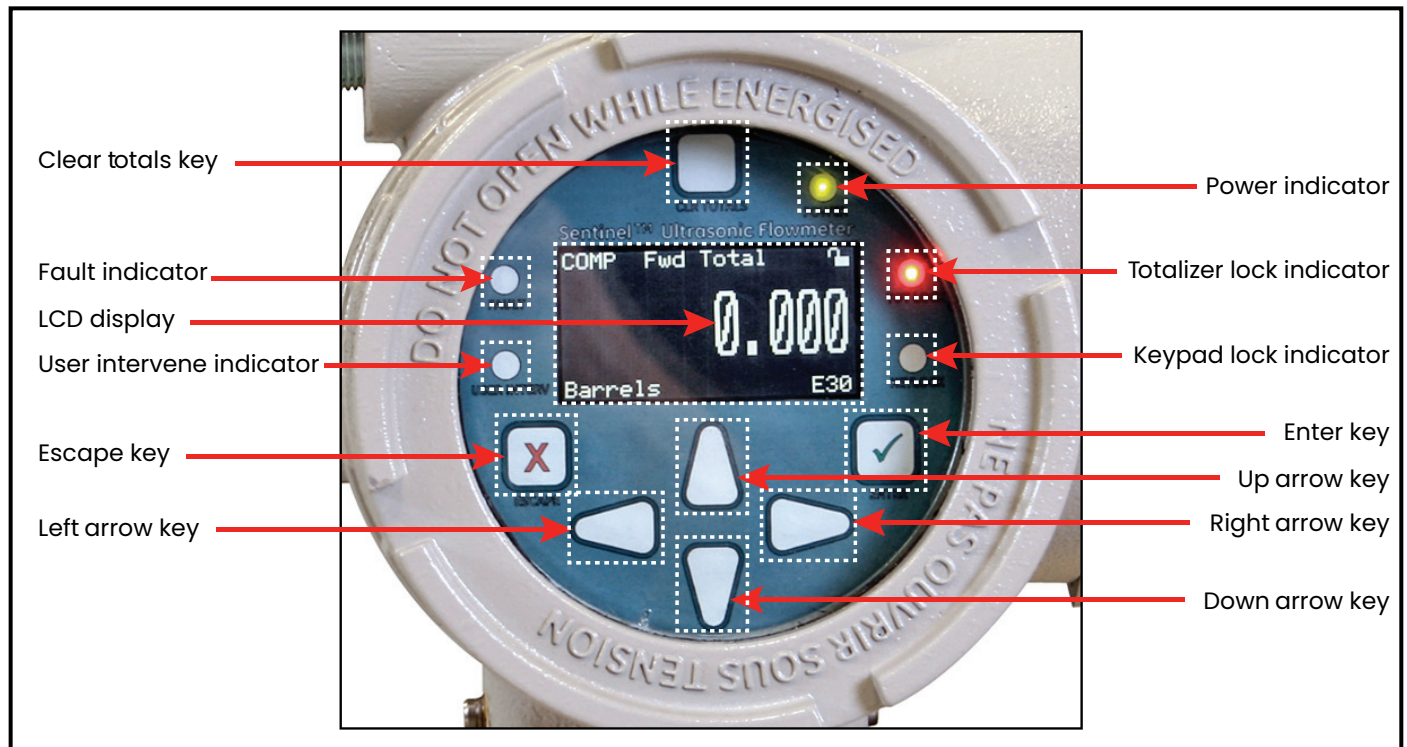


Figure 33: *Sentinel LCT8* HMI

The **Sentinel LCT8** HMI includes the seven keys listed in *Table 3* below.

Table 3: Keypad symbols and descriptions

Key symbol	Key name	Functions
CLR TOTALS	Clear totals key	To clear or reset accumulated totals
×	Escape key	To cancel a numeric entry change, or exit a menu or as back key
✓	Enter key	To accept a numeric entry or select a menu option
◀	Left arrow key	To navigate among menu choices or pages or set cursor position
▶	Right arrow key	To navigate among menu choices or pages or set cursor position
▲	Up arrow key	To navigate among menu choices or pages or increment numeric entries
▼	Down arrow key	To navigate among menu choices or pages or decrement numeric entries

3.1.2 Indicator lights

The **Sentinel LCT8** HMI includes the following indicator lights:

- The power indicator is normally lit when the instrument is powered on.
- The keypad lock indicator is lit if the internal keypad lock-out switch has been engaged.

Note: When the keypad lock indicator is lit, the keypad is not functional.

- The totalizer lock indicator is lit if the internal totals lock-out switch has been engaged.

Note: When the total lock indicator is lit, it is not possible to reset totals with the Clear totals key or through programming.

- If the fault indicator is lit, an instrument fault has been detected. This will also cause an error indication to be displayed in the lower right-hand corner of the measurement view screen.
- If the user intervene indicator is lit, an alarm has been triggered and will be kept latched until cleared by the user. See Section 2.5.6, "Wiring the alarm relay"

and Section 3.6, "Inputs/outputs" for more information.

3.1.3 Totalizer hard switch

The security switches on the front display can be locked, which will lock out the ability to do any programming changes, even from a PC connected to meter, and the totalizer only lockout, which will not allow anyone to reset the totalizer, even from a PC connected to the meter. The front window cover is screwed into place over the display.



Figure 34: Front cover screwed

The set screw in the cover can be screwed down to tight up against the enclosure. With the set screw in place, the lead and wire seal can be threaded through the channel in such a way that access to loosen the set screw is completely blocked.

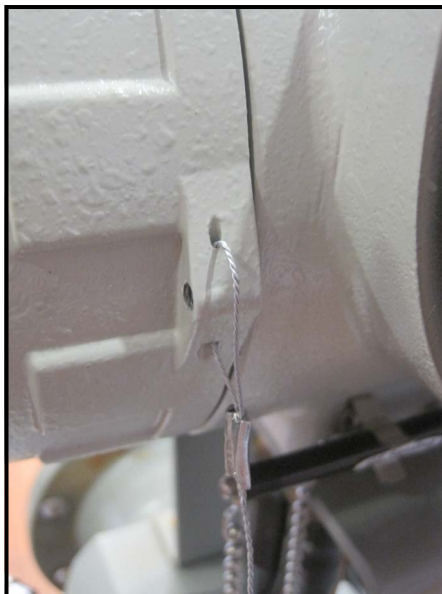


Figure 35: Set screw tied with wire seal

All connections can be made through the back cover while still protecting the key pad and the programming.



Figure 36: Back cover section

3.1.4 The magnetic stylus

Each of the keys can be selected using a hand-held magnet called a *magnetic stylus*, which is included with the meter (see *Figure 37* below). By touching the clear window at a key location, that key will be selected and will flash a red light to verify the contact.

Note: The red LED does not flash if contact is not made. Ensure the front cover is fully tightened.

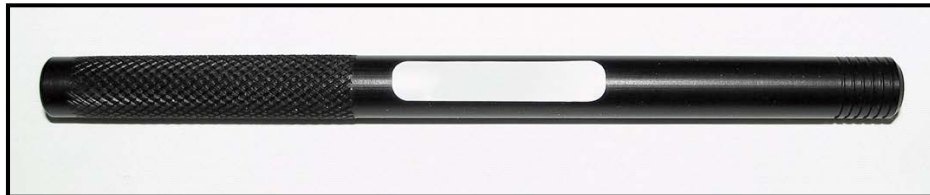


Figure 37: Magnetic stylus

3.2 Navigating through the program options

3.2.1 Conventions and guidelines

In this manual, menu navigation is illustrated with graphics that represent the **Sentinel LCT8** main display. The color of the boxes and arrows used in these illustrations follow the conventions listed in *Table 4* below.

Table 4: Color code descriptions

Color code	Monochrome code	Description
	Red box	Option is visible only when logged in with at least user 1 access
	Red arrow	The navigation is only possible when logged in with at least user 1 access
	Red dotted arrow	The navigation is only possible when logged in with at least user 1 access. The dotted arrow indicates that all intermediate display changes are not explicitly shown in the diagram.
	Green box	Option is visible only when logged in with at least user 3 access
	Green arrow	The navigation is only possible when logged in with at least user 3 access
	Green dotted arrow	The navigation is only possible when logged in with at least user 3 access. The dotted arrow indicates, that all intermediate display changes are not explicitly shown in the diagram.
	Yellow box	Option is visible only when logged in with at least user admin access

Table 4: Color code descriptions(Continued)

	Yellow arrow	The navigation is only possible when logged in with at least user admin access
	Yellow dotted arrow	The navigation is only possible when logged in with at least user admin access. The dotted arrow indicates, that all intermediate display changes are not explicitly shown in the diagram.
	Magenta arrow	The navigation is only possible when logged in with at least display locked access
	Magenta dotted arrow	The navigation is only possible when logged in with at least display locked access. The dotted arrow indicates, that all intermediate display changes are not explicitly shown in the diagram.
	Blue arrow	Login not required for this navigation
	Gray arrow	Used as pointers to notes and guidelines

3.2.2 Security access level and privileges

To prevent unauthorized tampering with either the display or the user program, the **Sentinel LCT8** has multiple security access codes which grant different access level privileges (see *Table 5* below).

Table 5: Security level descriptions

Level	Security access	Default passcode	Privilege details
0	Full lock	0000 (fixed)	Meter locked, need passcode to unlock for viewing data or configuration.
1	Display locked	2719 (fixed)	Viewing data, select parameters to show in the measurement view.
2	User 1	0001*	Basic user configuration privileges
3	User 2	0002*	
4	User 3	0003*	Basic + power user configuration privileges
5	User 4	0004*	
6	User admin	0005*	Basic + power + admin user configuration privileges

*Panametrics recommends user admin to set new passcodes for each user access level.

3.3 Measurement view, security and page overview

The initial screen displayed upon meter startup is known as *measurement view*. The elements of measurement view are shown in *Figure 38* below, with gray arrows pointing to each element.

Note: If necessary, refer to *Table 4* on *page 32* as a reminder about color code meanings.

Note the following:

- When logged in to *display locked* access level, the user can choose the measurement to be displayed in *measurement view* from a list of options.
- If there are no errors on the channel chosen for *measurement view*, the *error indicator* at the bottom right of the display is blank.

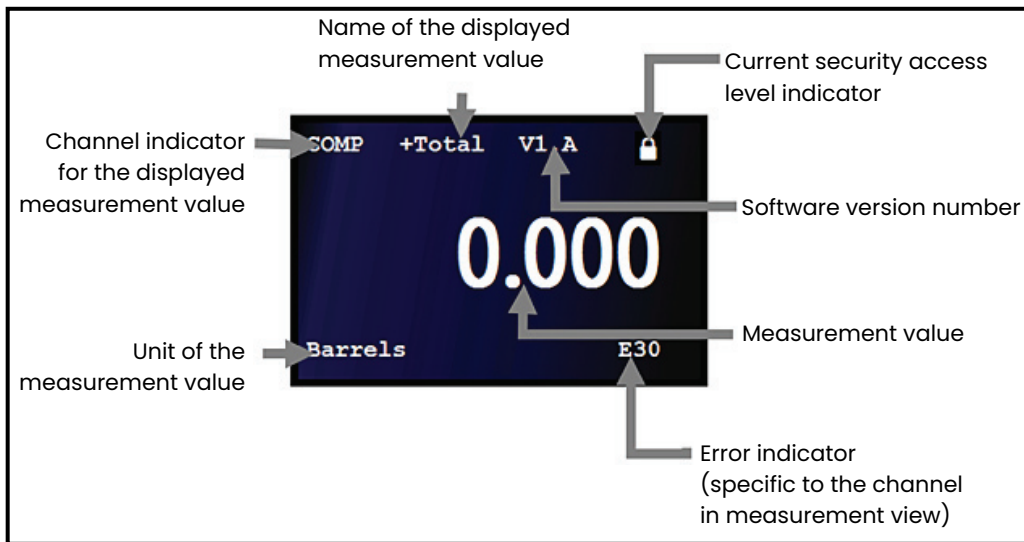


Figure 38: Measurement view

3.3.1 Unlocking the meter

Note: The user needs to enter a valid passcode to unlock the meter.

To unlock the display and/or the user program, refer to Figure 39 below and complete the following steps:

1. From *measurement view*, press the [X], [✓], and [X] keys in sequence (login is not required).
2. Use the [◀] and [▶] keys to highlight the desired digit in the passcode display. Then, use the [▲] and [▼] keys to increment or decrement the value for that digit. Repeat this process until all four digits of a valid passcode have been entered.

Note: The example passcode shown in Figure 39 below is the factory default user4 passcode. Your actual passcode may differ.

3. After the passcode has been entered, either press the [X] key to cancel the unlock sequence and return to the locked *measurement view* or press the [✓] key to login on the unlocked *measurement view*.

Note: If necessary, refer to Table 4 on page 32 as a reminder about color code meanings.

After unlocking the meter with the required level of security, the meter will remain active at this security level until the security level is changed or the meter keypad inactivity time limit (as set by a user admin) is exceeded.

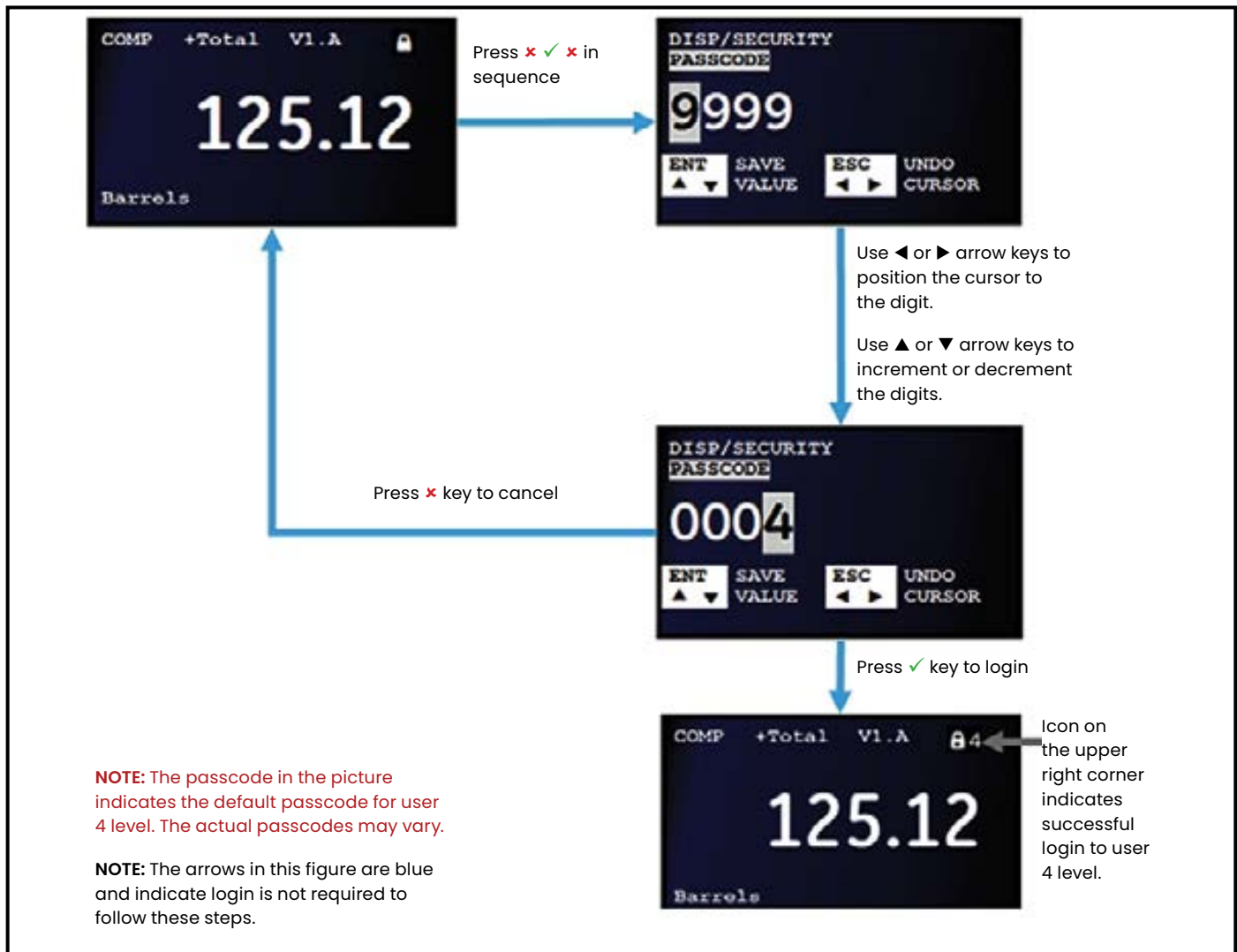


Figure 39: Steps to unlock the meter

3.3.3 Changing the access level

The user can change the access level in two ways:

- From *measurement view*
- From *user configurations*

3.3.3.1 Changing the access level from measurement view

To change the access level from *measurement view*, refer to Figure 41 below and complete the following steps:

Note: If necessary, refer to Table 4 on page 32 as a reminder about color code meanings.

1. From *measurement view*, use the [◀] and [▶] keys to highlight the security level icon (at least *display locked* access level is required to make these changes).
2. Press the [✓] key to access the security options list.
3. Use the [▲] and [▼] keys to highlight the desired *security level* option.
4. Press the [✓] key twice confirm your selection.

Note: The example screens shown above are for admin level access. The options vary for other access levels.

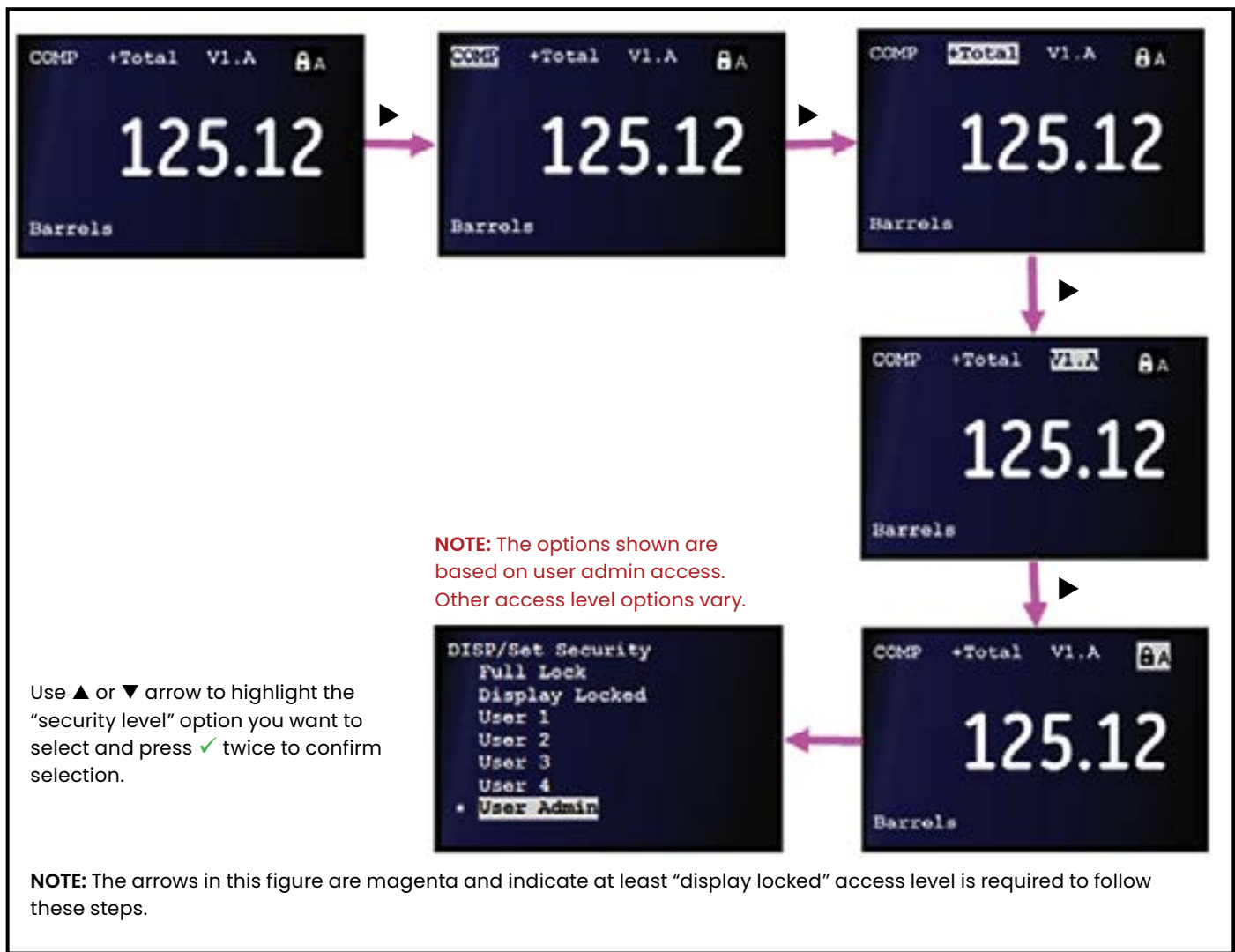


Figure 41: Setting the security level from measurement view

3.3.3.2 Changing the access level from user configurations

To change the access level from user configurations, refer to *Figure 42* below and complete the following steps:

Note: If necessary, refer to *Table 4* on page 32 as a reminder about color code meanings.

1. Refer to *Primary pages* on page 26 and navigate to *page 8: user configurations*.
2. Use the [▲] and [▼] keys to highlight the set security option. Then, press the [✓] key to access the security options list (at least user1 access level is required).
3. Use the [▲] and [▼] keys to highlight the desired security level option.
4. Press the [✓] key twice confirm your selection.

Note: The example screens shown above are for admin level access. The options vary for other access levels.



Figure 42: Setting the security level from user configurations

3.4 Programming menu options

3.4.1 Channel programming

The *channel program* allows the entry of *configuration data* and settings adjustments for each physical channel.

3.4.1.1 Activating a channel/path/CHX (status)

A channel/path should be activated when the unit is received, however, verify that the channel/path is active before trying to acquire data. To activate a channel/path, refer to *Figure 43* below and complete the following steps:

Note: If necessary, refer to *Table 4* on page 32 as a reminder about color code meanings.

1. Refer to *Primary pages* on page 26 and navigate to page 3: *program*.
2. Use the [▲] and [▼] keys to highlight the desired channel. Press the [✓] key twice to confirm your choice.
3. Use the [▲] and [▼] keys to highlight the *channel status* option. Then, press the [✓] key to confirm your selection or press the [✗] key to return to the previous screen.
4. Use the [▲] and [▼] keys to highlight either the *on* or *off* option. Then, press the [✓] key twice to confirm your selection or press the [✗] key to keep the original setting. You will then return to the previous screen.

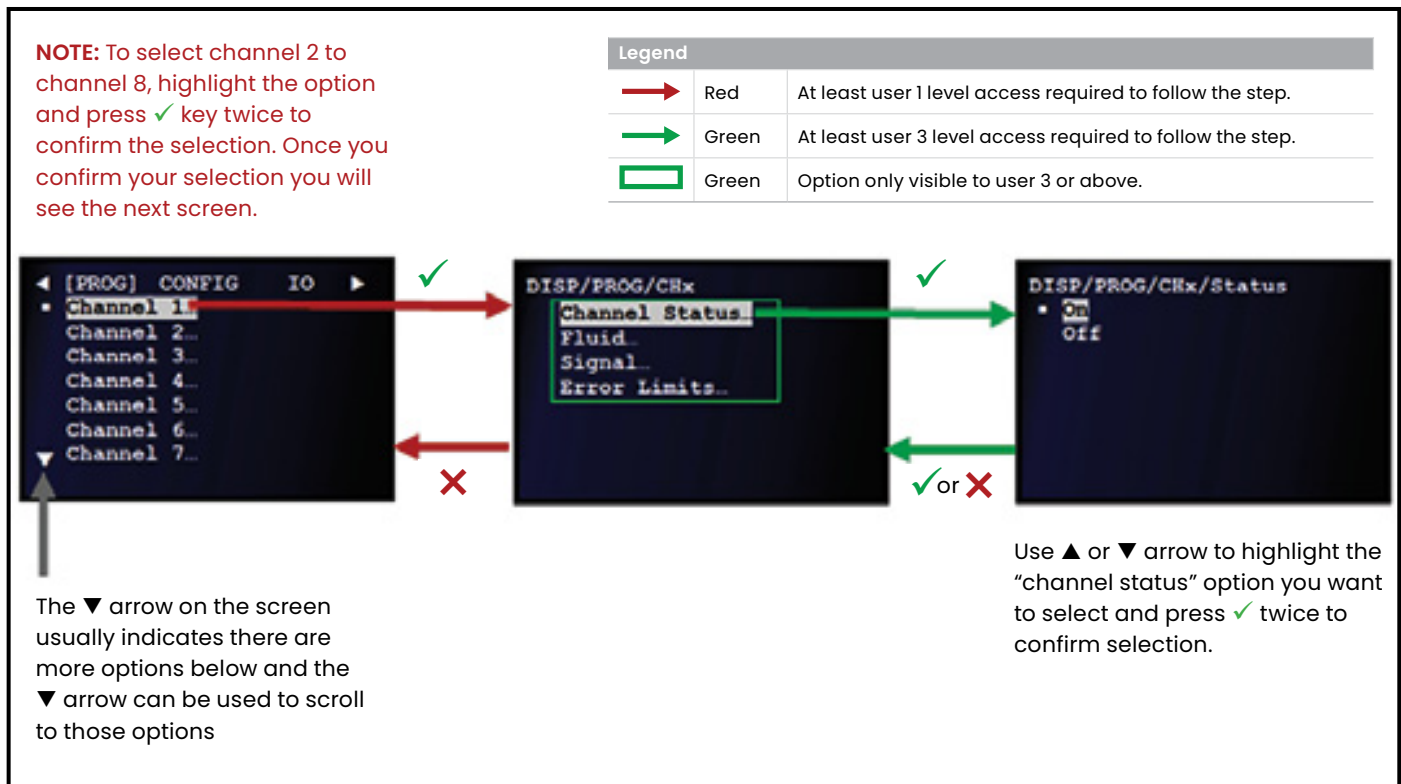


Figure 43: Activating a channel/path

3.4.1.2 Entering the signal parameters

Use the signal submenu, to set the **Sentinel LCT8** transducer signal parameters.

IMPORTANT: The factory default *signal parameters* are suitable for most applications. Consult the factory before changing any of these settings.

To configure the *signal parameters*, refer to Figure 44 below and complete the following steps:

Note: If necessary, refer to Table 4 on page 32 as a reminder about color code meanings.

1. Refer to *Primary pages* on page 26 and navigate to *Page 3: program*.
2. Use the [▲] and [▼] keys to highlight the desired channel.

Press the [✓] key twice to confirm your choice.

3. Use the [▲] and [▼] keys to highlight the signal option. Then, press the [✓] key to confirm your selection or press the [✗] key to return to the previous screen.
4. Use the [▲] and [▼] keys to highlight the zero cutoff or the active tw peak pcnt option. Then, press the [✓] key to confirm your selection or press the [✗] key to return to the previous screen.

Note: The zero cutoff parameter causes fluid velocities less than the setpoint to be reported as zero.

5. Enter the desired value for the signal parameter chosen in the previous step. Press the [✓] key to confirm the new value or press the [✗] key to keep the original value. You will then return to the previous screen.

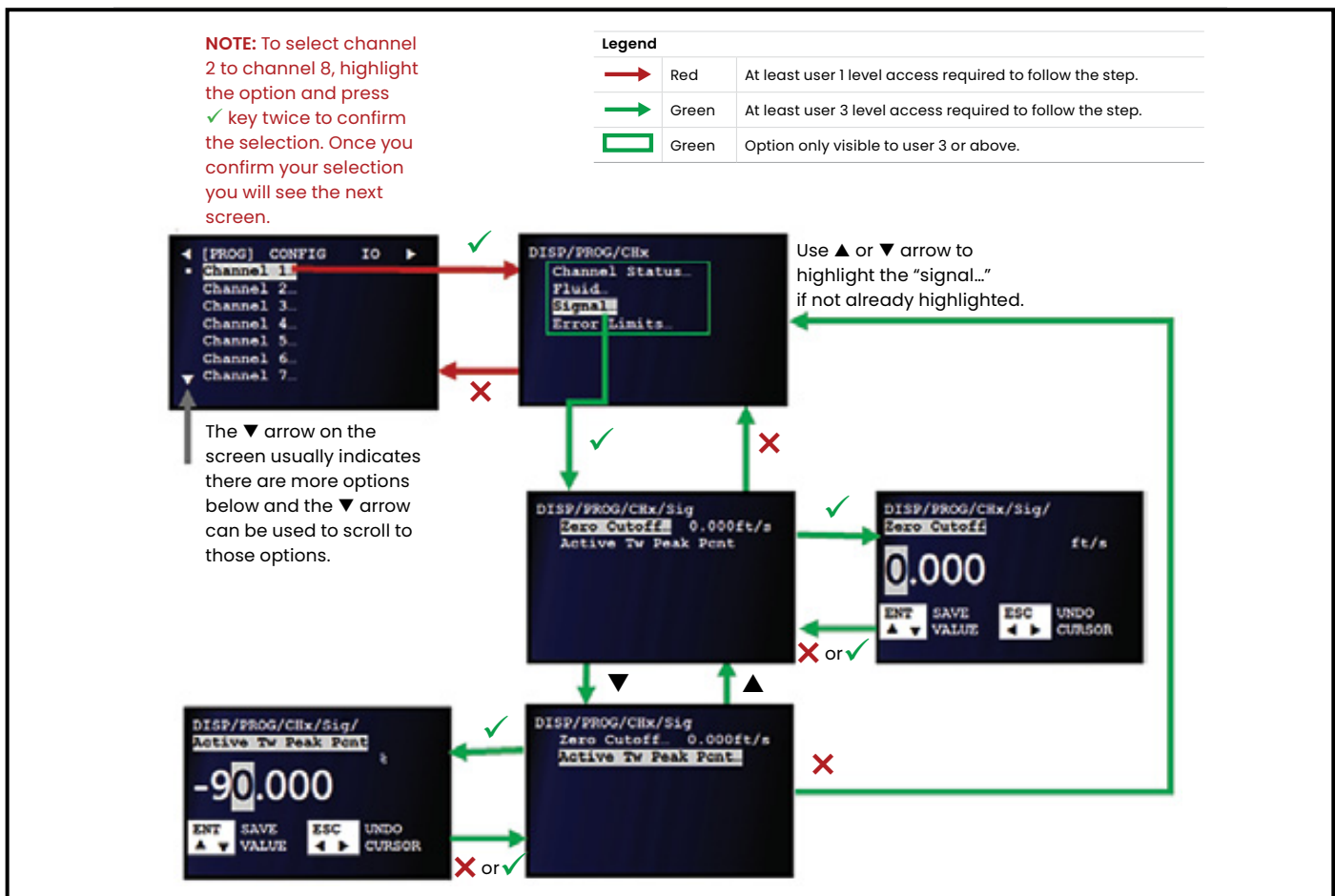


Figure 44: Entering the signal parameters

3.4.1.3 Entering the error limits

The *error limits* option enables setting limits for the acoustic signals. If a signal falls outside these programmed limits, an error code is displayed. To set the error limits, refer to Figure 45 below and complete the steps on the next page.

Note: If necessary, refer to Table 4 on page 32 as a reminder about color code meanings.

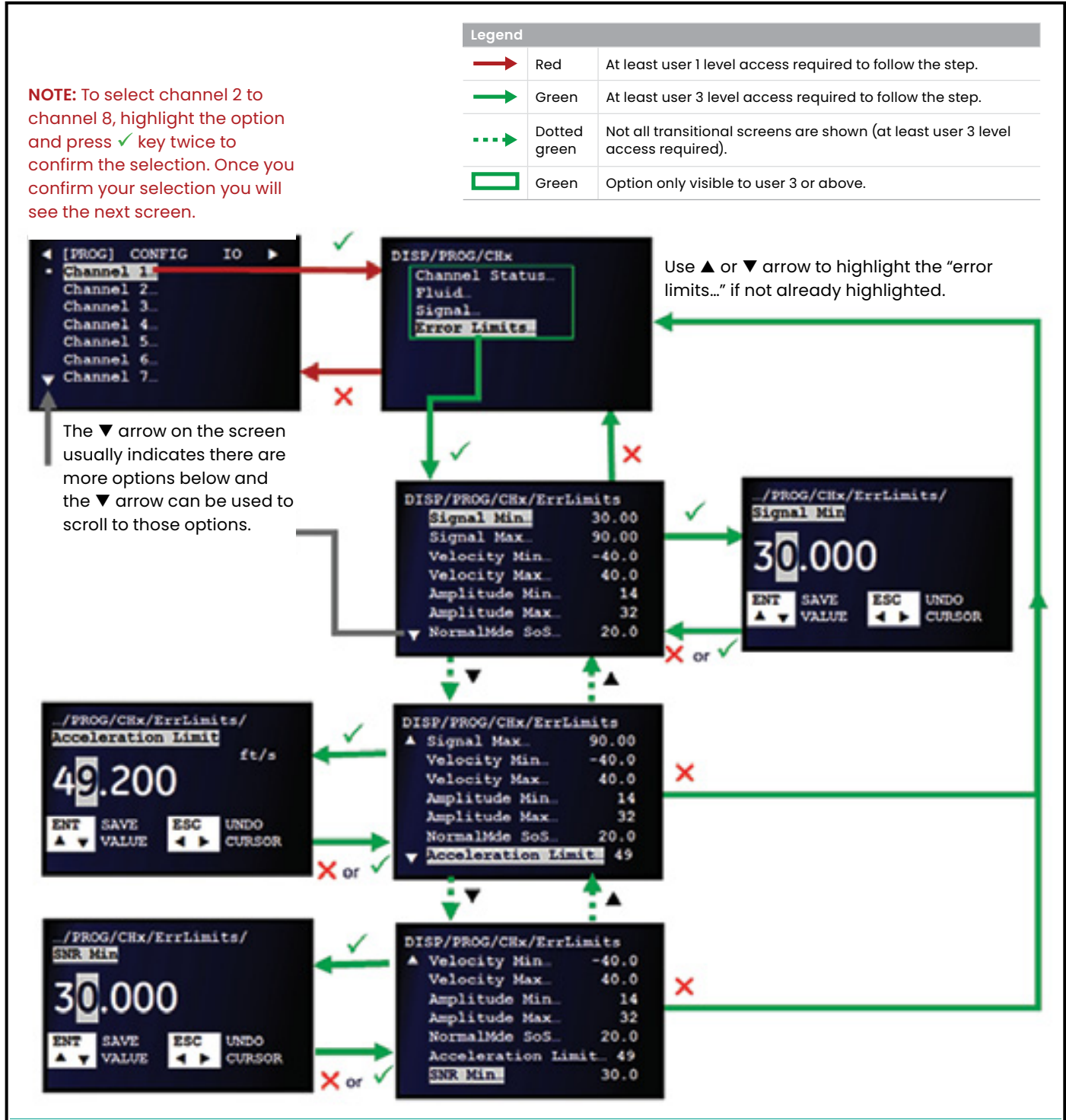


Figure 45: Entering the error limits

1. Refer to *Primary pages* on page 26 and navigate to *Page 3: program*.
2. Use the [▲] and [▼] keys to highlight the desired channel. Press the [✓] key twice to confirm your choice.
3. Use the [▲] and [▼] keys to highlight the *error limits* option. Then, press the [✓] key to confirm your selection or press the [✗] key to return to the previous screen.
4. Use the [▲] and [▼] keys to highlight the desired *signal parameter*. Then, press the [✓] key to confirm your selection or press the [✗] key to return to the previous screen.
5. Enter the desired *error limit* for the chosen signal parameter. Press the [✓] key to confirm the new value or press the [✗] key to keep the original value. In either case, you will then return to the previous screen.
6. Repeat steps 4 and 5 as necessary, to program additional signal parameter error limits.

3.4.1.4 Understanding the error limits

Note the following information about the **Sentinel LCT8** error limits:

- The *signal min* limit is the minimum acceptable value for the transducer signal received by the **Sentinel LCT8**. If the signal falls below the programmed limit, the **E1: LOW SIGNAL** error is displayed.
- The measured velocity value is expected to be within the *min velocity* and *max velocity* limits. If the measured velocity is outside the programmed range, a **W3: VELOCITY RANGE** warning is displayed.
- The amplitude of the received signal is expected to be within the *amplitude min* and *amplitude max*. programmed limits. If the signal falls outside these limits, the **E5: AMPLITUDE** error is displayed.
- If the fluid soundspeed exceeds that entered in the *normal mode of fluid* submenu by more than the percentage programmed in the *NormalMde SoS* error limit, the **E2: SOUNDSPEED** error is displayed.
- If the velocity changes by more than the programmed *acceleration* error limit from one measurement to the next, the **E6: ACCELERATION** error is displayed.
- If the SNR is below the programmed SNR error limit, the **W24:SNR** warning is displayed.

Note: Refer to “Table 14” for more details about errors and warnings.

3.4.2 Composite programming

The *composite program* allows entry of configuration data that applies to the composite calculations. The composite configurations are appropriately set for the intended application during commissioning. However, these settings should be verified before data is acquired or whenever the meter reports an error.

Note: Composite programming is accomplished via the program primary page (see Figure 40 on page 36).

NOTE: To select composite, highlight the option and press **✓** key twice to confirm the selection. Once you confirm your selection you will see the next screen.

Legend		
	Red	At least user 1 level access required to follow the step.
	Green	At least user 3 level access required to follow the step.
	Dotted green	Not all transitional screens are shown (at least user 3 level access required).
	Green	Option only visible to user 3 or above.



NOTE: Consult Panametrics factory before choosing normal fluid type| option or preprogrammed (tracking) options

Use **▼** arrow to highlight the "soundspeed max" option and press **✓** and then adjust the value, if not already highlighted.

Figure 46: Fluid type/tracking configuration

3.4.2.1 Fluid type/tracking configuration

It is critical to select the appropriate fluid type/tracking option for the application. Tracking refers to *tracking windows*, which is used to detect the receive signal when you are unsure of the fluid sound speed, or when the fluid sound speed changes drastically under process conditions. To program the fluid type/tracking options, refer to *Figure 46 on page 43* and complete the steps on the next page.

Note: If necessary, refer to *Table 4 on page 32* as a reminder about color code meanings.

1. Refer to *Primary pages on page 26* and navigate to *page 3: program*.
2. Use the [▲] and [▼] keys to highlight composite in the list of channels, and press the [✓] key twice to confirm your choice.
3. Use the [▲] and [▼] keys to highlight the fluid option. Then, press the [✓] key to confirm your selection or press the [✗] key to return to the previous screen.
4. At the next screen, fluid type is the only option and is already highlighted. Press the [✓] key to confirm this selection or press the [✗] key to return to the previous screen.

IMPORTANT: Consult the factory before choosing either the normal fluid type or preprogrammed tracking options.

5. Use the [▲] and [▼] keys to highlight tracking. Then, press the [✓] key twice to confirm your selection or press the [✗] key to return to the previous screen.
6. Use the [▲] and [▼] keys to highlight either *preprogrammed* or *other*, then, press the [✓] key twice to confirm your selection or press the [✗] key to return to the previous screen.
 - a. If *preprogrammed* was selected, use the [▲] and [▼] keys to highlight the desired option. Press the [✓] key twice to confirm your selection or press the [✗] key to cancel. You will return to the previous screen.
 - b. If *other* was selected, use the [▲] and [▼] keys to highlight the Soundspeed min option. Press the [✓] key to confirm your selection. Enter the desired value and press the [✓] key to confirm your entry or press the [✗] key to cancel the change. When, you return to the previous screen, repeat the process to enter the *Soundspeed max* value.

3.4.2.2 Signal parameter configuration



CAUTION! The SIGNAL default settings are suitable for most applications. Consult the Panametrics factory before changing these settings.

Use the signal submenu to set the parameters that apply compensations and handle noisy signals. To adjust the error Allowed options, refer to *Figure 47* below and complete the following steps:

Note: If necessary, refer to *Table 4* on page 32 as a reminder about color code meanings.

1. Refer to *Primary pages* on page 26 and navigate to *page 3: program*.
2. Use the [▲] and [▼] keys to highlight *composite* in the list of channels, and press the [✓] key twice to confirm your choice.
3. At the next screen, use the [▲] and [▼] keys to highlight the *signal* option. Then, press the [✓] key to confirm your selection or press the [✗] key to return to the previous screen.
4. At the next screen, use the [▲] and [▼] keys to highlight the *error allowed* option. Then, press the [✓] key to confirm your selection or press the [✗] key to return to the previous screen.
5. At the next screen, enter the desired value and press the [✓] key to confirm your entry or press the [✗] key to cancel the change.

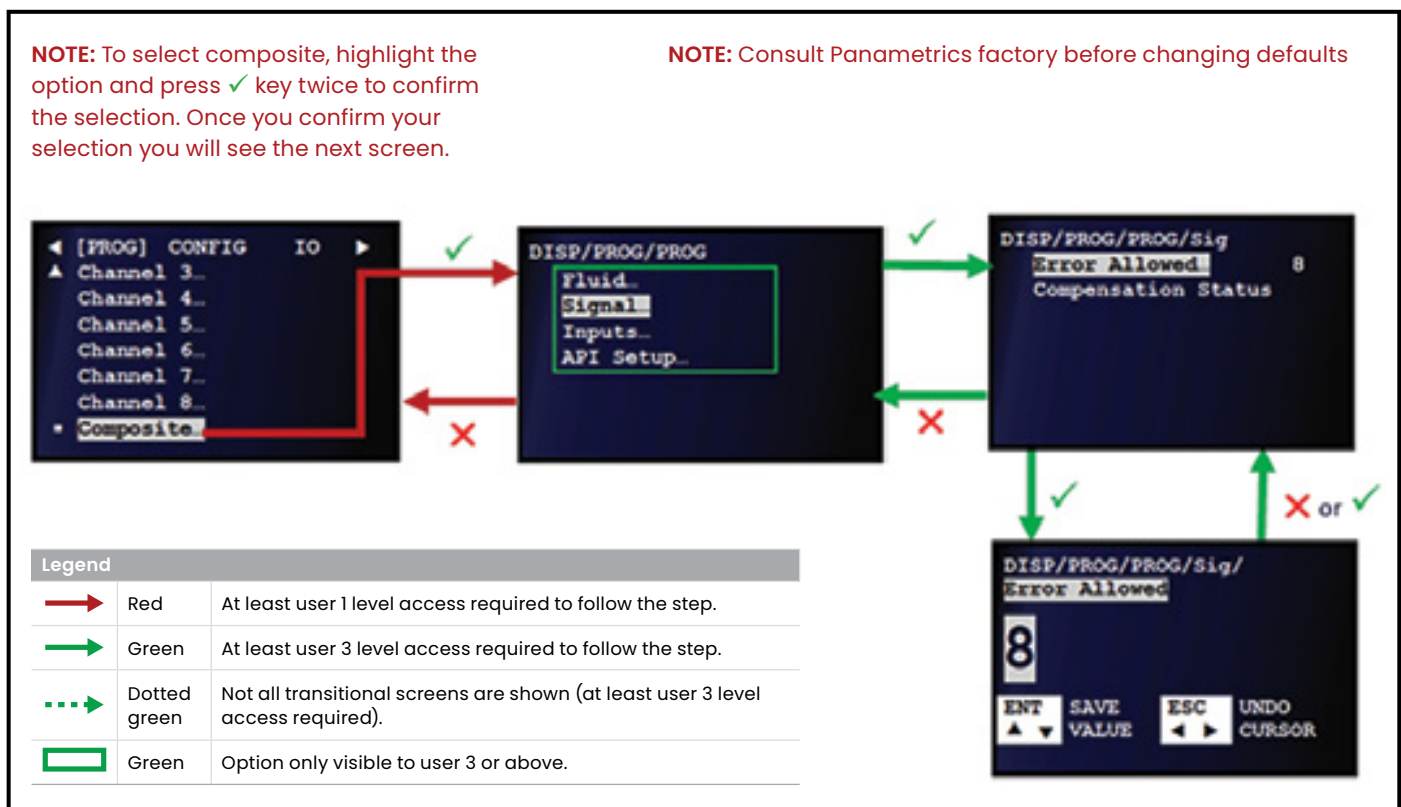


Figure 47: Setting the error allowed

Turning *dimensional compensation* on enables the meter to perform calculations that correct for geometric changes in the flowcell caused by temperature variations. This may be helpful in applications where the temperature in or around the flowcell is known to vary significantly. To select the *dimensional compensation status*, refer to Figure 48 below and complete the following steps:

Note: If necessary, refer to Table 4 on page 32 as a reminder about color code meanings.

- 1. Refer to Primary pages on page 26 and navigate to page 3: program.
- 2. Use the [▲] and [▼] keys to highlight *composite* in the list of channels, and press the [✓] key twice to confirm your choice.
- 3. At the next screen, use the [▲] and [▼] keys to highlight the *signal* option. Then, press the [✓] key to confirm your selection or press the [✗] key to return to the previous screen.
- 4. At the next screen, use the [▲] and [▼] keys to highlight the *compensation status* option. Then, press the [✓] key to confirm your selection or press the [✗] key to return to the previous screen.
- 5. At the next screen, use the [▲] and [▼] keys to highlight *on* or *off* and press the [✓] key twice to confirm your status selection or press the [✗] key to cancel the change.

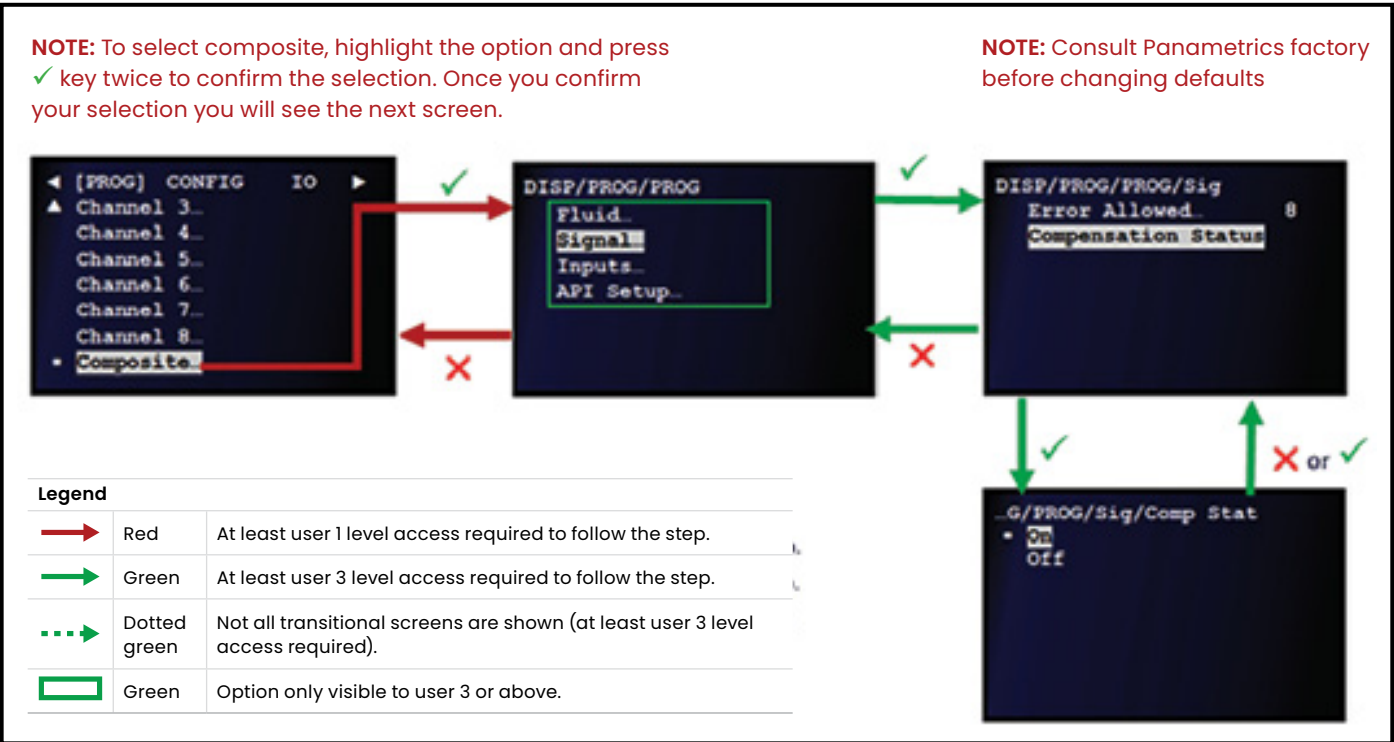


Figure 48: Setting the dimensional compensation status

3.4.3 setting up the input data feeds

Use the *inputs* submenu to select where the *temperature*, *pressure* and *density* inputs are used. To set up the desired inputs, refer to Figure 49 below and complete the steps on the next page.

Note: If necessary, refer to Table 4 on page 32 as a reminder about color code meanings.

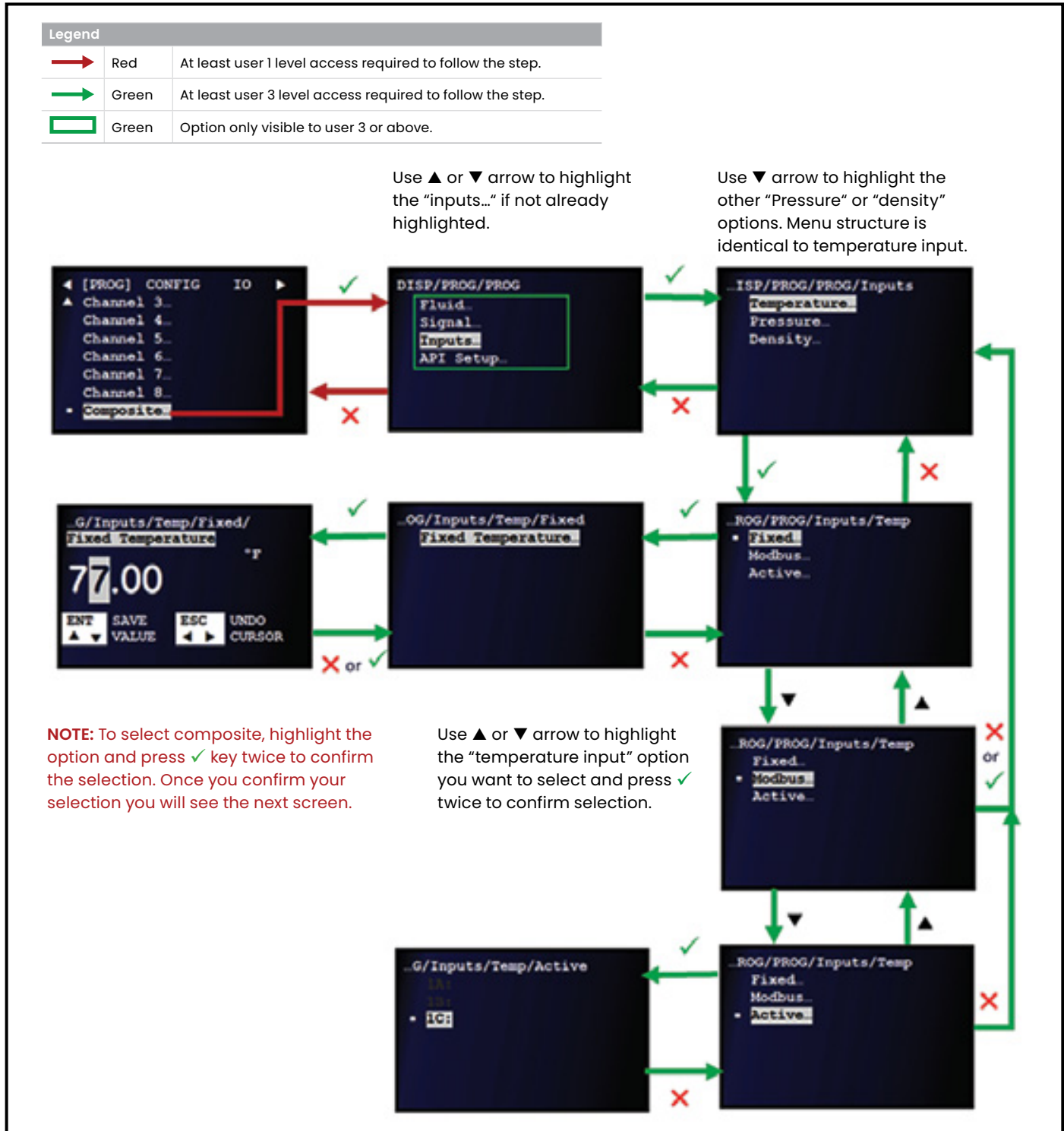


Figure 49: Temperature, pressure and density data feeds

1. Refer to *Primary pages on page 26* and navigate to *page 3: program*.
2. Use the [▲] and [▼] keys to highlight *composite* in the list of channels, and press the [✓] key twice to confirm your choice.
3. At the next screen, use the [▲] and [▼] keys to highlight the *inputs* option. Then, press the [✓] key to confirm your selection or press the [✗] key to return to the previous screen.
4. At the next screen, use the [▲] and [▼] keys to highlight the desired data feed parameter. Then, press the [✓] key to confirm your selection or press the [✗] key to return to the previous screen.

Note: The following steps are the same for all three data feed parameters.

5. At the next screen, use the [▲] and [▼] keys to highlight the desired option and press the [✓] key twice to confirm your selection or press the [✗] key to return to the previous screen.
 - a. If you selected **fixed**, enter the appropriate value and press the [✓] key to confirm the new value or press the [✗] key to cancel the change.
 - b. If you selected **modbus**, select the desired input option and press the [✓] key twice to confirm your selection or press the [✗] key to cancel the change.
 - c. If you selected **active**, select the desired input option and press the [✓] key twice to confirm your selection or press the [✗] key to cancel the change.

3.4.4 Setting up the API

Note: API is optional and this section is applicable only

if the API option was ordered.

Use the *API setup* submenu by completing the following steps:

1. Refer to *Primary pages on page 26* and navigate to *page 3: program*.
2. Use the [▲] and [▼] keys to highlight *composite* in the list of channels, and press the [✓] key twice to confirm your choice.
3. Proceed to the following subsections to complete the setup.

3.4.4.1 Choosing the API table type

To select the appropriate API table type, refer to *Figure 50 on page 49* and complete the steps on the next page.

Note: If necessary, refer to *Table 4 on page 32* as a reminder about color code meanings.

1. At the next screen, use the [▲] and [▼] keys to highlight the *API setup* option. Then, press the [✓] key to confirm your selection or press the [✗] key to return to the previous screen.
2. At the next screen, use the [▲] and [▼] keys to highlight the *API table type* option. Then, press the [✓] key to confirm your selection or press the [✗] key to return to the previous screen.
3. At the next screen, use the [▲] and [▼] keys to highlight the *table type* appropriate for your application. Then, press the [✗] key twice to confirm your selection or press the [✗] key to return to the previous screen.
4. At the next screen, with *thermal expansion coefficient (TEC)* highlighted, press the [✓] key to confirm the selection or press the [✗] key to return to the previous screen.
5. Enter the appropriate value and press the [✓] key to confirm the new value or press the [✗] key to cancel the change.

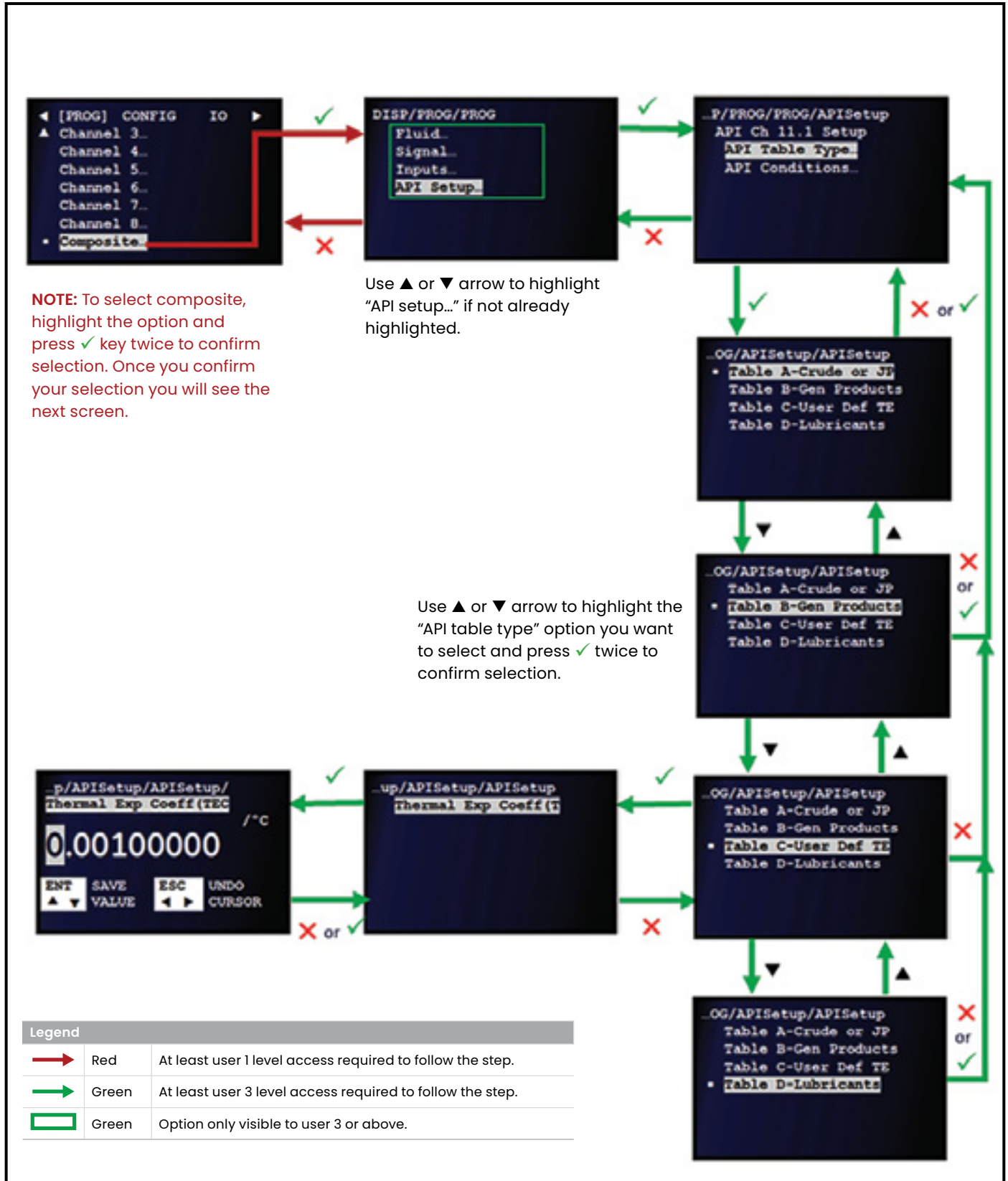
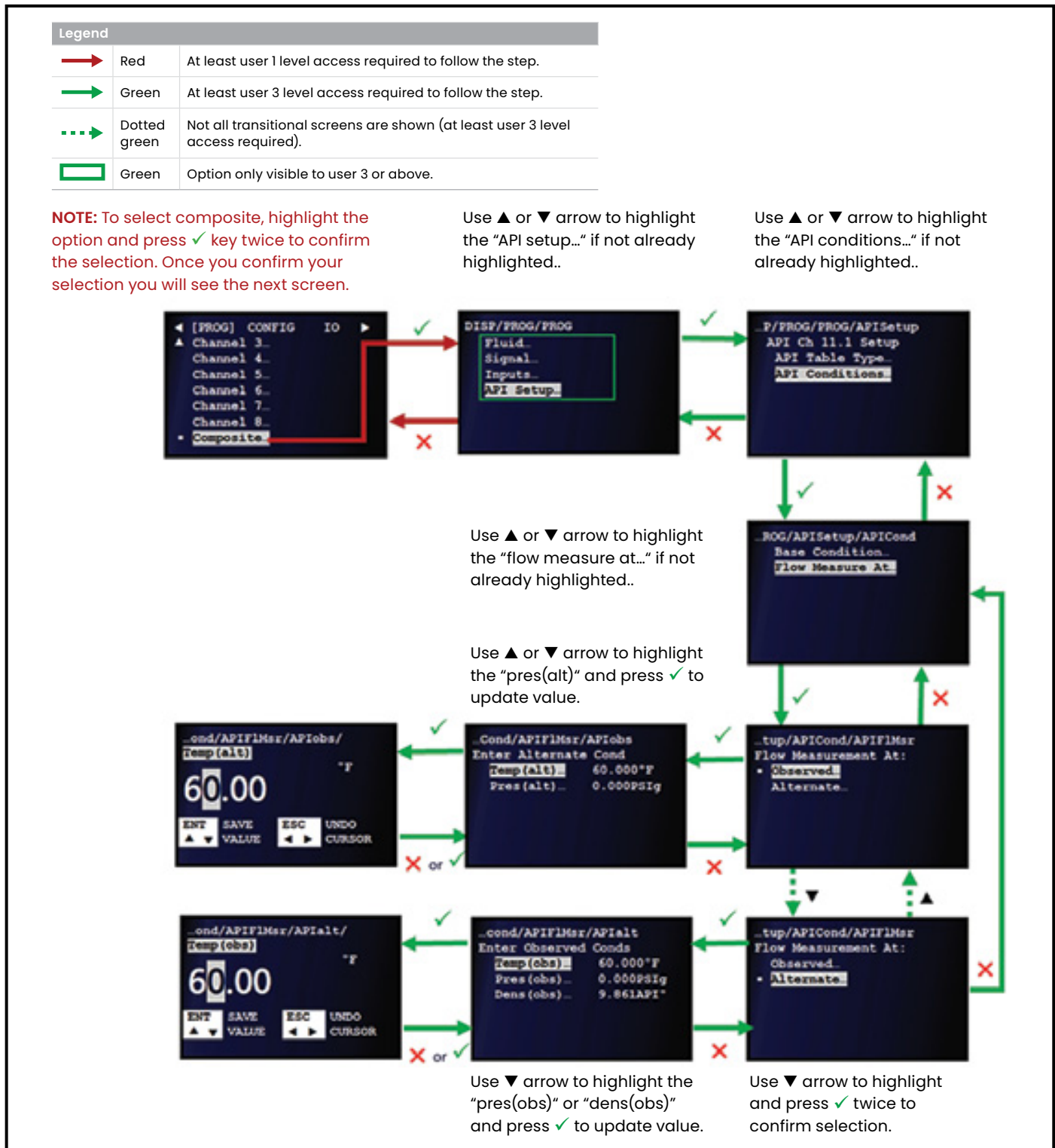


Figure 50: API table type selection



1. At the next screen, use the [▲] and [▼] keys to highlight the *API setup* option. Then, press the [✓] key to confirm your selection or press the [✗] key to return to the previous screen.
2. At the next screen, use the [▲] and [▼] keys to highlight the *API conditions* option. Then, press the [✓] key to confirm your selection or press the [✗] key to return to the previous screen.
3. At the next screen, use the [▲] and [▼] keys to highlight the *flow measure at* option. Then, press the [✓] key to confirm your selection or press the [✗] key to return to the previous screen.
4. To set the observed conditions:
 - a. Use the [▲] and [▼] keys to highlight the *observed* option. Then, press the [✓] key twice to confirm your selection or press the [✗] key to return to the previous screen.
 - b. Use the [▲] and [▼] keys to highlight one of the available variables. Then, press the [✓] key to confirm your selection or press the [✗] key to return to the previous screen.
 - c. Enter the appropriate value for your application and press the [✓] key to confirm the new value or press the [✗] key to cancel the change.
 - d. Repeat the previous two steps until all of the desired variables have been set for your application
5. To set the alternate conditions:
 - a. Use the [▲] and [▼] keys to highlight the *alternate* option. Then, press the [✓] key twice to confirm your selection or press the [✗] key to return to the previous screen.
 - b. Use the [▲] and [▼] keys to highlight one of the available variables. Then, press the [✓] key to confirm your selection or press the [✗] key to return to the previous screen.
 - c. Enter the appropriate value for your application and press the [✓] key to confirm the new value or press the [✗] key to cancel the change.
 - d. Repeat the previous two steps until all of the desired variables have been set for your application.

3.5 Generic meter configuration

This section describes the procedures for configuring the following:

- **Units** (see below)
- **Communication** (see Section 3.5.2, “Setting up communication” on page 54) **Reset totals** (see Section 3.5.4, “Setting reset totals” on page 60) **Totalize on error** (see Section 3.5.5, “Setting up totalizer error handling” on page 61) **Date/time** (see Section 3.5.6, “Setting the date and time” on page 62)

3.5.1 Selecting the preferred unit type

To select the desired units, refer to Figure 53 below and complete the following steps:

Note: If necessary, refer to Table 4 on page 32 as a reminder about color code meanings.

1. Refer to *Primary pages* on page 26 and navigate to *page 4: configuration (generic)*.
2. Use the [▲] and [▼] keys to highlight *units* and press the [✓] key to confirm your choice.
3. At the next screen, use the [▲] and [▼] keys to highlight either the *metric* or *English* option. Then, press the [✓] key twice to confirm your selection.

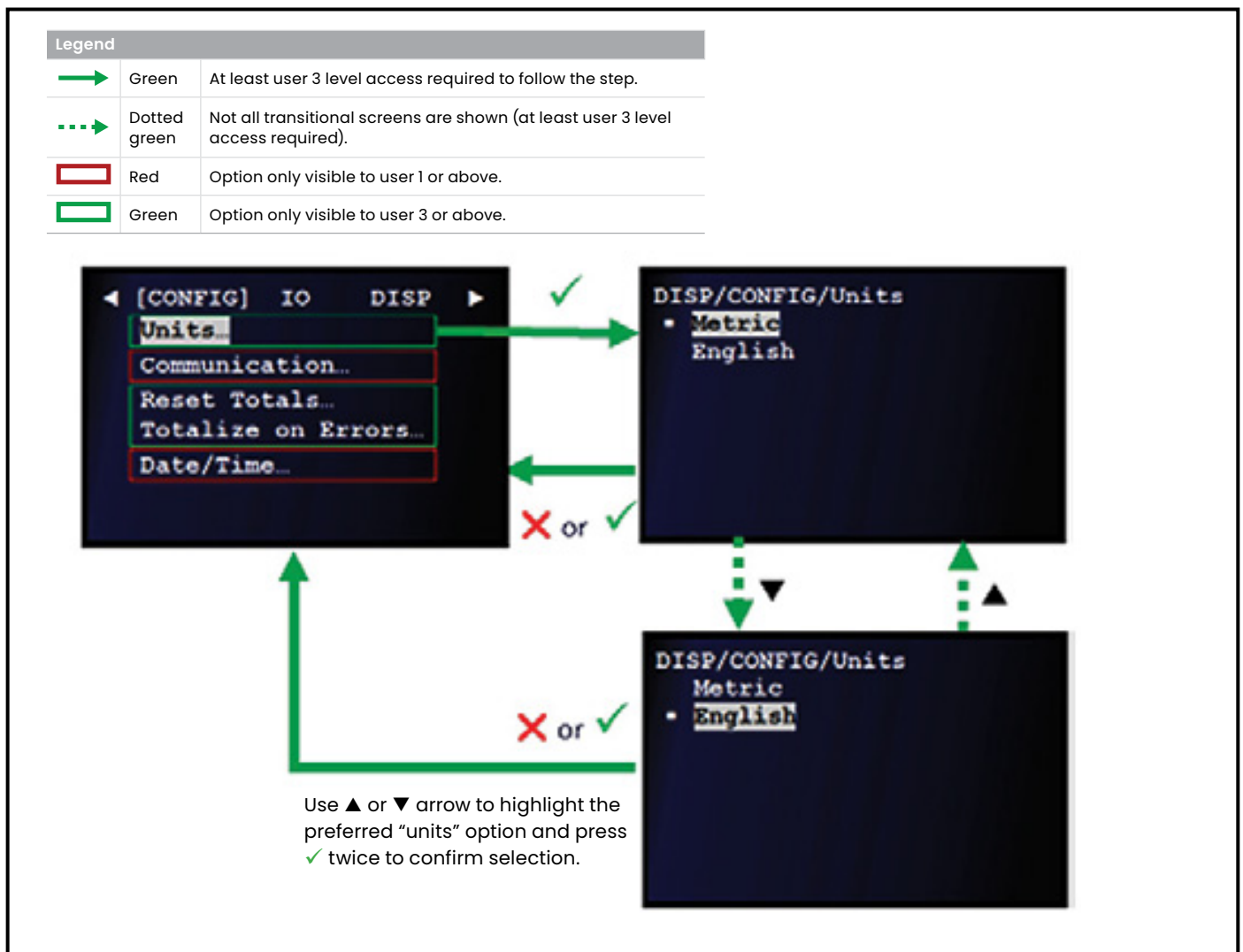


Figure 53: Unit type selection

1. Refer to *Primary pages on page 26* and navigate to *page 4: configuration (generic)*.
2. Use the [▲] and [▼] keys to highlight *communication* and press the [✓] key to confirm your choice.
3. At the next screen, use the [▲] and [▼] keys to highlight the *Panalink* option. Then, press the [✓] key to confirm your selection or press the [✗] key to cancel and return to the previous screen.
4. Set the various parameters as follows:
 - a. Use the [▲] and [▼] keys to highlight the *node ID* option and press the [✓] key to confirm your selection. Then, enter the desired value and press the [✓] key to confirm the new value or press the [✗] key to cancel the change and return to the previous screen.
 - b. Use the [▲] and [▼] keys to highlight the *interface* option and press the [✓] key to confirm your selection. Then, select the desired option from the list and press the [✓] key twice to confirm the selection or press the [✗] key to cancel the change and return to the previous screen.
 - c. Use the [▲] and [▼] keys to highlight the *baud rate* option and press the [✓] key to confirm your selection. Then, select the desired option from the list and press the [✓] key twice to confirm the selection or press the [✗] key to cancel the change and return to the previous screen.
 - d. Use the [▲] and [▼] keys to highlight the *parity* option and press the [✓] key to confirm your selection. Then, select the desired option from the list and press the [✓] key twice to confirm the selection or press the [✗] key to cancel the change and return to the previous screen.
 - e. Use the [▲] and [▼] keys to highlight the *stop bits* option and press the [✓] key to confirm your selection. Then, select the desired option from the list and press the [✓] key twice to confirm the selection or press the [✗] key to cancel the change and return to the previous screen.
 - f. Use the [▲] and [▼] keys to highlight the *data bits* option and press the [✓] key to confirm your selection. Then, select the desired option from the list and press the [✓] key twice to confirm the selection or press the [✗] key to cancel the change and return to the previous screen.

1. Navigate to the mode option on the freq/tot status screen (see Section 3.6.2, “Setting up a frequency/totalizer output” on page 65). Then, press the [✓] key to confirm this choice.
2. Use the [▲] and [▼] keys to highlight the frequency option. Then, press the [✓] key twice to confirm your selection or press the [✗] key to cancel and return to the previous screen.
3. Use the [▲] and [▼] keys to select and program each of the six frequency output options. Refer to Table 8 below for guidance in choosing the appropriate setting for your application. Also, see Table 9 below for descriptions of the available options for the error level setting.
4. After programming all of the frequency output options, press the [✓] key to accept your new settings or press the [✗] key to keep the previous settings and return to the previous screen.

Table 8: Frequency output options

Option	Description
Units	Choose the channel, parameter and units to output.
Fbase	Enter the lowest value of the frequency range you want to output. Typically 0Hz.
Fspan	Enter the highest value of the frequency range you want to output. max possible 10000Hz.
Value (min)	Enter the value of the parameter you want to correspond to the min. value of the frequency range.
Value (max)	Enter the value of the parameter you want to correspond to the max. value of the frequency range.
Error level	Choose the output response during an error condition: force lo, force hi, hold last, or force value. During a meter error, the chosen error level will be sent to the frequency output.

Table 9: Frequency output error level options

Option	Description
Force low (4 mA)	Forces output to Fbase
Force low (20 mA)	Forces output to Fspan
Hold value	Holds the last “good” reading
Force value	Outputs a user-defined value (from 4 to 20 mA) during an error condition

3.6.2.3 Programming a totalizer output

To program a totalizer output, refer to *Figure 64 on page 68* and proceed as follows:

1. Navigate to the mode option on the freq/tot status screen (see *Section 3.6.2, “Setting up a frequency/totalizer output” on page 65*). Then, press the [✓] key to confirm this choice.
2. Use the [▲] and [▼] keys to highlight the totalizer option. Then, press the [✓] key twice to confirm your selection or press the [✗] key to cancel and return to the previous screen.
3. Use the [▲] and [▼] keys to select and program each of the four totalizer output options. Refer to *Table 10* below for guidance in choosing the appropriate setting for your application.
4. After programming all of the totalizer output options, press the [✓] key to accept your new settings or press the [✗] key to keep the previous settings and return to the previous screen.

Table 10: Totalizer output options

Option	Description
Units	Choose the channel, parameter and units to output.
Units/ pulse	Choose how many units of the chosen parameter are accumulated before a pulse is output.
Pulse width	Choose the duration of each pulse that is output.
	NOTE: Make sure the meter is not configured to output more than one pulse during this time, as this could lead to missed pulses.
Polarity	Choose the negative or positive edge of the pulse.

3.6.5 Setting up an RTD input (optional)

If an option card with an RTD input is installed, to set up the *RTD input*, refer to *Figure 67* below and complete the steps on the next page.

Note: If necessary, refer to *Table 4* on page 32 as a reminder about color code meanings.

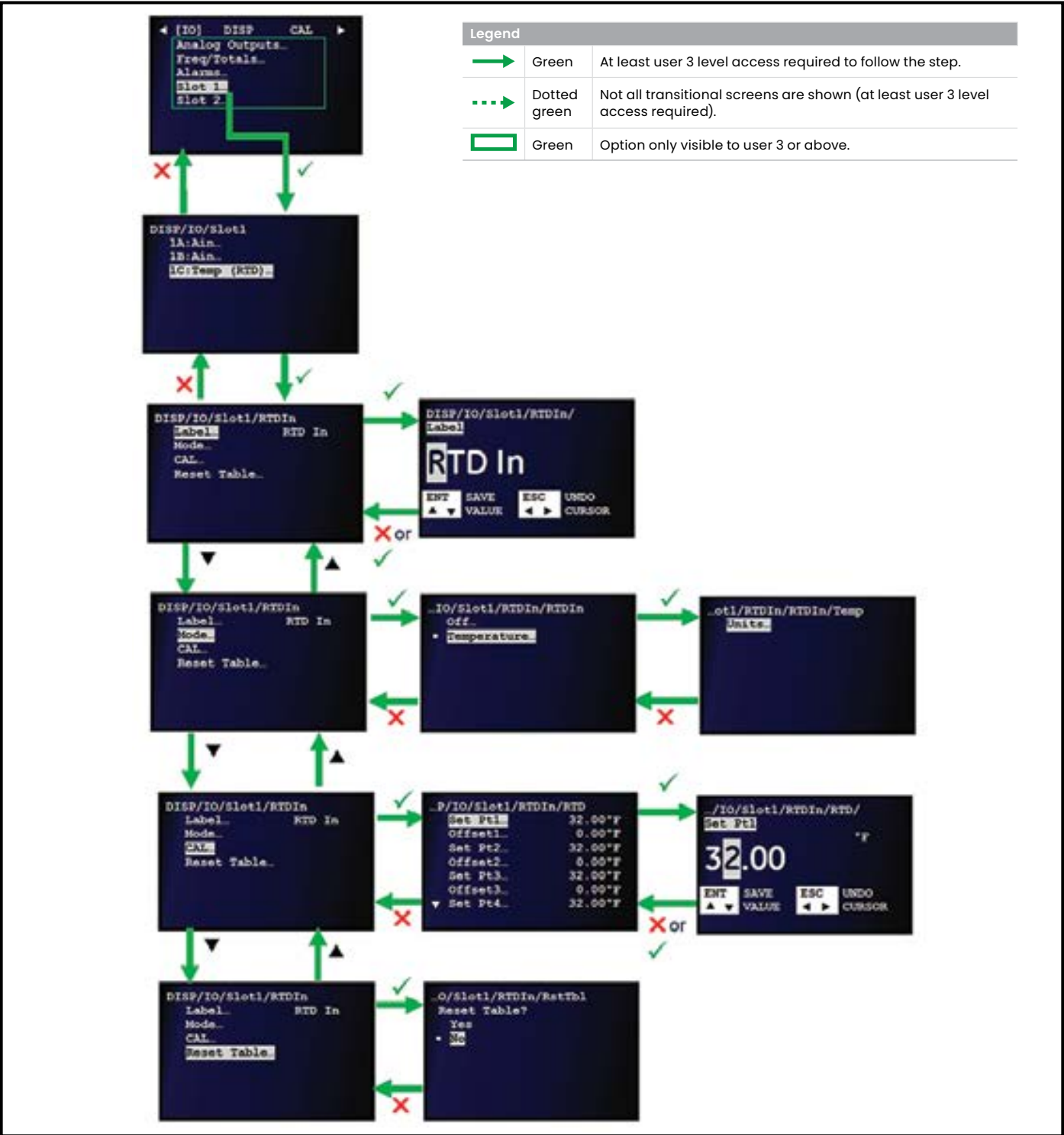


Figure 67: Setting Up an RTD input

1. Refer to *Primary pages on page 26* and navigate to *page 6: display*.
2. Use the [▲] and [▼] keys to highlight *views* and press the [✓] key to confirm your choice.
3. Use the [▲] and [▼] keys to highlight either *1 view* or *2 views* and press the [✓] key twice to confirm your selection.
4. Use the [▲] and [▼] keys to highlight the *view #* you wish to configure and press the [✓] key to confirm your selection.
5. Highlight and configure each of the following options:
 - a. **Channel** – Select the desired channel to be displayed in this view. Then, press the [✓] key twice to confirm your selection or press the [✗] key to cancel and return to the previous screen.
 - b. **Publisher** – Select the measurement parameter to be displayed in this view. Then, press the [✓] key twice to confirm your selection or press the [✗] key to cancel and return to the previous screen.
 - c. **Format** – program the *width*, *decimal*, *min*, and *max* settings for the display in this view. Then, press the [✓] key to confirm your selection or press the [✗] key to cancel and return to the previous screen.
6. Use the [▲] and [▼] keys to highlight *contrast* and press the [✓] key to confirm your selection. Then, adjust the display contrast as desired and press the [✓] key to confirm your setting or press the [✗] key to cancel and return to the previous screen.
7. Use the [▲] and [▼] keys to highlight *backlight* and press the [✓] key to confirm your selection. Then, adjust the display backlight as desired and press the [✓] key to confirm your setting or press the [✗] key to cancel and return to the previous screen.
8. Use the [▲] and [▼] keys to highlight *mode* and press the [✓] key to confirm your selection. Then, configure the display mode and press the [✓] key to confirm your setting or press the [✗] key to cancel and return to the previous screen.

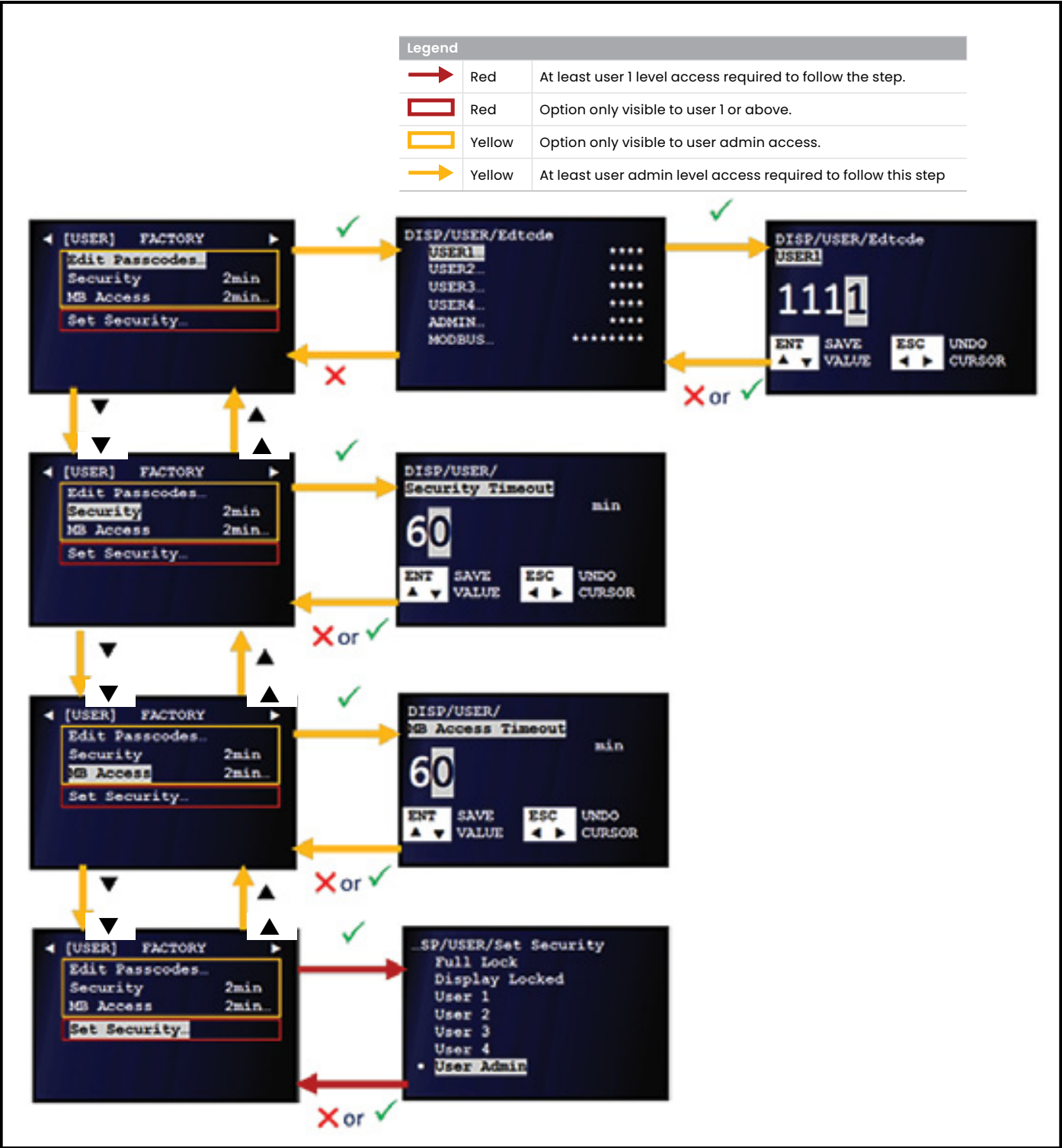
IMPORTANT: Make sure the ammeter used is properly calibrated.

1. Refer to *Primary pages on page 26* and navigate to *page 7: CAL*.
2. Connect an ammeter to the **Sentinel LCT8** analog output terminals.
3. With *4-20 loop* highlighted, press the [✓] key twice to confirm your choice.
4. With *mode* highlighted, press the [✓] key to confirm your choice.
5. Choose one of the following options:
 - Use the [▲] and [▼] keys to highlight *normal* and press the [✓] key twice to confirm your selection and return to the previous screen. After completing an analog input calibration, the *mode* should always be reset to *normal* using this step.
 - Use the [▲] and [▼] keys to highlight *test (trim)* and press the [✓] key twice to confirm your selection and proceed to the next screen. Continue to the next step.
6. Use the [▲] and [▼] keys to highlight *base trim* and press the [✓] key to confirm your selection and proceed to the next screen.
 - a. If the *base trim* value is not 4 mA, set it to 4 mA.
 - b. Enter the value read on the ammeter into the *base trim* screen.
 - c. Verify that the ammeter now reads 4 mA ± 0.02 mA. If necessary, repeat these steps until the reading is correct. Then, press the [✓] key to save the value and return to the previous screen, or press the [✗] key to cancel the trim and return to the previous screen.
7. Use the [▲] and [▼] keys to highlight *span trim* and press the [✓] key to confirm your selection and proceed to the next screen.
 - a. If the *span trim* value is not 20 mA, set it to 20 mA.
 - b. Enter the value read on the ammeter into the *span trim* screen.
 - c. Verify that the ammeter now reads 20 mA ± 0.02 mA. If necessary, repeat these steps until the reading is correct. Then, press the [✓] key to save the value and return to the previous screen, or press the [✗] key to cancel the trim and return to the previous screen.
8. Use the [▲] and [▼] keys to highlight *percent* and press the [✓] key to confirm your selection. If the value is not already at 100%, set it to 100%. Then, press the [✓] key to save the value and return to the previous screen, or press the [✗] key to cancel and return to the previous screen.

3.9 User configuration setting

To configure the **Sentinel LCT8** User settings, refer to Figure 70 below and complete the steps on the next page.

Note: If necessary, refer to Table 4 on page 32 as a reminder about color code meanings.



1. Refer to *Primary pages on page 26* and navigate to *page 8: user configuration*.
2. Use the [▲] and [▼] keys to highlight the *edit passcodes, security, MB access, or set security* option and press the [✓] key (press twice for the set security option) to confirm your choice.
3. After you have finished configuring these options, press the [✓] key to confirm your selection or press the [✗] key to cancel and return to the previous screen.

IMPORTANT: See the following sections for information in the available *user configuration* options.

3.9.1 The edit passcodes option

This *user* option is available only at the *user-admin* access level. By means of this option, the *passcodes* for *user-1* to *user-admin* access levels can be modified. In addition, the *user-admin* can also modify the passcode for *modbus* access. The *user-1* to *user-admin* passcode must be four (4) characters long, and the *modbus access* passcode must be from six (6) to nine (9) characters long.

3.9.2 The security timeout option

Use this option to set a timeout period from 1 minute to 60 minutes, after which the meter will switch back to Full-lock mode if no keypad activity is detected. The programmed *security timeout* period is applicable for *user-1* to *useradmin* access levels.

3.9.3 The modbus access timeout option

Use this option to set a timeout period from 1 minute to 60 minutes for *modbus* access, after which the meter will block *modbus* writes. This programmed *modbus access timeout* period is applicable only to *modbus access*.

3.9.4 The set security option

The *user* can set a security level, only if it is below the current level.

3.10 Factory status

Attention! Always consult the Panametrics factory before using the default meter and Upgrade options!

To configure the **Sentinel LCT8** factory settings, see Figure 71 below and complete the steps on the next page.

Note: If necessary, refer to Table 4 on page 32 as a reminder about color code meanings.

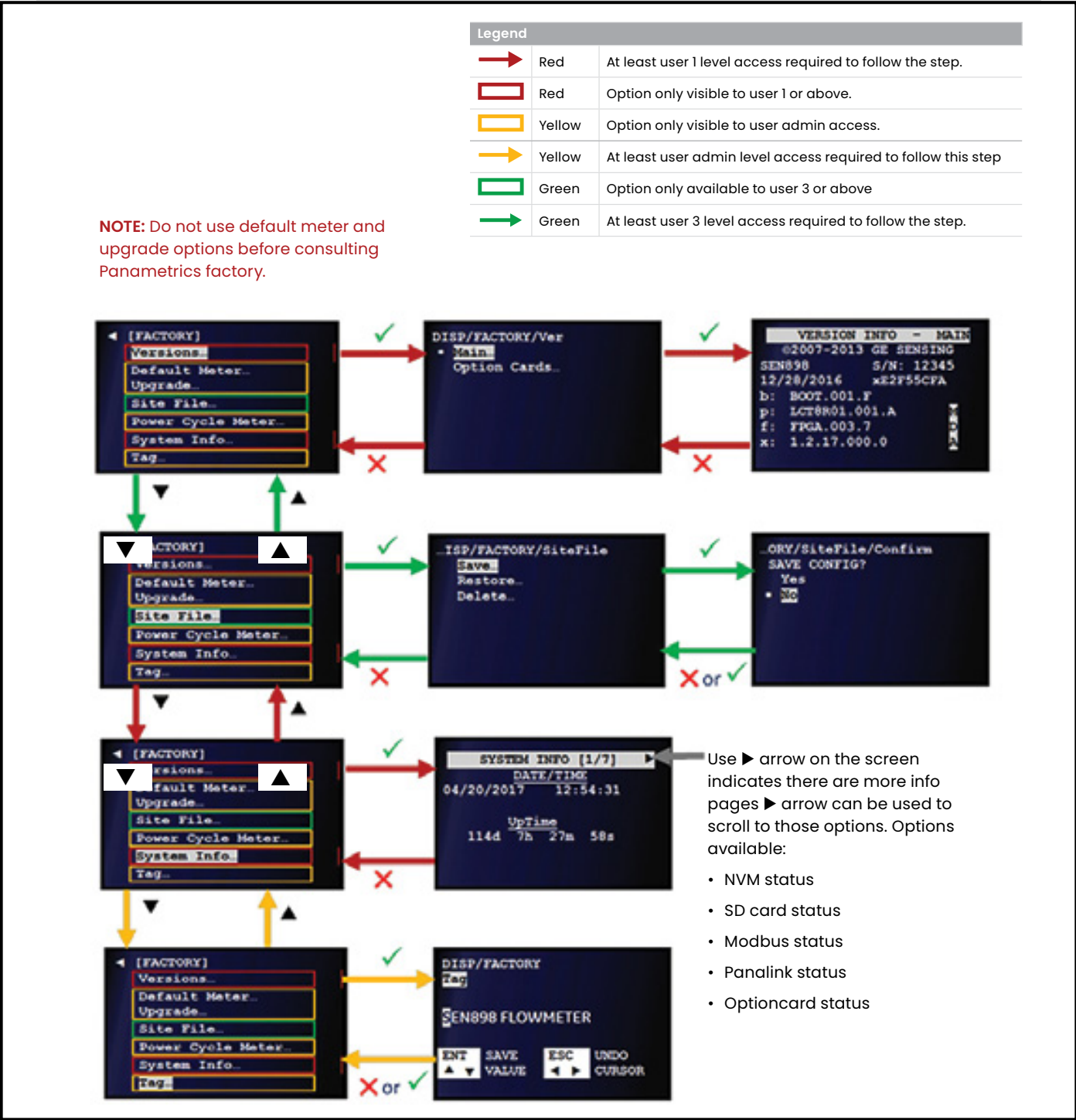


Figure 71: Setting the factory options

1. Refer to *Primary pages on page 26* and navigate to *page 9: factory*.
2. Use the [▲] and [▼] keys to highlight *versions* and press the [✓] key to confirm your choice.
3. Use the [▲] and [▼] keys to highlight *main* or *option cards* and press the [✓] key twice to confirm your choice and view the currently installed hardware and software versions. Then, press the [✗] key to return to the previous screen.
4. Use the [▲] and [▼] keys to highlight *site file* and press the [✓] key to confirm your choice.
5. Use the [▲] and [▼] keys to highlight *save*, *restore* or *delete* and press the [✓] key to confirm your choice or press the [✗] key to return to the previous screen.
6. Use the [▲] and [▼] keys to highlight *yes* or *no* about your intention to save, restore, or delete the current site file. Then, press the [✓] key twice to confirm your selection or press the [✗] key to cancel and return to the previous screen.
7. To turn the meter off and reboot it, use the [▲] and [▼] keys to highlight *power cycle meter* and press the [✓] key to confirm your choice.
8. Use the [▲] and [▼] keys to highlight *system info* and press the [✓] key to confirm your choice.
9. Use the [◀] and [▶] keys to view the following pages: *system info*, *NVM status*, *SD card status*, *modbus status*, *Panalink status*, and *option card status*. After you have finished viewing these pages, press the [✓] key to return to the previous screen.
10. Use the [▲] and [▼] keys to highlight *tag* and press the [✓] key to confirm your choice.
11. If desired, change the current meter tag (i.e., name), and press the [✓] key to confirm your selection or press the [✗] key to cancel and return to the previous screen.

[no content intended for this page]

4.1.2 Save, restore or delete a site file

Anytime the meter programming is changed, the current site file should be saved. If a software corruption occurs, this allows the possibility of loading the saved site file to quickly resolve the problem and resume normal operation. Using Panametrics' Panaview SEN898 PC software provides the additional option of saving a site file to a location external to the meter. During commissioning, the trained Panametrics service engineer will save the initial site file for you.



CAUTION! Accidentally saving or deleting a site file can have unintended consequences when you attempt to restore the site file. For example, restoring an accidentally saved version of the site file will overwrite the current site file and may change your meter configuration.

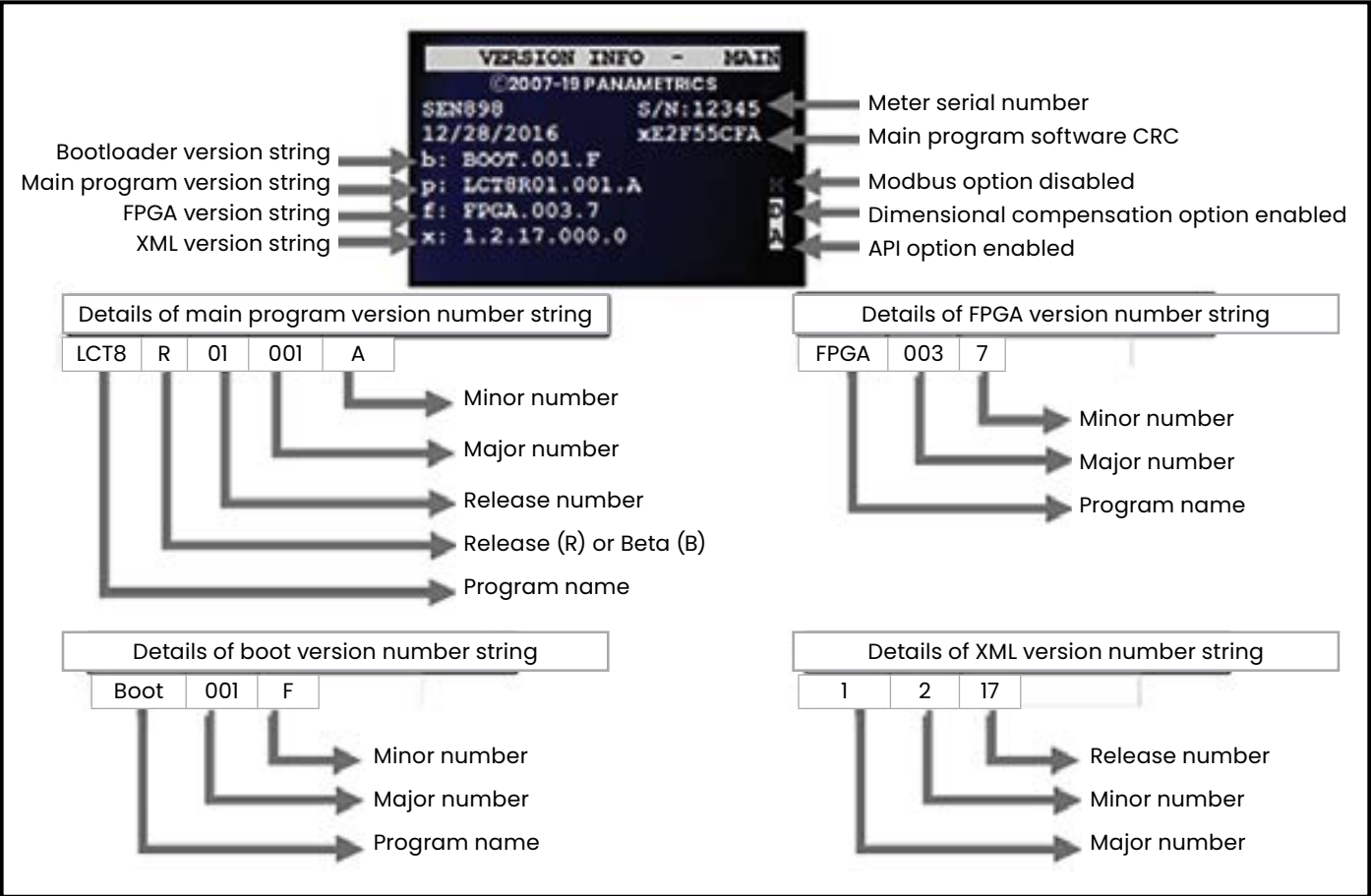


Figure 73: Version info-main Layout and details

To save, restore or delete a site file, refer to Figure 74 below and complete the steps on the next page.

Note: If necessary, refer to Table 4 on page 32 as a reminder about color code meanings.

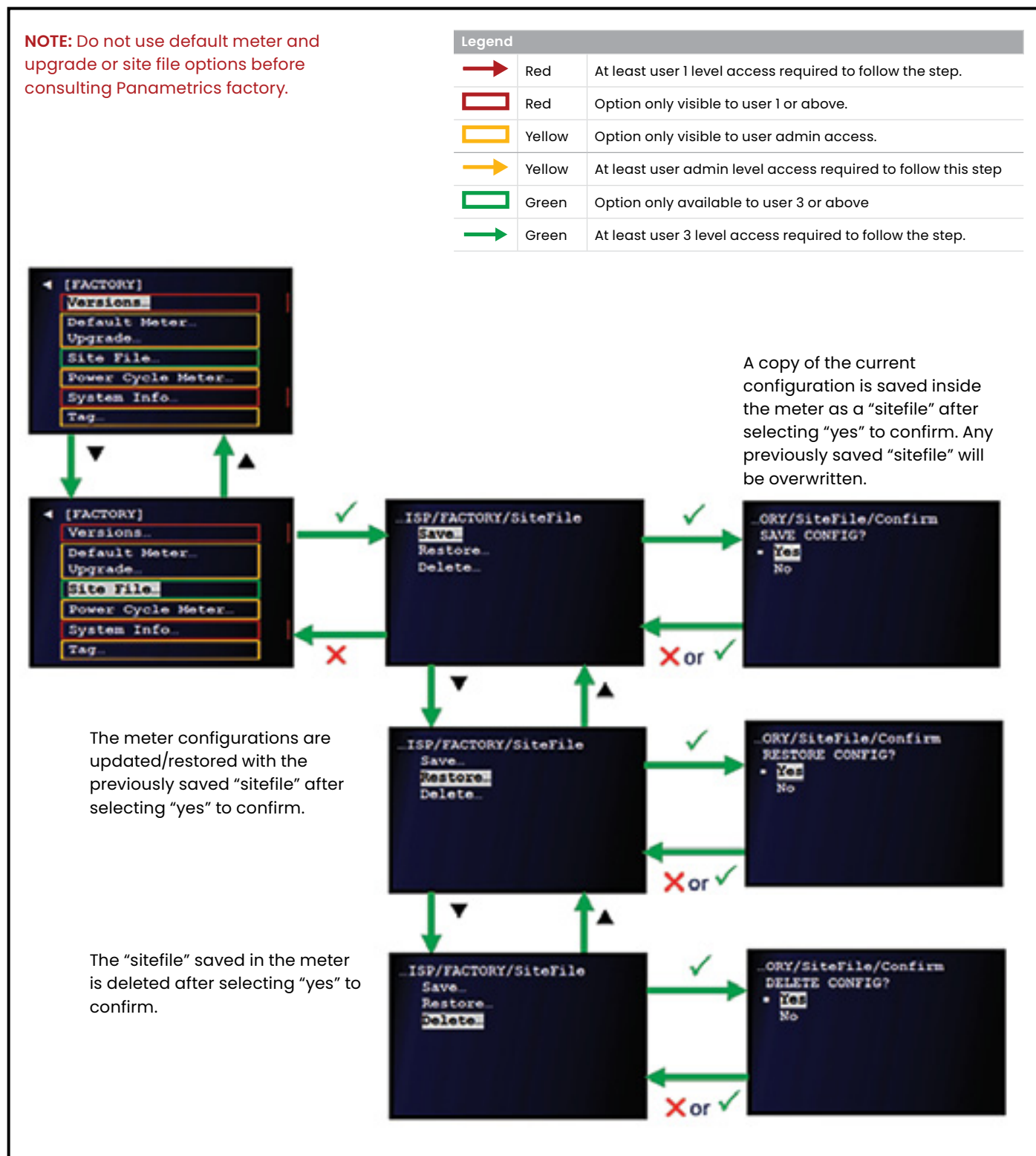


Figure 74: Save, restore or delete a site file

6. On the *Tera Term* terminal window click on the *setup menu* and select *serial port* to configure the COM port, as shown in *Figure 76* below. Then, click OK

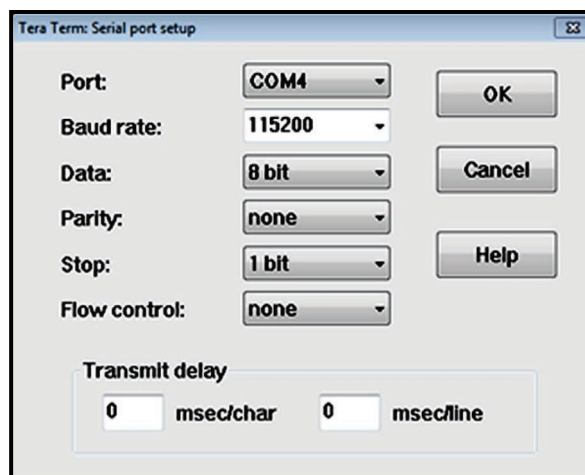


Figure 76: Configure the com port

7. There are two methods that can be used to update the meter software. Choose one of the following methods:
 - d. **Method 1:** see Section 4.1.3.1, “Meter software update method 1” on page 91 for detailed instructions.
 - e. **Method 2:** see Section 4.1.3.2, “Meter software update method 2” on page 94 for detailed instructions.

4.1.3.1 Meter software update method 1

To update the meter software from the factory Page, refer to *Figure 77* below and complete the following steps.

Note: If necessary, refer to Table 4 on page 32 as a reminder about color code meanings.

1. Refer to *Primary pages* on page 26 and navigate to page 9: factory.
2. Use the [▲] and [▼] keys to highlight Upgrade and press the [✓] key to confirm your choice.
3. Use the [▲] and [▼] keys to highlight Yes or No and press the [✓] key twice to confirm your selection or press the [✗] key to cancel and return to the previous screen.
4. At the next screen, the meter is ready to receive the new software over the serial port. Proceed to the next step.
5. In the *Tera Term* terminal window (see *Figure 78* on page 92), select *file*, *transfer*, *XMODEM*, and *send* in the subsequent drop-down menus.

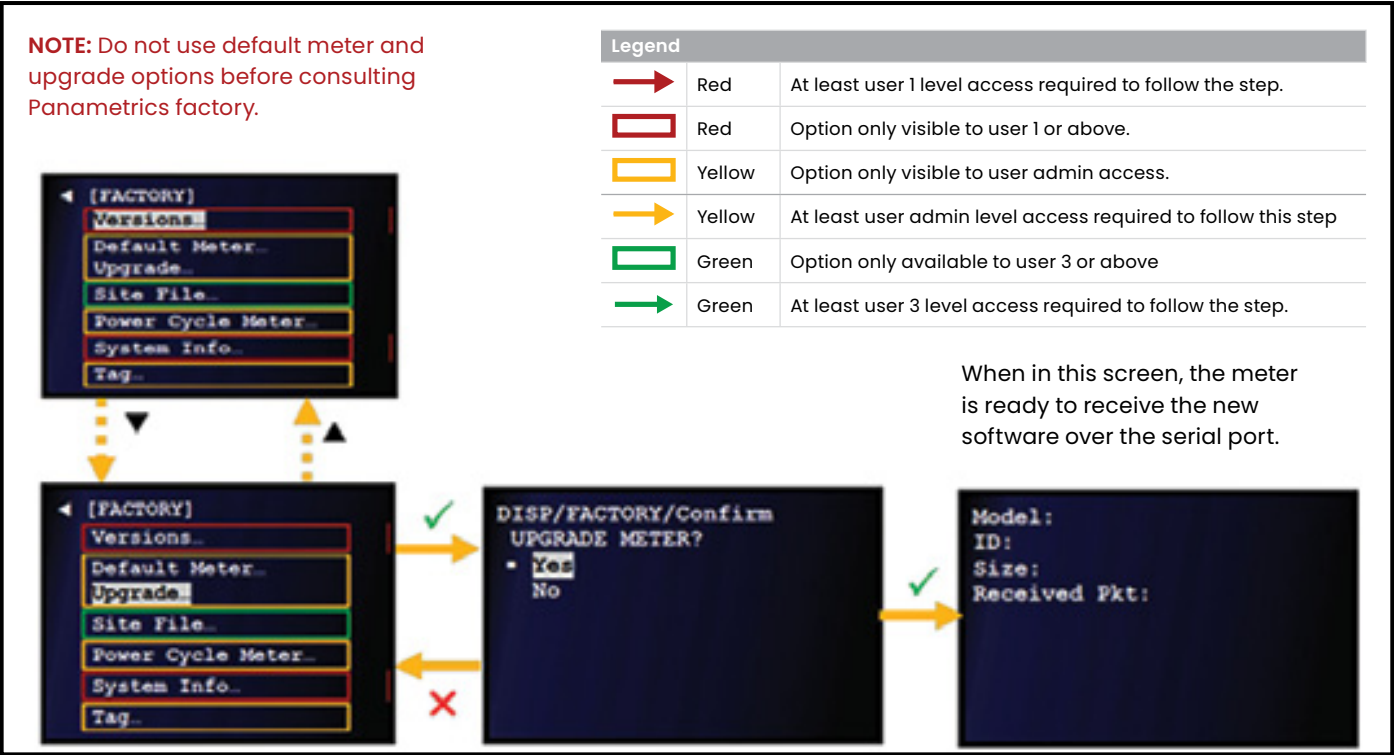


Figure 77: Update the meter software from the factory page

6. When the Tera Term: XMODEM send file selector window opens (see Figure 79 on page 93), locate and select the .cod extension file from your PC. After selecting the .cod extension file, click open and the status window shown on the left in Figure 80 on page 93 opens. At this time, the meter display shows the file receive status (see the right of Figure 80 on page 93).

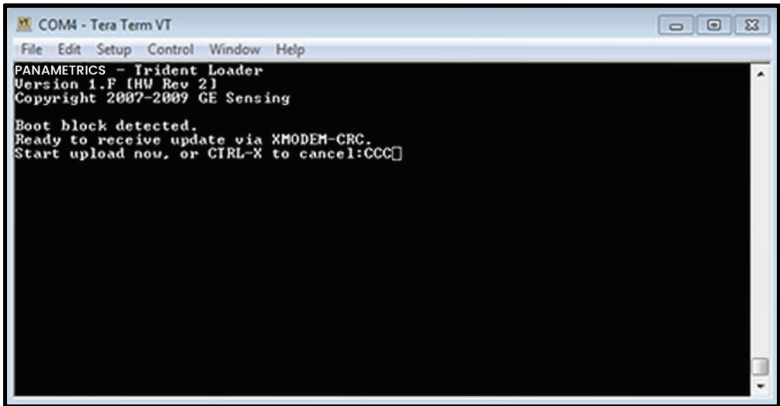


Figure 78: Tera Term indicates meter ready to receive update

7. After the file transfer is complete, the *Tera Term* terminal window will appear as in *Figure 81* on page 93, and the meter will start up.
8. The meter software update is now complete. Proceed to *Section 4.1.3.3, "Post update recommendations"* on page 96.

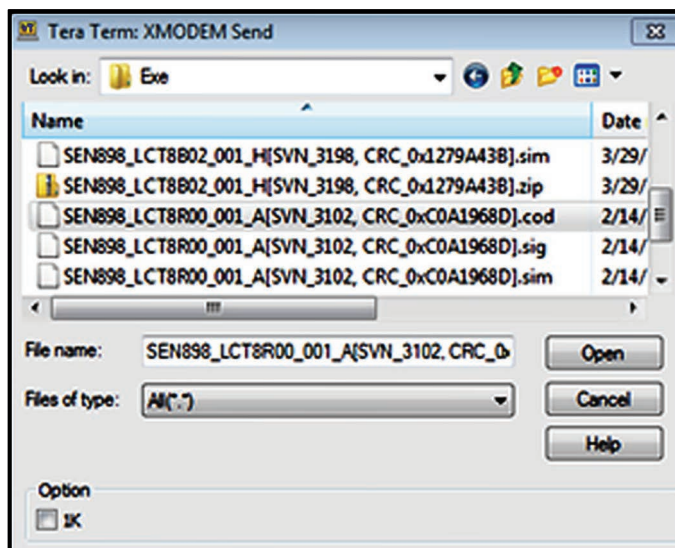


Figure 79: XMODEM send file selector

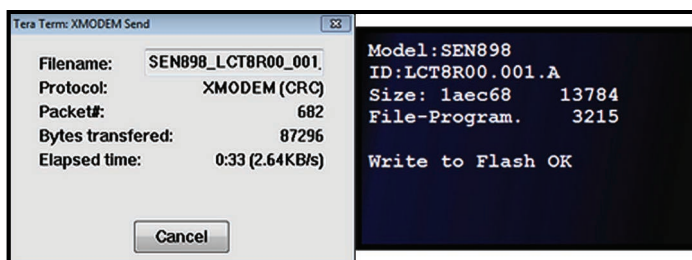


Figure 80: XMODEM Send status (left) and meter display file receive status (right)

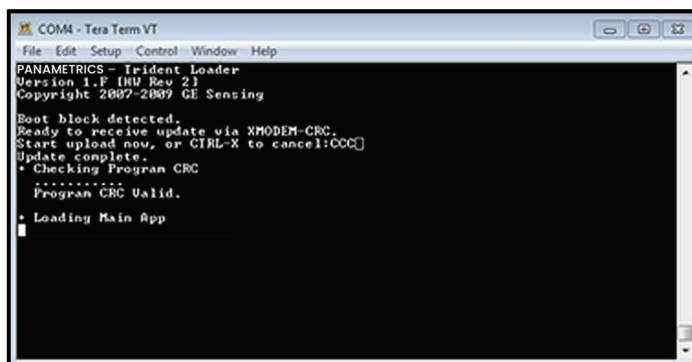


Figure 81: Update complete message in Tera Term

4.1.3.2 Meter software update method 2

To update the meter software using the *Tera Term* software, proceed as follows:

1. Power on the **Sentinel LCT8**, then launch the *Tera Term* software and press **ESC** on your PC keyboard. The Tera Term terminal window indicates that the meter is awaiting your input, as in *Figure 82* below.

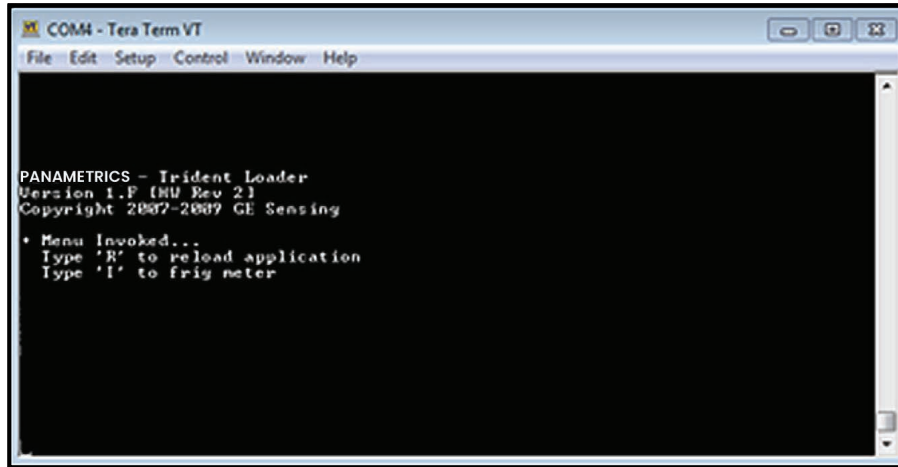


Figure 82: Tera Term Awaiting input

2. Press **R** (not case sensitive) using your PC keyboard and the *Tera Term* terminal window indicates that the meter is ready to receive the update via XMODEM-CRC (see *Figure 83* below). Select *file*, *transfer*, *XMODEM*, and *send* in the subsequent drop-down menus.

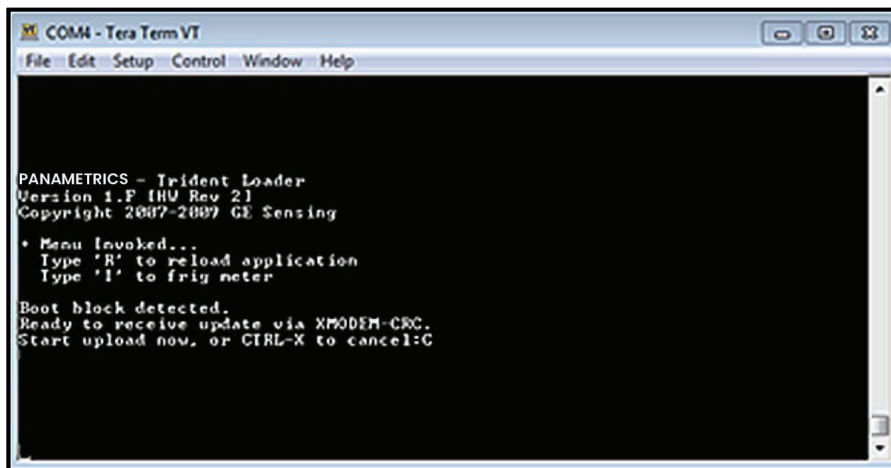


Figure 83: Tera Term indicates meter is ready to receive Update

3. When the *Tera Term: XMODEM send file selector window* opens (see *Figure 84* below), locate and select the *.cod* extension file from your PC. After selecting the *.cod* extension file, click *open* and the status window shown on the left in *Figure 84* below opens. At this time, the meter display shows the file receive status (see the right of *Figure 85* on page 95 below).

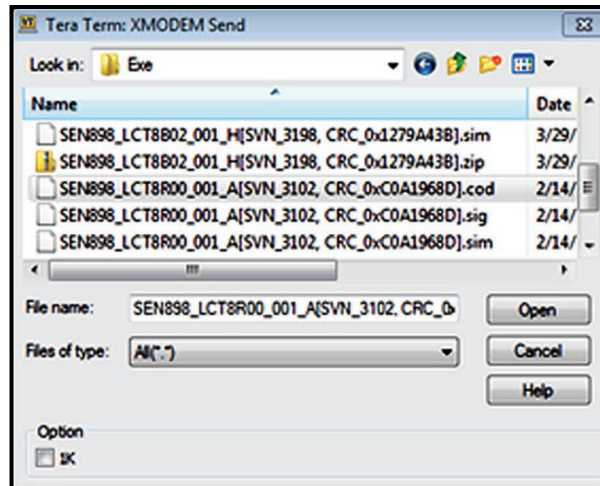


Figure 84: XMODEM Send file selector

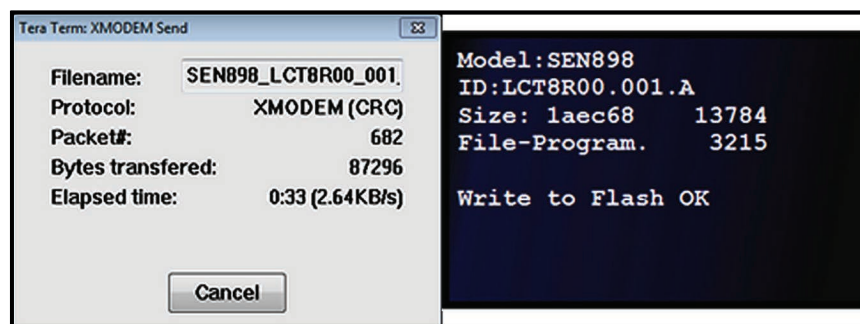


Figure 85: XMODEM Send status (left) and meter display file receive status (right)

4. After the file transfer is complete, the Tera Term terminal window will appear as in *Figure 86* below, and the meter will start up.

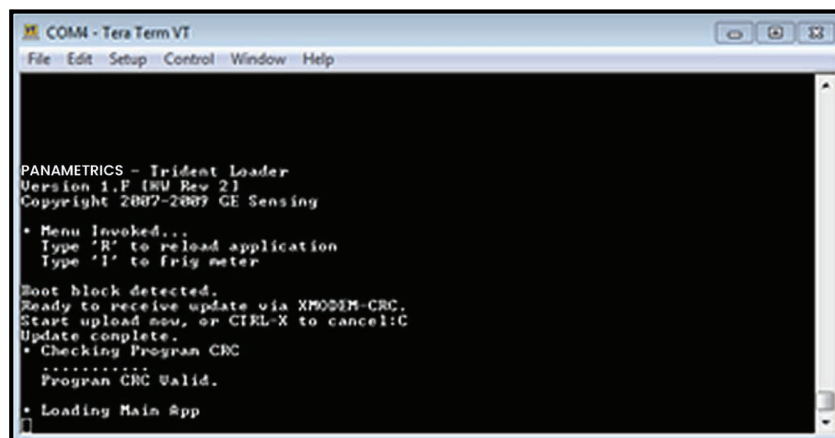


Figure 86: Update complete message in Tera Term

5. The meter software update is now complete. Proceed to *Section 4.1.3.3, "Post update recommendations" on page 96.*

4.1.3.3 Post update recommendations

To ensure that the **Sentinel LCT8** operates correctly, Panametrics recommends defaulting the meter after software updates.



CAUTION! All site configuration and calibration data will be lost when the meter is defaulted! It is highly recommended that a site file archive is captured via PanaView SEN898 or using the *site file menu* under the *factory menu*. This archive can then be used to restore the site and calibration data after the meter default is complete (see *Section 4.1.2, "Save, restore or delete a site file" on page 88*).

Note: After the **Sentinel LCT8** has been defaulted, it restarts in the locked mode. See *Section 3.3.1 on page 35* for instructions on unlocking the meter.

To default the meter, use either of the two following methods:

Method 1: Using the factory menu

Refer to *Figure 87* below and complete the step-by-step instructions after the figure.

Note: If necessary, refer to *Table 4 on page 32* as a reminder about color code meanings.

- 1. Refer to *Primary pages on page 26* and navigate to *page 9: factory*.
- 2. Use the [▲] and [▼] keys to highlight default meter and press the [✓] key to confirm your choice.
- 3. Use the [▲] and [▼] keys to highlight yes or no and press the [✓] key twice to confirm your selection or press the [✗] key to cancel and return to the previous screen.
- 4. If you selected and confirmed yes, verify that the meter restarts.

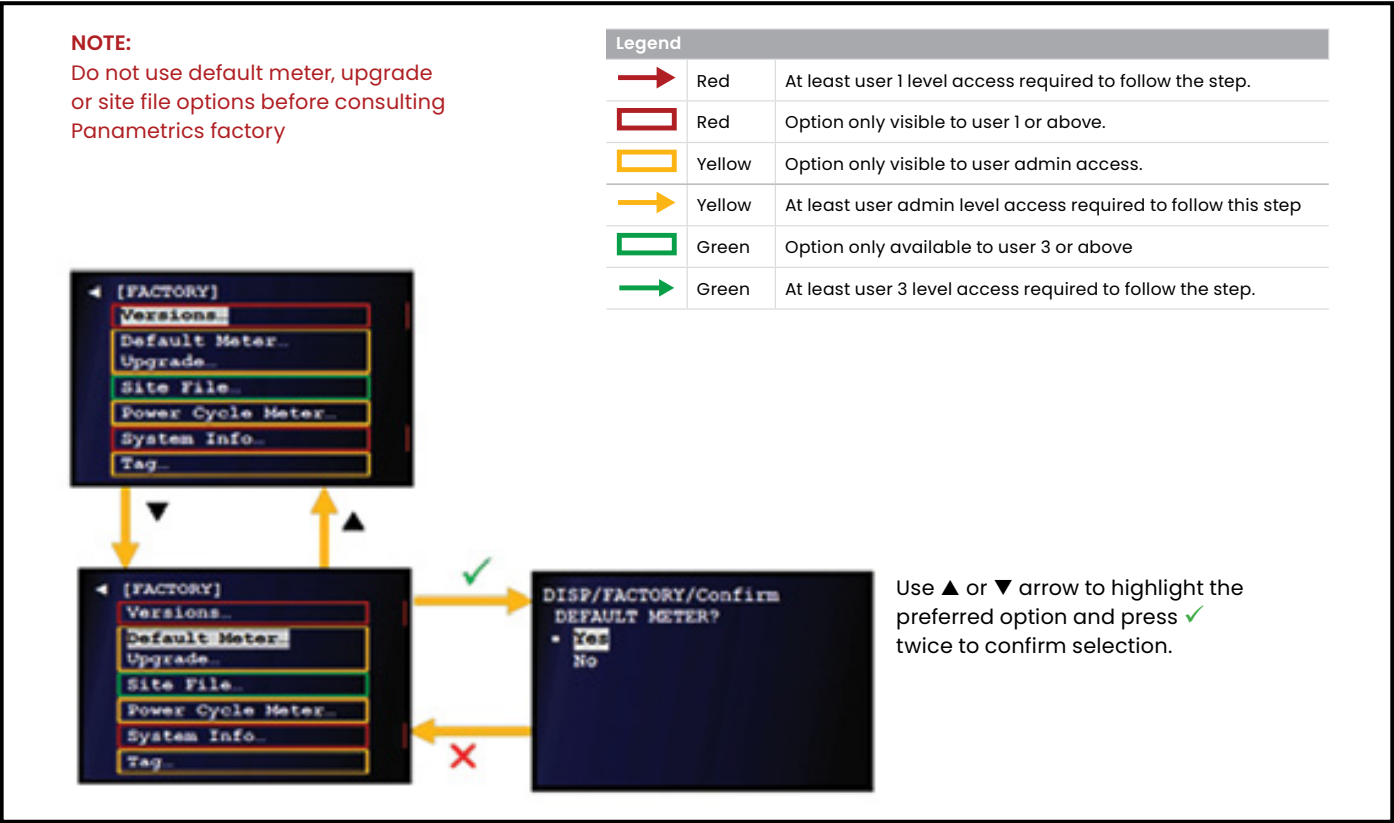


Figure 87: Defaulting the meter from the factory menu

Method 2: During power on

Refer to *Figure 88* below and complete the step-by-step instructions after the figure.

Note: If necessary, refer to *Table 4* on page 32 as a reminder about color code meanings.

1. Press and hold the **CLR TOTALS** key during power on until the *default meter?* screen opens, then release the key.
2. Do one of the following:
 - Press the [▼] key to power on the meter without defaulting it.
 - Press the [▲] key to quickly power on the meter and begin defaulting it.

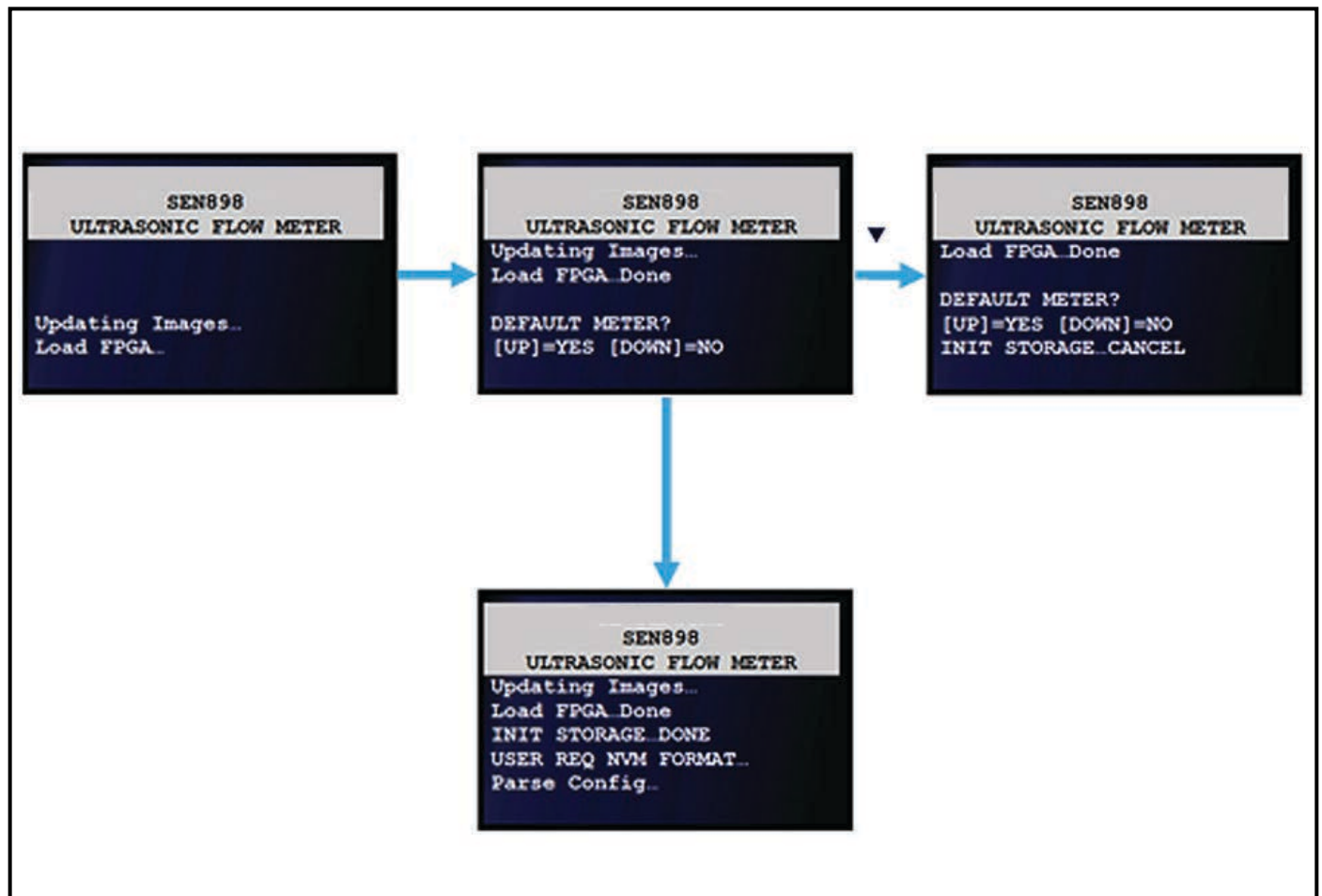


Figure 88: Defaulting the meter during power on

4.2 Mechanical



WARNING! Before opening the pressure vessel, it must be completely de-pressurized! This warning applies to all three interfaces described in this section (flange interface, transmitter connection and sensor ports). The appropriate procedure should be followed to properly relieve any pressure build up in the system prior to servicing the equipment.



WARNING! All equipment must be de-energized prior to servicing.

Attention! Only trained and qualified personnel should service the pressure vessel.

The **Sentinel LCT8** system has three serviceable interfaces (see Figure 89 below):

- **Flanges** (see Section 4.2.1, “Servicing the pipe flange interface” on page 98)
- **Sensor ports** (see Section 4.2.2, “Servicing the sensor ports and transmitter connection” on page 99)
- **Transmitter connection** (see Section 4.2.2, “Servicing the sensor ports and transmitter connection” on page 99)

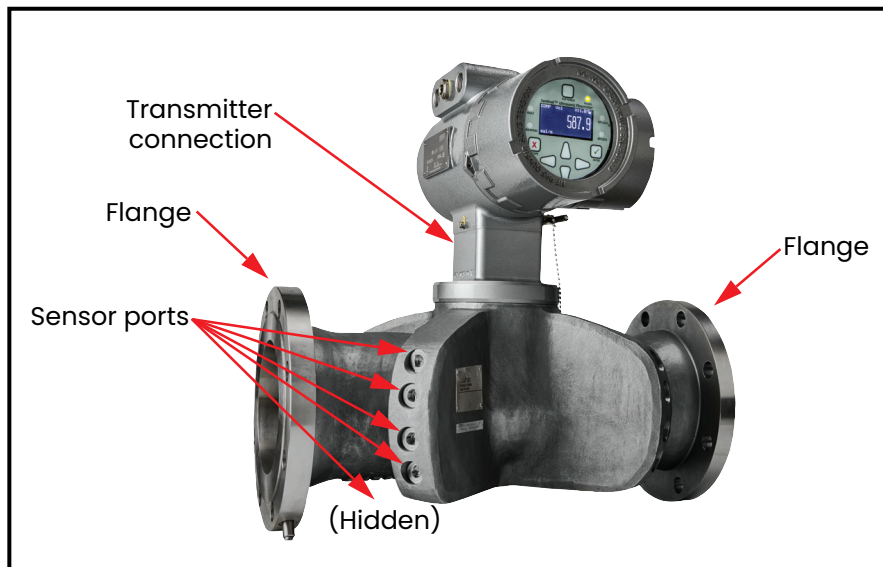


Figure 89: *Sentinel LCT8* serviceable interfaces

4.2.1 Servicing the pipe flange interface



WARNING! Before opening the pressure vessel, it must be completely de-pressurized!

Only properly trained personnel, such as pipe fitters, should service the pipe flanges. The proper gasket material, bolts, bolt torque, and tightening sequence must always be used. See the procedure in Section 2.4, “Mechanical installation” on page 10 for reference.

4.2.2 Servicing the sensor ports and transmitter connection



WARNING! Before you open the sensor ports or the transmitter connection, the system must be completely de-pressurized!

The sensor ports contain the sensors and sensor wiring. These ports should only be serviced by properly trained and qualified service technicians. Modification or alteration in any manner may degrade the performance of the system.

4.2.2.1 Required equipment

Before proceeding, ensure that the following tools are available:

- 10 mm hex drive socket or wrench
- 12 mm hex drive socket or wrench

4.2.2.2 Checking for internal leaks

To relieve the system pressure, see *Figure 90* below and *Figure 91* below to complete the following steps:

1. Locate the upstream **"A"** plane sensor quadrant. This quadrant can be found by locating the tag plates on the pressure vessel (see *Figure 2* on page 4).

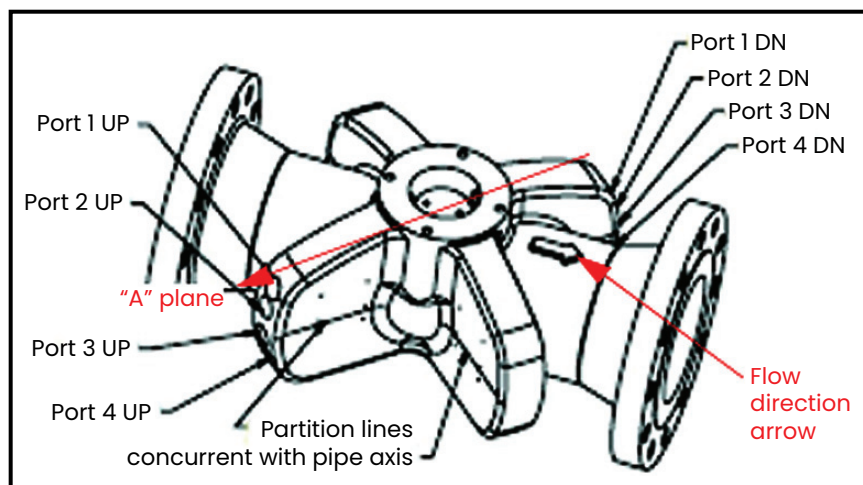


Figure 90: Upstream "A" plane sensor quadrant - top view

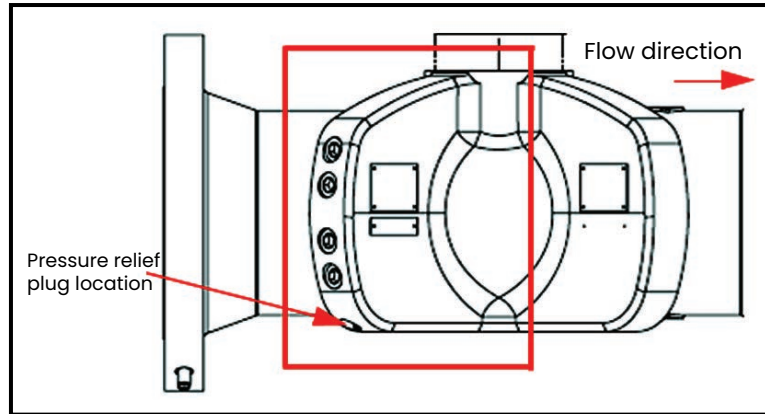


Figure 91: Upstream "A" plane sensor Quadrant - side view

2. Relieve potential pressure build-up by loosening the *pressure relief plug* on the bottom of the upstream "A" plane sensor quadrant (see *Figure 91* above), using a 10 mm hex drive socket or wrench. Slowly loosen the pressure relief plug 2-3 full turns or until the plug bottoms out on the built-in safety stop.
3. Listen to and observe the area near the pressure relief plug:
 - a. If any hissing is heard, indicating air or gas release, stop loosening the plug and wait for the hissing to stop. If the hissing continues for more than 10 minutes, re-tighten the plug and consult Panametrics.
 - b. If any liquid discharge is observed, stop loosening the plug and re-tighten it completely.



WARNING! If any liquid discharge is observed at the pressure relief plug, then the process pressure must be removed from the pipeline prior to servicing the sensor ports or transmitter connection.

- c. If no hissing or discharge is observed and the plug has been backed out to the safety stop, then any pressure buildup has been released and the ports are now serviceable.
4. Avoid servicing the equipment contained within the sensor ports and transmitter connection, as it is serviceable only by factory trained service technicians.
5. After the service work is complete, all *sensor port plugs* and the *pressure relief plug* should be reinstalled and tightened fully.

4.2.3 Spare parts list

The **Sentinel LCT8** is a high-accuracy calibrated flow meter. Local custody transfer requirements may disallow field replacement of any parts in this flow metering system without a proper calibration of the entire system at an approved calibration facility. Check with local authorities to determine if field replacement of parts is allowed.

If fault is found with the flow meter electronics, the entire measurement head can be replaced to ensure hardware and firmware compatibility. The replacement part number will be as shown in *Section 1.7.5, "Transmitter tag plate" on page 5*. To ensure that the correct part number is ordered, provide your local Panametrics representative with the serial number of the meter, which is located as shown in *Section 1.7.4, "Part string and serial number tag plate" on page 5*.

If it is determined that a flow transducer has been damaged or is faulty, it may also be replaced in the field with no need for recalibration. Please contact Panametrics for the appropriate part number.

Table 13 below lists the available spare parts for the **Sentinel LCT8**.

Table 13: Available spare parts

Option code	Description	Option code	Description
703-1653-00	SEN898 main PCB assembly	LCT8-SPARE-XDCR-KIT-2MHZ	LCT8 transducer kit pair (2MHz) for 6"-8" flowcells
705-1912-00	SEN898 flow/receiver PCB assembly	LCT8-SPARE-XDCR-KIT-1MHZ	LCT8 transducer kit pair (1MHz) for 10"-24" flowcells
703-1506-03	SEN898 analog input option card (AAR)	LCT8-SPARE-CBL-KIT-6IN	LCT8 cable kit for 6" flowcells
703-1506-04	SEN898 analog input option card (AAA)	LCT8-SPARE-CBL-KIT-8IN	LCT8 cable kit for 8" flowcells
705-1217-01	SEN898 HMI assembly	LCT8-SPARE-CBL-KIT-10IN	LCT8 cable kit for 10" flowcells
705-1246-00	SEN898 AC power supply PCB assembly	LCT8-SPARE-CBL-KIT-12IN	LCT8 cable kit for 12" flowcells
705-1247-00	SEN898 DC power supply PCB assembly	LCT8-SPARE-CBL-KIT-14IN	LCT8 cable kit for 16" flowcells
193-076-14	Fuse AC power supply	LCT8-SPARE-CBL-KIT-16IN	LCT8 cable kit for 18" flowcells
193-076-20	Fuse DC power supply	LCT8-SPARE-CBL-KIT-18IN	LCT8 cable kit for 20" flowcells
SEN_KIT-WAND	Magnetic wand with lanyard + screw + washer kit	LCT8-SPARE-CBL-KIT-20IN	LCT8 cable kit for 24" flowcells
412-1906	Stopping plug, ½" NPT (ATEX, IECEx, FM, CSA) - SS	LCT8-SPARE-CBL-KIT-24IN	LCT8 spare plug kit for 6"-14" flowcells
419-373	Stopping plug, ¾" NPT (ATEX, IECEx, FM, CSA) - SS	LCT8-SPARE-PLG-KIT-6_14	LCT8 spare plug kit for 16"-24" flowcells
401-083	Pyrogel couplant (4 oz tube)	LCT8-SPARE-PLG-KIT-16_24	LCT8 spare plug kit for 16"-24" flowcells

[no content intended for this page]

Chapter 5. Troubleshooting

5.1 Introduction

The **Sentinel LCT8** flow transmitter is a reliable, easy to maintain instrument. When properly installed and operated, as described in *Chapter 2, "Installation"*, the meter provides accurate flow rate measurements with minimal user intervention. However, if a problem should arise with the electronics enclosure or transducers, this chapter explains how to troubleshoot the **Sentinel LCT8**. Indications of a possible problem include:

- Display of an error message on the LCD screen
- Erratic flow readings
- Readings of doubtful accuracy (e.g., readings that are not consistent with readings from another flow measuring device connected to the same process)

If any of the above conditions occur, proceed with the instructions presented in this chapter.

Note: *For high electrical noise areas, it is recommended that you follow the wiring instructions in Appendix A, "CE Mark compliance and high noise environments," on page 133.*

5.2 Error codes

5.2.1 Overview

If a problem occurs with the electronics or transducers, a built-in error code message system greatly simplifies the troubleshooting process.

All the possible **Sentinel LCT8** error code messages are discussed in this chapter, along with the possible causes and the recommended actions. When an error code is generated, it will appear in the lower right corner of the LCD screen, as discussed in *Chapter 3, "Programming," on page 29*.

If an error message appears on the display screen during operation of the **Sentinel LCT8**, refer to the appropriate section of this chapter for instructions on how to proceed. You may be asked to contact Panametrics. It would be very helpful to enter all of the diagnostic data and parameter information for each channel in *Appendix B, "Service record," on page 135* prior to calling your local Panametrics sales or service center.

5.2.2 General guidelines for troubleshooting with error codes

Refer to *Section 5.3, "Flow info" on page 108* to identify the number of channels reporting an error, then proceed to the appropriate section below. Also, refer to *Table 14 on page 105* for causes and recommended actions for each error code.

5.2.2.1 Only one channel in error

If only one channel is in error, the most likely causes are:

- Incorrect programming of the *error limits* or flow condition changes that now make previous programming invalid.
- Defective or damaged cables, transducers, couplant, buffer, or electronics.

If the error still exists after you have tried eliminating or correcting the most likely causes mentioned above, check for these process and/or flow conditions changes:

- Excessive turbulence
- Discontinuities in fluid characteristics such as: multiphase flow, flashing, pockets of gas, the presence of bubbles or solid particles, cavitation, or rapidly changing fluid type
- Extreme fluid properties, such as pressure or temperature conditions
- Wax build-up on the face of a buffer/transducer, or clogged transducer ports due to sedimentation
- A pipe that is not completely full

5.2.2.2 More than one channel in error

If more than one channel is in error, the most likely cause is changes in process and/or flow conditions such as:

- Excessive turbulence
- Discontinuities in fluid characteristics such as: multiphase flow, flashing, pockets of gas, the presence of bubbles or solid particles, cavitation, or rapidly changing fluid type
- Extreme fluid properties, such as pressure or temperature conditions
- Wax build-up on the face of a buffer/transducer, or clogged transducer ports due to sedimentation
- A pipe that is not completely full

If the error still exists after you have tried eliminating or correcting the most likely causes mentioned above, check for the following:

- Incorrect programming of the *error limits* or flow condition changes that now make previous programming invalid.
- Defective or damaged cables, transducers, couplant, buffer, or electronics.

If you are unable to clear the errors, collect diagnostic data and parameter information for each channel and enter it in *Appendix B, "Service record," on page 135* prior to calling your local Panametrics sales or service center. Refer to *Section 5.3, "Flow info" on page 108* to gather the required diagnostics data.

5.2.2.3 Table of error codes

Table 14: Error code descriptions

Error code		Problem	Cause	Recommended action
E0:	No error	No error condition currently exists	This message appears briefly to indicate that the meter is now measuring without errors and any previous errors have now cleared.	No action is required.
E1:	Low signal	The ultrasonic signal strength is poor or the signal exceeds the programmed limits.	Poor signal strength may be caused by a defective cable, a flow cell problem, an empty pipe at the channel, a defective transducer or a problem in the electronics console. A signal that exceeds the programmed limits is probably caused by the entry of an improper value in the error limits option.	Check the value entered into the signal min error limits option (see the entering error limits and understanding error limits sections). Also, refer to the fluid and pipe problems and the transducer problems sections to correct for any issues.
E2:	Soundspeed	The measured soundspeed exceeds the programmed limits.	The error may be caused by incorrect programming, poor flow conditions, changing fluid properties that are outside expected values. It may also occur if signal quality is poor.	Compare the measured soundspeed to tabulated nominal values for the process fluid and correct any programming errors. Refer to the fluid and pipe problems and transducer problems sections to correct for any issues. In case you are unable to clear the errors, refer to the flow info section to gather diagnostics data before contacting Panametrics.
W3:	Velocity range	The measured velocity exceeds the programmed limits.	This warning may be caused by incorrect programming, poor flow conditions and/or excessive turbulence.	Make sure the actual flow rate is within the programmed error limits (see the entering error limits and understanding error limits sections). refer to the fluid and pipe problems and the transducer problems sections to correct any issues.
E5:	Amplitude	The signal amplitude exceeds the programmed limits.	This error may occur due to high signal attenuation or amplification due to changes in fluid properties, transducer/buffer/couplant issues.	Make sure the amplitude is within the programmed error limits (see the entering error limits and understanding error limits sections). Refer to the fluid and pipe problems and transducer problems sections to correct any issues. Refer to the flow info section to gather diagnostics data before contacting Panametrics.
E6:	Cycle skip (or) acceleration	A cycle skip is detected while processing the signal for measurement.	This is usually due to poor signal integrity, possibly because of bubbles in the pipeline, sound absorption by very viscous fluids, or cavitation.	If this error is caused by changes in flow rate, it will be auto corrected when the flow rate stabilizes after initial acceleration. But, if the error remains, refer to the fluid and pipe problems section to correct any issues. Check the threshold peak percentage, refer to the flow info section to gather diagnostics data before contacting Panametrics.

Table 14: Error code descriptions(Continued)

Error code		Problem	Cause	Recommended action
E7:	Analog output	The current setting is outside the programmed limits.	The calculated output value exceeds the programmed limits.	Verify that the 4-20 mA loop configuration base and span settings are correct for the process. Revise the output range as necessary.
E13:	Settle tracking AGC	The meter is unable to find a signal that is of sufficient quality.	Every time the meter is in E1, E2, E5 or E6, the meter also has an E13 error.	Refer to the actions for E1, E2, E5 or E6 errors.
E14:	Tracking seek mode	The signal is intermittent.	Discontinuities in the fluid characteristics such as multi-phase flow, flashing, pockets of gas, or rapidly changing fluid type make it difficult for the meter to lock in on the signal.	Check the process conditions. If thermal insulation is present, ensure an even application to mitigate hot or cold spots. In case you are unable to clear the errors, refer to the flow info section to gather diagnostics data before contacting Panametrics.
E15:	Active Tw	The active Tw measurement is invalid.	A transducer or cable is damaged, or a transducer needs to be re-coupled. This may also be due to incorrect programming, or extreme process temperatures.	Refer to the transducer problems section to correct any issues. If you are unable to clear the errors, refer to the flow info section to gather diagnostics data before contacting Panametrics.
E16:	Totalizer overflow	The totalizers are unable to keep up with the total accumulated flow signals	The programmed units/pulse value is too small.	Select a larger number for the units/pulse value (see the setting up frequency/totalizer and setting up totalizer sections).
E17:	Temperature input	This message indicates a temperature input error	The temperature exceeds the specified limits for the analog/RTD inputs, or no input device is connected.	Check the temperature transmitter and the connecting cable. Recalibrate the analog/RTD inputs
E18:	Pressure input	This message indicates a pressure input error.	The pressure exceeds the specified limits for the analog inputs, or no input device is connected.	Check the pressure transmitter and the connecting cable. Recalibrate the analog input.
E19:	Density input	This message indicates a density input error.	The density exceeds the specified limits for the analog inputs, or no input device is connected.	Check the density input device and the connecting cable. Recalibrate the analog input.
E21:	API	This message indicates an error in the API calculations.	The combination of pressure, temperature, density, and/or flow inputs causes the calculation to not properly resolve.	The specific API error can be found in the API info section of the meter program.
E22:	Degraded performance	One of the measurement channels is in error.	One measurement channel is in error, and the accuracy of the measurement may be degraded because the meter is using a chord substitution.	Check the individual channel errors, and refer to this table for recommended actions to correct those channel errors.
E23:	Reduced accuracy	Three or more related measurement channels are in error.	All 4 outer measurement channels or all 4 inner measurement channels are in error. The accuracy of the measurement is compromised because the meter is unable to use chord substitution.	Check the individual channel errors, and refer to this table for recommended actions to correct those errors. Refer to the more than one channel in error section for general troubleshooting guidelines.

Table 14: Error code descriptions(Continued)

Error code		Problem	Cause	Recommended action
W24:	Low SNR	The signal to Noise ratio is low.	The acoustic signal from the process is of very low quality due to excessive noise in the signal. This could be due to bubbles, solids or other non-homogeneous fluid conditions, or issues with transducers, couplant or buffers.	Refer to the fluid and pipe problems and transducer problems sections to correct any issues. Refer to the flow info section to gather diagnostics data before contacting Panametrics.
E25:	Half full pipe	The pipe might not be filled completely.	If the top-most channel on each plane is in error, the pipe might not be completely filled. The meter is using chord substitution to continue measuring. Please check the individual chord diagnostics to diagnose problem.	Check if the pipe is full. Check for individual channel errors, and refer to this table for recommended actions to correct those errors.
E26:	Possible sediment	Possible sedimentation covering the sensors	If the bottom-most channel on each plane is in error, there could be sedimentation covering the sensor faces. The meter is using chord substitution to continue measuring. Check the individual chord diagnostics to diagnose the problem.	Check for individual channel errors, and refer to this table for recommended actions to correct those errors. Refer to the more than one channel in error section for general troubleshooting guidelines.
E27:	Inner chord(s)	Two or more inner chords in error.	Two or more inner chords are in error. The meter is using chord substitution to continue measuring. Check the individual chord diagnostics to diagnose the problem.	Check for individual channel errors, and refer to this table for recommended actions to correct those errors. Refer to the more than one channel in error section for general troubleshooting guidelines.
E28:	Symmetry	The velocity symmetry is compromised.	Two or more chords are in error, and the velocity symmetry is compromised. The meter is using chord substitution to continue measuring. Check the individual chord diagnostics to diagnose problem.	Check for individual channel errors, and refer to this table for recommended actions to correct those errors. Refer to the more than one channel in error section for general troubleshooting guidelines.
E29:	Stale data	Internal data may be stale.	There is an internal data processing failure.	This condition is self-recovering and the error will be automatically corrected.
E30:	Channel off	Channel is currently disabled.	The channel is currently disabled. The meter will continue to measure with the enabled channels. However, the accuracy of the measured flow may be compromised.	Check the channel status in the meter program.

5.3 Flow info

The **Sentinel LCT8** offers built-in diagnostic parameters to aid in troubleshooting. To view multiple diagnostics for all channels via the flow info form, refer to *Figure 92* below and complete the steps on the next page.

Note: If necessary, refer to *Table 4* on page 32 as a reminder about color code meanings.

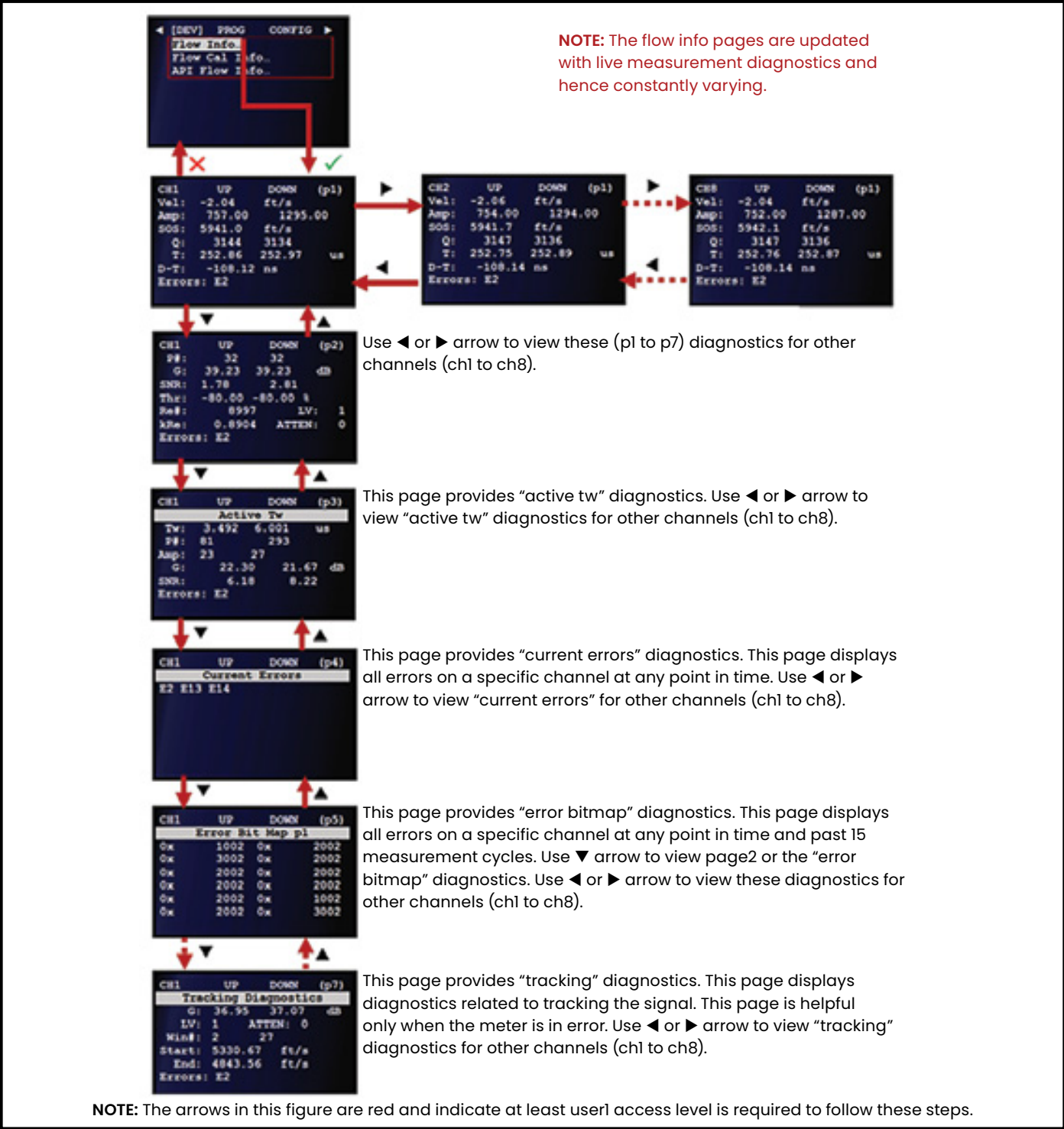


Figure 92: Using flow info in troubleshooting

1. Refer to *Primary pages on page 26* and navigate to *page 2: device info*.
 2. Use the [▲] and [▼] keys to highlight flow info and press the [✓] key to confirm your choice.
- Note:** *Because the flow info pages are updated with flow measurement diagnostics, they vary constantly.*

3. Use the [▲] and [▼] keys to view the following flow info pages:
 - a. **P1:** Use the [◀] and [▶] keys to view this diagnostic data for channels 1-8.
 - b. **P2:** Use the [◀] and [▶] keys to view this diagnostic data for channels 1-8.
 - c. **P3:** Use the [◀] and [▶] keys to view the *active tw* diagnostic data for channels 1-8.
 - d. **P4:** Use the [◀] and [▶] keys to view the *current errors* diagnostic data for channels 1-8.
 - e. **P5:** Use the [◀] and [▶] keys to view the *error bitmap* diagnostic data for channels 1-8.
 - f. **P6:** Use the [◀] and [▶] keys to view this diagnostic data for channels 1-8.
 - g. **P7:** Use the [◀] and [▶] keys to view the *tracking* diagnostic data for channels 1-8.
4. After you have finished viewing the diagnostic data, use the [▲] and [▼] keys to return to the **P1** screen and press the [✕] key to return to the previous screen.

Note: *For future reference, the flow info may be recorded in the tables in Appendix B, "Service record," on page 135.*

5.4 Fluid and pipe problems

If preliminary troubleshooting with the *error code messages* and the *diagnostic parameters* indicates a possible problem, proceed with this section. Measurement problems fall into two categories:

- **Fluid problems**
- **Pipe problems**

Read the following sections carefully to determine if the problem is related to the fluid or the pipe. If the instructions in this section fail to resolve the problem, contact Panametrics for assistance.

5.4.1 Fluid problems

Most fluid-related problems result from a failure to observe the flow meter system installation instructions, as described in *Chapter 2, "Installation,"* on page 7. Refer to that chapter to correct any installation problems.

If the physical installation of the system meets the recommended specifications, it is possible that the fluid itself may be preventing accurate flow rate measurements. The fluid being measured must meet the following requirements:

- **The fluid must be homogeneous, single-phase, relatively clean and flowing steadily.**
Although a low level of entrained particles may have little effect on the operation of the **Sentinel LCT8**, excessive amounts of solid particles will absorb or disperse the ultrasound signals. This interference with the ultrasound transmissions through the fluid will cause inaccurate flow rate measurements. In addition, temperature gradients in the fluid flow may result in erratic or inaccurate flow rate readings.
- **The fluid must not cavitate near the measurement point.**
Fluids with a vapor pressure relatively close to the process pressure may cavitate near the measurement point. This causes problems resulting from gas bubbles in the fluid. Cavitation can usually be controlled through proper system design.
- **The fluid must not excessively attenuate ultrasound signals.**
Some fluids, particularly those that are very viscous, readily absorb ultrasound energy. In such cases, signal warning and error messages will appear on the display screen to indicate that the ultrasonic signal strength is insufficient for reliable measurements.
- The fluid soundspeed must not vary excessively.
The **Sentinel LCT8** will tolerate relatively large changes in the fluid soundspeed, as may be caused by variations in fluid composition and/or temperature. However, such changes must occur slowly. Rapid fluctuations in the fluid soundspeed, to a value that is considerably different from that programmed into the **Sentinel LCT8**, will result in erratic or inaccurate flow rate readings. This may occur when changing batch fluids, though most likely the **Sentinel LCT8** will recover.

Note: Refer to Chapter 3, "Programming," on page 29 to make sure the appropriate soundspeed is programmed into the meter.

5.4.2 Pipe problems

Pipe-related problems may result from improper choice in meter location or errors in programming. The following may result in problematic installations:

- The collection of solid material at one or more transducer locations.
Accumulated debris at the transducer location(s) will interfere with transmission of the ultrasound signals. Choose an installation point for the meter where solid particles will not settle into the transducer ports. Refer to *Chapter 2, "Installation,"* on page 7, for more details on proper installation practices.
- The inner surface of the pipe is not sufficiently clean.
Excessive buildup of scale, rust or debris will change the inner dimensions of the pipe, which results in inaccuracies in the calculation of the flow rate from the fluid velocity measurement.

5.5 Transducer problems

The **Sentinel LCT8** transducers are rugged, reliable devices that do not come into contact with the process fluid. If erratic or inaccurate readings can be tracked to a problem with one or more transducers, such as physical damage, the Panametrics field service team has the appropriate methods and tools to properly replace the transducer to maintain the accuracy of your flow meter system without the need to recalibrate the system. Contact your local Panametrics representative to schedule this service.

5.6 Uncertainty in flow rate for a non-insulated flowcell

Dimensional compensation considers the effect on the geometrical dimensions of the flowcell due to the material thermal expansion or contraction. The fluid temperature inside the flowcell is measured and used for this purpose. Under severe ambient conditions, such as -40°C in winter, the fluid temperature can be very different, by up to 10°C , from the pipe wall temperature. This will cause about a 0.04% error in the measured flow rate. *Figure 93* below indicates that the errors increase as the difference between the fluid and the ambient temperatures for both insulated and non-insulated flowcells. For non-insulated flowcells, at large temperature differences, the error is about one order of magnitude higher than that for insulated flowcells. Therefore, for applications in severe weather conditions, it is recommended that the flowcell be insulated to ensure the accuracy of the meter.

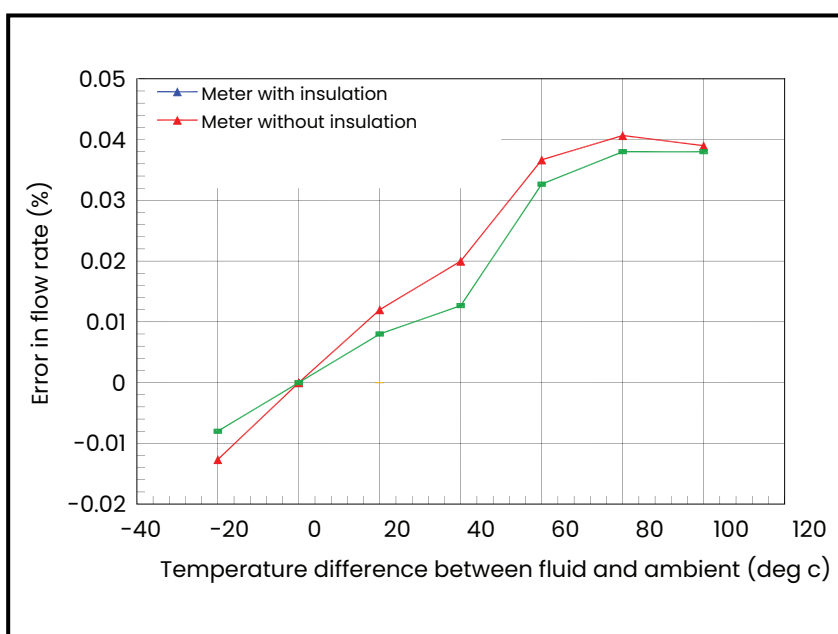


Figure 93: Example of flow error at Various temperature differences

5.7 Manufacturing tests

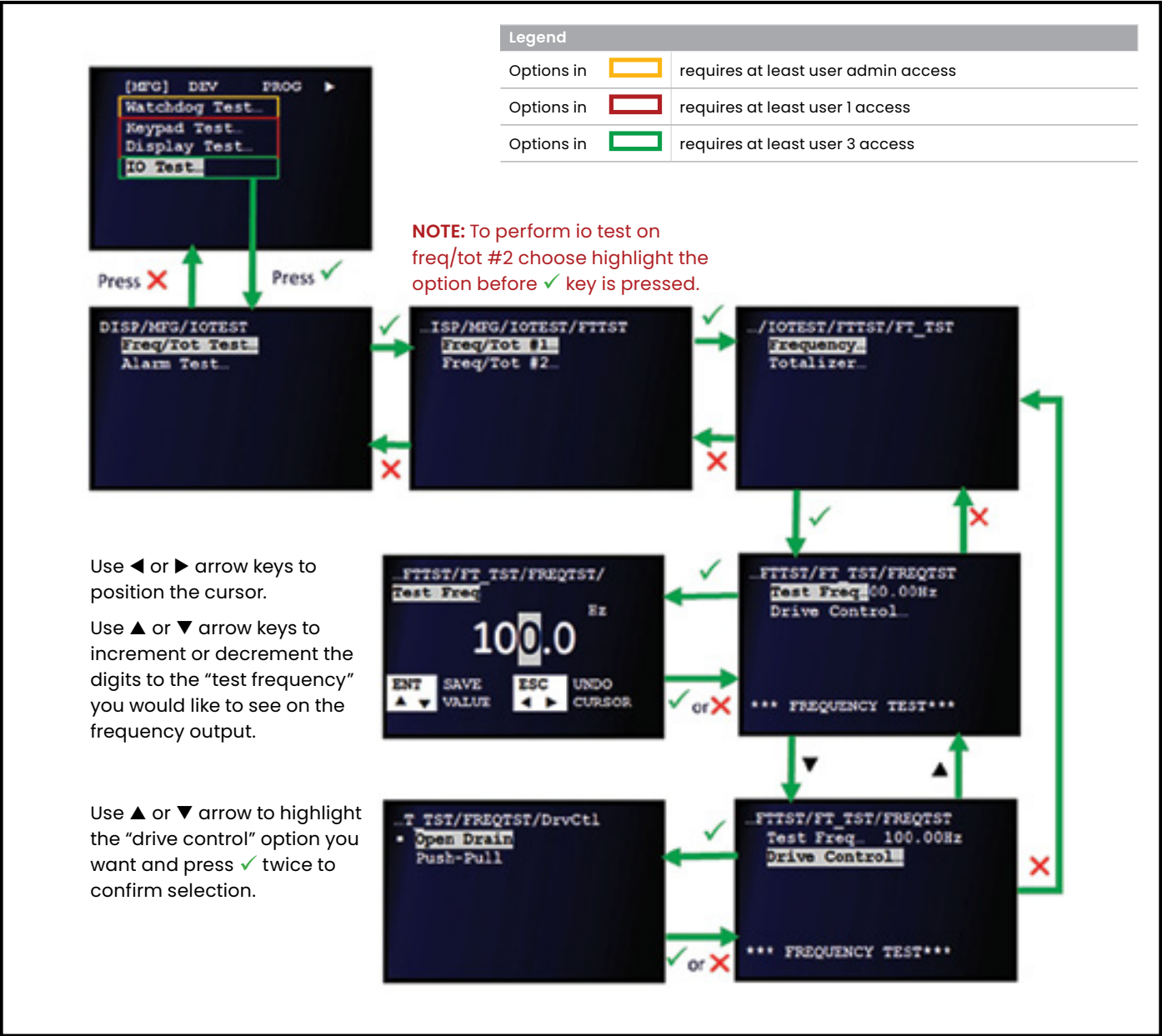
The procedures for testing certain key functionalities of the **Sentinel LCT8** are described in this section. The **Sentinel LCT8** Watchdog test, keypad test, display test and IO test are available to the user. As an example, the IO test is discussed in detail in this chapter. All other manufacturing tests are performed in a similar manner.

The IO test is used to troubleshoot any problems associated with damaged electronics or changes in the process conditions that may be affecting the **Sentinel LCT8** inputs and/or outputs. Proceed to the following three sections for instructions on how to test specific IO functions.

5.7.1 Frequency output test

To test a frequency output, refer to *Figure 94* below and complete the steps on the following page.

Note: If necessary, refer to *Table 4* on *page 32* as a reminder about color code meanings.



1. Refer to *Primary pages on page 26* and navigate to *page 1: manufacturing tests*.
2. Use the [▲] and [▼] keys to highlight *IO test* and press the [✓] key to confirm your choice.
3. Use the [▲] and [▼] keys to highlight *freq/tot test* and press the [✓] key to confirm your choice or press the [✗] key to return to the previous screen.
4. To test the desired *frequency output*, use the [▲] and [▼] keys to highlight either *freq/tot #1* or *freq/tot #2*. Then, press the [✓] key to confirm your choice or press the [✗] key to return to the previous screen.
5. Use the [▲] and [▼] keys to highlight *frequency* and press the [✓] key to confirm your choice or press the [✗] key to return to the previous screen.
 - a. Use the [▲] and [▼] keys to highlight *test freq* and press the [✓] key to confirm your choice. At the next screen, enter the test frequency value to be output. Then, press the [✓] key to save the new value or press the [✗] key to keep the old value and return to the previous screen.
 - b. Use the [▲] and [▼] keys to highlight *drive control* and press the [✓] key to confirm your choice. At the next screen, use the [▲] and [▼] keys to highlight either *open drain* or *push-pull* and press the [✓] key twice to confirm your choice or press the [✗] key to cancel and return to the previous screen.

6.4.12 Hazardous area certifications

- USA/Canada: Class 1, div 1, Groups B, C, and D
- Europe: ATEX II 2 G Ex d IIB+H2 (Ex de as an option)
- IEC Ex: Ex d IIB+H2 (Ex de as an option)

6.4.13 CE Mark compliance

- 2014/30/EU EMC Directive
- 2014/35/EU LVD Directive
- 2014/34/EU ATEX Directive
- 2012/19/EU WEEE Directive
- 2011/65/EU RoHS Directive

6.4.14 Custody transfer performance approvals

Multiple country-specific approvals available upon request

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7.2 Wiring connections for increased safety

Power connection	Maximum size*:	Solid - 4.0 mm ² (12 AWG) stranded - 2.5 mm ² (14 AWG)
	Number of conductors**:	2 Solid - max 1.5mm ² (16 AWG)
		2 Stranded - max 1.0 mm ² (18 AWG)
All other screw terminal connections	Maximum size*:	Solid - 4.0 mm ² (12 AWG) stranded - 2.5 mm ² (14 AWG)
	Number of conductors**:	2 Solid - max 1.5 mm ² (16 AWG)
		2 Stranded - max 1.5 mm ² (16 AWG)
* Single conductor; **Multiple conductors of same cross-section		

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