CiDRA® SONARtrac® digital

FLOW AND ENTRAINED AIR MEASUREMENT SYSTEM

(with Type DTX-1 Transmitter and Type DSE-1 Sensor Head Electronics Module)

22040-1-EN, Rev 01
Ordinary Location Manual

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1 Introduction

1.1 Scope

NOTE: The capitalized terms are defined in section 1.4.

This is a basic manual for Ordinary Location *SONARtrac® digital* SYSTEMs comprised of DTX-1 TRANSMITTERs with DSE-1 Sensor Head Electronics Modules (MODULEs) with 8 sensor channels for any size pipe (2” to 60”) in horizontal or vertical orientations with fiberglass or stainless steel COVERs sized for the pipe, and either of the 2 CiDRA-sourced cables (unarmored or armored with aluminum-interlocked armor). This manual assumes that, unless otherwise indicated, all configurations of the available interfaces (two 4-20mA outputs, HART, 4-20mA input, Pulse output, or Modbus) are done through the front panel keypad/display interface. For other configuration issues, the user will be directed to reference other manuals – some or all of which may be accessible via the internet. See the Customer Support section of this manual (section 4.8).

For the initial Rev 01 release of this manual and for all subsequent releases until this disclaimer is modified and ultimately removed, this manual is intended for systems with fiberglass COVERs on pipes between 2” and 30” in diameter and with only a single sensor BAND. References in this manual to larger pipes, stainless steel COVERS, and SYSTEMS with 2 BANDs and the associated Y-cable assemblies and special thermal blankets and umbilical cable routing issues are anticipatory and should not be considered either accurate or complete. Installers and users of such systems should NOT use this version of this manual and instead use a later version without this disclaimer.

CAUTION

USE THIS REVISION OF THIS MANUAL ONLY FOR SYSTEMS WITH 2” TO 30” PIPES. THE INSTRUCTIONS FOR LARGER PIPES ARE PRELIMINARY AND MAY BE INCOMPLETE OR INACCURATE.

PRUDENCE

UTILISEZ CETTE RÉVISION DE CE MANUEL UNIQUEMENT POUR LES SYSTÈMES AVEC DES TUYAUX DE 2” À 30”. LES INSTRUCTIONS POUR LES TUYAUX PLUS GRANDS SONT PRÉLIMINAIRES ET PEUVENT ÊTRE INCOMPLÈTES OU INEXACTES.

There are 3 major functional variants of the SYSTEM: (1) FLOW AND ENTRAINED AIR MEASUREMENT SYSTEM; (2) FLOW AND ENTRAINED AIR MEASUREMENT SYSTEM, HD SERIES; and (3) FLOW MEASUREMENT SYSTEM, PW SERIES. This manual applies to all 3 variants, though the 3rd variant does not include the ability to measure SOS, GVF, or TLF. Where those measurements and their configurations are mentioned in this manual, understand that they do not apply to that 3rd variant. For that 3rd variant, the firmware will ignore and the front panel may reject attempts to configure the related parameters. There are minor variants of the SYSTEM as well. Typically, only one of the HART or Modbus interfaces will be enabled, but neither will be enabled if the SYSTEM includes one of the optional modular communications options (Profibus DP, Foundation Fieldbus, and Profibus PA). The configuration and use instructions in this manual do not apply for disabled interfaces. The enabled features can be checked using sub-menu *Info/Config*.

Note that the *SONARtrac® digital* product is distinct from the legacy *SONARtrac®* product. It has its own separate set of manuals and certifications. Though designed for the same purposes and generally similar in appearance, the components of these two products are NOT interchangeable or intermixable.

This manual's description of the front-panel interactions and the menu structure reflect the firmware version that existed at the time that the manual was written or revised. Some discrepancies may be created by subsequent firmware versions. If significant discrepancies are observed, ask Customer Support if a more recent revision of the manual is available.

Systems comprised of DTX-1 TRANSMITTERs with DSE-1 Sensor Head Electronics Modules are for use in non-hazardous locations only (no explosive gases or dusts) and this manual is explicitly for those models. If yours is not an Ordinary Location DTX-1 with DSE-1 system (e.g. the DTX-2 with DSE-2, or DTX-3 with DSE-3, then this is the WRONG MANUAL for you to use.

WARNING

EXPLOSION HAZARD – SYSTEMS COMPRISED OF DTX-1 WITH DSE-1 ARE SUITABLE ONLY FOR INSTALLATION IN NON-HAZARDOUS LOCATIONS AND FOR SUCH SYSTEMS THIS MANUAL IS SUFFICIENT. SYSTEMS COMPRISED OF DTX-2 WITH DSE-2, OR DTX-3 WITH DSE-3 ARE SUITABLE FOR INSTALLATION IN HAZARDOUS LOCATIONS AND FOR SUCH SYSTEMS THIS IS THE WRONG MANUAL.

	**AVERTISSEMENT** **RISQUE D'EXPLOSION – LES SYSTÈMES COMPOSÉS DE DTX-1 ET DSE-1 NE CONVIENNENT QU'À UNE INSTALLATION DANS DES ENDROITS NON DANGEREUX ET POUR DE TELS SYSTÈMES, CE MANUEL EST SUFFISANT. LES SYSTÈMES COMPOSÉS DE DTX-2 AVEC DSE-2, OU DTX-3 AVEC DSE-3 SONT ADAPTÉS À UNE INSTALLATION DANS DES ZONES DANGEREUSES ET POUR DE TELS SYSTÈMES, CE N'EST PAS LE BON MANUEL.**

1.2 Intended Use

SONARtrac® digital systems include the Type DSE-1 Sensor Head Electronics Module and an array of clamp-on sensors on the exterior of the end user's process pipe to collect, condition, and digitize flow turbulence and acoustic signals and transmit them to the Type DTX-1 TRANSMITTER where patented sonar array processing techniques are used to calculate fluid flow rates and/or gas void fractions (GVF) and report the results to the end user by a variety of means. The clamp-on design eliminates the need for cutting pipe or interrupting process flow during installation. *SONARtrac digital* is a platform of products designed to serve a variety of industrial applications including homogeneous fluids, difficult-to-characterize solid/liquid slurry mixtures, or bubbly fluids.

It is unsafe to use this product in a manner not specified by the manufacturer.

1.3 Certifications

Ordinary Location safety per IEC 61010-1 CB scheme and the derivative safety standards and National Differences, including those for the United States, Canada, Europe, and Japan.

This equipment is compliant with Class A limits for radiated and conducted radio noise emissions, as defined in Subpart A of Part 15 of the FCC rules for the US, as well as the requirements defined in ICES-001 for Canada.

> This Class A digital apparatus complies with Canadian ICES-001.
>
> Cet appareil numérique de la classe A est conforme à la norme NMB-001 du Canada.

This equipment is compliant with the emissions and immunity requirements set forth in EN 61326-1 for Europe.

For the purpose of Electromagnetic Compatibility (EMC) requirements, this product is categorized as Group 1, Class A ISM equipment. This categorization applies to Industrial, Scientific or Medical equipment that intentionally generates or uses conductively coupled (but not intentionally radiated) radio-frequency energy that is necessary for the internal functioning of the equipment. The level of EMC compliance is consistent with industrial use but not for domestic purposes.

CAUTION

Class A equipment is intended for use in an industrial environment. There may be potential difficulties in ensuring electromagnetic compatibility in other environments, due to conducted as well as radiated disturbances.

PRUDENCE

Les équipements de classe A sont destinés à être utilisés dans un environnement industriel. Il peut être difficile d'assurer la compatibilité électromagnétique dans d'autres environnements, en raison de perturbations conduites et rayonnées.

All EMC testing was conducted with shielded cables. For customer I/O cable selection it is recommended that shielded cables be used with the shield connected to earth at one end. When Ethernet is used, a shielded cable with both ends earthed is recommended.

1.4 Overview and Terminology

The purpose of this section is to identify the hardware that this manual pertains to and to define the capitalized words (e.g. SYSTEM, TRANSMITTER, MODULE, BAND, COVER, SENSOR HEAD, SENSOR HEAD CABLE) used as shorthand in this manual.

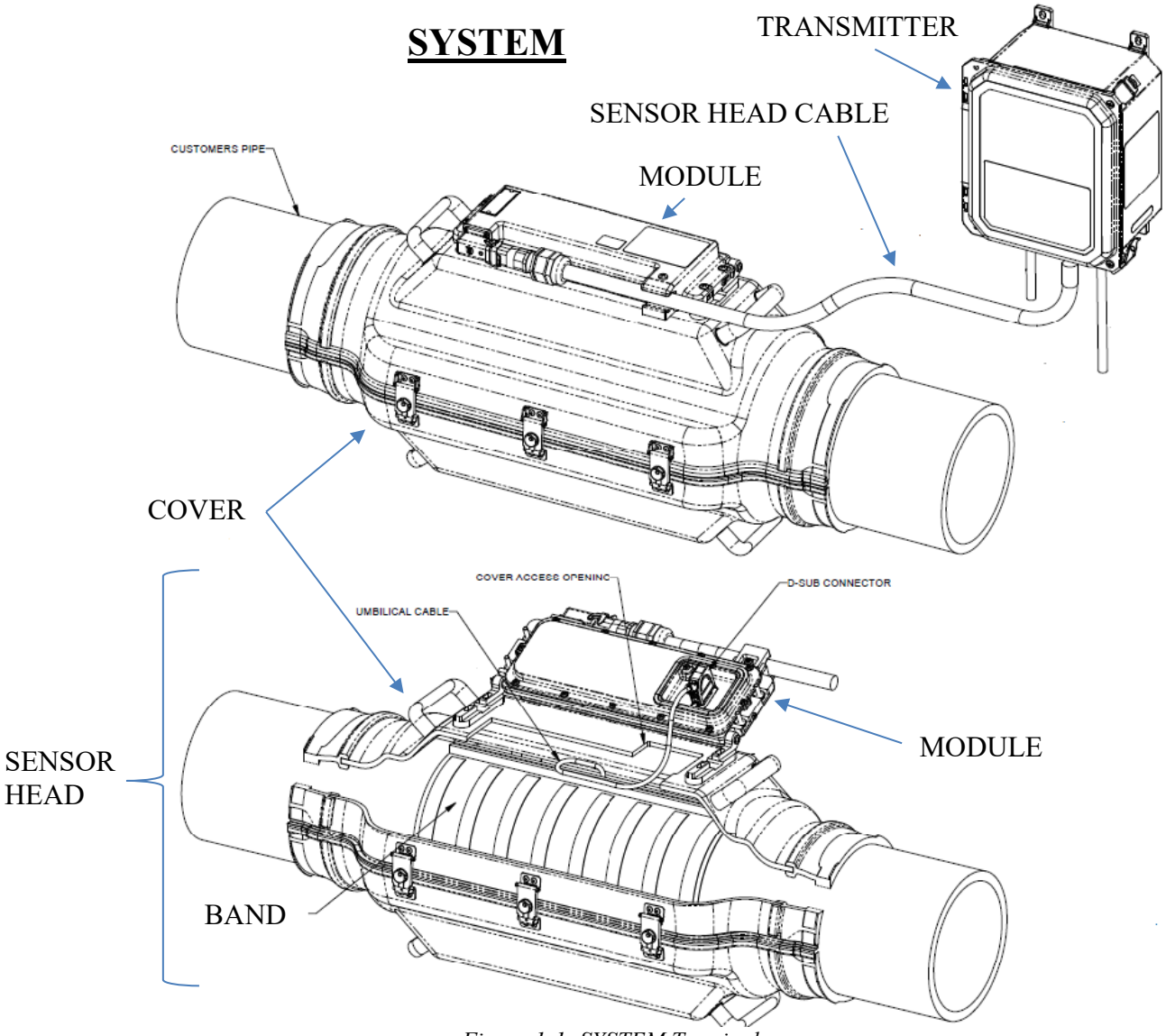

Figure 1-1: SYSTEM Terminology

Figure 1-1 shows the CiDRA *SONARtrac digital* flowmeter and/or gas-void-fraction monitoring system (SYSTEM) featuring the Type DTX-1 Transmitter (TRANSMITTER) and the Type DSE-1 Sensor Head Electronics Module (MODULE). There is a Sensor Band (BAND) – or sometimes two side-by-side Sensor Bands - which is an array of sensors snugly affixed to the outer surface of the customer's pipe which includes umbilical cable(s) that connect to the MODULE. A Sensor Band Cover (COVER) protects the BAND and provides a mounting surface for the MODULE. SENSOR HEAD is a term used collectively for the MODULE and COVER and sometimes (usually obvious from the context) the BAND. A cable (SENSOR HEAD CABLE) connects the TRANSMITTER to the MODULE to provide power and communications.

Note that SYSTEM refers to the entire collection of components shown in *Figure 1-1*, but that it sometimes also refers to the larger collection of components including components provided by the customer (e.g. the customer's power source, power cable, external current-limiting and ON/OFF switch; the customer-provided cabling for the TRANSMITTER I/Os and Modular Comms terminals and their equipment on the far end of that cabling). It should be clear from the context of use what the meaning of SYSTEM is when used.

CiDRA is short for CiDRA Corporate Services LLC of Wallingford, Connecticut USA (www.cidra.com). *SONARtrac digital* is the CiDRA trademark for this passive sonar measurement SYSTEM that includes the DTX-1 TRANSMITTER and DSE-1 MODULE, and the *SONARtrac* portion of the name is registered with the US Patent and Trademark Office. Passive sonar is a measurement technique based on arrays of passive sensors and sonar array processing algorithms. The sensors passively "listen" to the strains in the pipe wall and the acoustics in the fluid caused by fluid flow in the customer's process piping. The SYSTEM includes no active strain or acoustic sources. The SYSTEM hardware is suitable for either measuring the flow rate of the fluid flowing in the process piping, or of measuring the gas void fraction within that fluid based on a measurement of the speed of sound in the fluid. The software determines which of those parameters (or both) are calculated. The Type DTX-1 TRANSMITTER is the Ordinary Location rated version of the Type DTX TRANSMITTER family, and it comes in either an AC-powered or DC-powered version. The specific version can be determined from the certification label on the right-hand side of the exterior of the TRANSMITTER. The certification label includes the electrical ratings of the DTX-1 TRANSMITTER, and a smaller nearby label gives the complete DTX-1 model number with additional fields that indicate the power type and other variable options. The Type DSE-1 MODULE is the Ordinary Location rated version of the Type DSE MODULE family and is identified by the labels on top of the MODULE. The certification label identifies it as Type DSE-1, while a smaller nearby label gives the complete DSE-1 model number with additional fields that indicate other variable options. The Type DTX-1 TRANSMITTER and Type DSE-1 MODULE are the only two components of the SYSTEM with active electrical/electronic components which consume electrical power and generate heat and therefore they are the two principal components focused on by the Ordinary Location safety standards (all based on IEC 61010-1) "Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use".

1.5 Definitions of Symbols

The following terms and symbols are used in this document and on the equipment where safety related issues occur.

1.5.1 Warning or Caution Symbol

Figure 1-2: Warning or Caution Symbol

The Exclamation Symbol in *Figure 1-2* appears in Warning and Caution boxes throughout this document. This symbol is an alert to the potential for personal injury or damage to the equipment. When used on the equipment it indicates that the manual should be consulted for relevant safety instructions.

1.5.2 Earth (Ground) Terminal

Figure 1-3: Earth (Ground) Terminal Symbol

The Earth (Ground) Terminal Symbol in *Figure 1-3* appears on labels affixed to the equipment. This symbol identifies components that are part of the earth circuit.

1.5.3 Protective Conductor Terminal

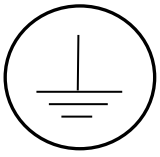

Figure 1-4: Protective Conductor Terminal Symbol

The Protective Conductor Terminal Symbol in *Figure 1-4* appears on the TRANSMITTER. This symbol identifies the terminal which is intended for connection to an external protective conductor for protection against electric shock in case of a fault. See section 2.5.6.2 for instructions for wiring this protective earth circuit to a local earth ground.

1.5.4 Electric Shock Hazard

Figure 1-5: Electric Shock Hazard Symbol

The Electric Shock Hazard warning symbol in *Figure 1-5* appears on a label near the mains power terminals of the AC-powered TRANSMITTER and in this manual in conjunction with warnings about the hazard of electric shock. Those mains power terminals, and the associated wires and fuses are the primary risks of electric shock in the AC-powered TRANSMITTER. The risk is mitigated by keeping the cover over the sub-compartment with the power terminals closed and secured with the screw. The TRANSMITTER, itself, does not generate voltages higher than nominal 24VDC, so there is no electric shock risk from the other terminals.

1.6 Warranty

The terms and conditions, including warranty, of the purchase of this product is outlined in the document entitled “CiDRA’s Terms and Conditions of Sale”.

1.7 Intellectual Property Notices

This product may be covered by one or more of the following granted U.S. Patent(s): 7,249,525; 7,343,820; 7,363,800; 7,380,438; 7,389,687; 7,418,877; 7,426,852; 7,437,946; 7,440,873; 7,503,227; 7,526,966; 7,603,916; 7,624,650; 7,624,651; 7,657,392; 7,661,302; 7,672,794; 7,673,524; 7,673,526; 7,690,266; 7,725,270; 7,752,918; 7,810,400; 7,882,750; 7,895,903; 7,962,293; 8,061,186; 8,229,686; 8,286,466; 8,346,491; 8,641,813; 8,713,988; 8,739,637; 8,862,411; 8,931,520; 9,057,635; 9,062,682; 9,291,490; 9,297,733; 9,404,893; 9,645,001; 9,995,609; 10,031,009; 10,060,570; 10,071,352; 10,216,204; 10,228,706; 10,394,207; 10,677,624; 10,830,623. Other patents are pending; see www.cidra.com for the latest list of patents.

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2 Equipment Installation

2.1 Installation Checklist

The purpose of this section is to provide a checklist for installing the SYSTEM.

1. ___Determine installation location electrical classification rating.
2. ___Ensure equipment to be installed has the correct electrical classification.
3. ___**Read Installation Manual**.
4. ___Clean pipe per Manual Section 2.3.2.
5. ___Measure pipe using PI Tape and ultrasonic thickness gauge OR obtain pipe size measurements from engineering drawings or information printed on the pipe.
6. ___Install BAND (or BANDS) & tighten BAND screws per Manual Section 2.3.5.
7. ___Install thermal barrier over BAND per Manual Section 2.3.5.4 (and possibly Y-cable per Manual Section 2.3.5.5).
8. ___Install COVER per Manual Section 2.3.6. Install MODULE onto COVER per Manual Section 2.3.6.3, if not pre-installed.
9. ___Connect BAND umbilical cable to MODULE per Manual Section 2.3.6.5.
10. ___Lay SENSOR HEAD CABLE per Manual Section 2.4.
11. ___Connect MODULE to SENSOR HEAD CABLE connector per Manual Section 2.4.2.
12. ___Connect power wires to terminals in TRANSMITTER per Manual Section 2.5.6.2.
13. ___Connect SENSOR HEAD CABLE wires to terminals in TRANSMITTER per Manual Section 2.5.6.3.
14. ___Connect customer I/O and modular communication (if any) wires to terminals in TRANSMITTER per Manual Section 2.5.6.4.
15. ___Apply power to the TRANSMITTER per Manual Section 2.5.9
16. ___Configure the TRANSMITTER using Display and Keypad per Manual Section 3. Alternatively, if a custom configuration file has been provided, load file per the instructions provided by Customer Support.
17. ___Perform the self-tests per Manual Section 3.3.2. If failures, contact Customer Support.
18. ___If process is in operation, perform ‘GAIN’ setup per Manual Section 3.3.1.4. If process is not in operation, wait and perform this step after process has been started.
19. ___If Customer Support needs raw baseline data and/or photos from commissioning, then take photos of the installed SYSTEM and when the process is running normally, collect a snapshot with a USB stick and transfer that data to Customer Support per directions that they will provide.

Contact Customer Support with any questions.

2.2 General Warnings and Cautions

Observe these rules when operating or servicing this equipment:

- The safety of any customer system incorporating this product as an element is the responsibility of the assembler of that system.
- Prior to operation of this equipment, personnel should read the instruction manual thoroughly.
- Follow all warnings on the unit and in the operating instructions.
- This product should only be powered as described in the manual. Read the instructions for proper input voltage range selection.
- This equipment is grounded through the protective earth grounding conductor of the input power cable.
- Ensure that the power cable, SENSOR HEAD CABLE, and customer I/O cables are properly routed and secured to prevent damage to them. Cable conduit may be desirable to minimize potential damage.
- Do not run power and signal wires in a common conduit.
- During installation or removal of the SYSTEM, ensure that proper PPE (Personal Protective Equipment) is worn as needed or mandated by the work site (e.g. gloves, safety boots, etc).
- **Moving parts / Pinch Hazards:** The SYSTEM has no moving parts after installation. Avoid pinching wires or fingers when closing and securing the TRANSMITTER's hinged enclosure door, when mating the two halves of the COVER, when using the hinge on the MODULE's mounting blocks, when operating the retention latches on the MODULE's cable connector, and when tightening the strain relief clamp on the side of the MODULE.

2.3 SENSOR HEAD Installation

2.3.1 Selecting a location

- The SENSOR HEAD must be installed on a straight smooth section of pipe. Consider the length of the COVER that is being installed. The pipe preparation procedure is applicable to that entire length. The pipe smoothness is especially critical to meter performance in the section covered by the BAND(s).
- Pipe sizes 2" to 30" typically use a single BAND and a fiberglass COVER. The COVER is typically no more than 34.7" (881mm) long and the BAND is ~19" (483mm) long and centered in the COVER.
- Pipe sizes >30" to 36" typically use a single BAND and a stainless steel COVER. The COVER is typically 31.7" (805mm) long and the BAND is ~19" (483mm) long and centered in the COVER.

- Pipe sizes above 36” typically use two side-by-side BANDs (separated by 0.27” or 6.86mm) and a stainless steel COVER. The COVER is typically 51.2” (1300mm) long and the BANDs cover a combined length of ~38.3” (973mm), centered in the COVER.
- Select locations with a full pipe and well-developed flow profiles.
- Avoid installation locations directly after piping configurations that cause flow jetting.
- Install SENSOR HEAD upstream of control valves, “T”’s, orifice plates, pipe taps (such as those used for temperature and pressure sensors) and any other severe source of flow disturbance.
- Good piping practices are required near flanges. This includes good alignment of pipes, and properly sized and installed gaskets that do not disturb the flow profile.

*Table **2-1*** lists the recommended installation distances of the SENSOR HEAD from flow disturbances. These recommendations apply to flow measurement installations.

Feature	Minimum for Repeatable Operation		Standard Specifications	
	Upstream (of Sensor Head)	**Downstream** (of Sensor Head)	**Upstream** (of Sensor Head)	**Downstream** (of Sensor Head)
Elbow	1/2	1/2	15	5
Diffuser (expansion)	6	1	30	5
Reducer	2	2	15	5
Pump	10	5	20	5
Shut-off Valve (fully opened)	2-4	5	2-4	5
Valve Variable Position i.e. Control Valve	40	10	40	10

Table 2-1: Recommended Distances (Pipe Diameters) from Flow Disturbances

Note: The distances from flow disturbances are only guidelines. For any other configuration or application-specific questions, please contact Customer Support.

2.3.2 Pipe Preparation

Remove pipe insulation if it is present.

	**WARNING** **Asbestos containing insulation materials may be present. Asbestos fibers have been known to cause health problems. If unsure of the contents of pipe insulation materials contact the plant representative for that area.**
	**WARNING** **Process Heating Tapes may be present. This may present an electrical shock hazard. Follow plant Lock-out / Tag-out requirements.**
	**WARNING** **Process pipes may be hot. A burn hazard may exist. Use care when working with hot pipes.**

	**AVERTISSEMENT** **Des matériaux isolants contenant de l'amiante peuvent être présents. Les fibres d'amiante sont connues pour causer des problèmes de santé. Si vous n'êtes pas certain du contenu des matériaux isolants des tuyaux, communiquez avec le représentant de l'usine de cette région.**
	**AVERTISSEMENT** **Des rubans chauffants de processus peuvent être présents. Cela peut présenter un risque d'électrocution. Respectez les exigences de verrouillage et d'étiquetage de l'usine.**
	**AVERTISSEMENT** **Les tuyaux de traitement peuvent être chauds. Il peut exister un risque de brûlure. Soyez prudent lorsque vous travaillez avec des tuyaux chauds.**

Clean pipe surface using a scraper, sandpaper strips, a water rinse and final wipe with a clean rag. The pipe surface under the BAND(s) should be clean and free of rust and rust spots, grit, grease, protruding weld spots and weld splatter. A good guideline is to clean the pipe as if it were going to be painted.

Remove any pipe tong marks, sharp weld seam material, or other raised or sharp metal on the pipe with a file. In addition to interfering with the required full-contact connection of the BAND to the pipe OD, raised points risk puncturing the BAND's insulator sheet and creating an unintended short circuit from the BAND to the pipe.

Avoid dents as they can create flow disturbances within the pipe. Select a location that ensures full contact between the BAND(s) and the pipe.

Painted surfaces are normally satisfactory provided they are smooth and free of chips over 0.25 inch (6.4 mm) diameter. Ensure a smooth painted finish by sanding the area where the BAND(s) will be mounted. Finally, wipe the pipe using a damp cloth rag or paper towel.

2.3.3 Determine the Pipe Dimensions

Record the pipe dimensions based on the nominal pipe size and pipe schedule (or SDR), as this will be needed for configuring the TRANSMITTER.

In the absence of knowledge of the nominal dimensions or for higher flow measurement accuracy, measure and record the actual pipe dimensions. Accurately measure the pipe outside diameter (OD) using a PI tape (or, alternatively, use a regular measuring tape to measure the pipe circumference and then divide by 3.14). Use an ultrasonic thickness measurement gauge to determine the wall thickness (t_w) at a minimum of 4 locations equally spaced around the pipe and average the measurements.

If this is a lined pipe, you will need to know the thickness of the liner to properly configure the TRANSMITTER.

Note: The accuracy of all these measurements (OD, wall thickness, liner thickness) is critical to the accuracy of the calculation of the inner diameter. The meter measures linear flow rate and then uses the inner diameter to convert that to volumetric flow rate. A 0.1% error in the inner diameter calculation creates a 0.2% error in the conversion to volumetric flow rate.

2.3.4 BAND Labels, and Spacer Tools

Prior to installing the BAND(s), remove from the BAND and save the plastic bag that contains sensor calibration factor labels and the sensor gap gauge tool. For dual BANDs, this kit also includes a BAND spacer tool and some adhesive labels "A" and "B" and is found inside the bag that includes the Y-cable assembly. These will be used as described later in this manual.

The labels with the calibration factors look like this.

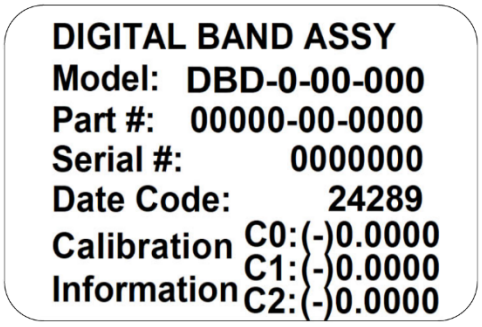


Figure 2-1: BAND label

The MODULEs are for 8-channels (distinguished by a single D-sub connector on the bottom) and are suitable only for a single 8-channel BAND for pipes smaller than 36”, or two identical 4-channel BANDs married to the single D-sub of the 8-channel MODULE through use of the Y-cable assembly for pipes larger than 36”.

2.3.5 BAND Installation

The BAND(s) should be handled by the attachment rails to avoid damaging sensors and/or injury from sharp edges along the sides of the BAND. It is recommended that proper PPE (Personal Protective Equipment) such as gloves be used to protect against cuts while handling the BAND(s).

It will be helpful to have a second person available to assist with holding the BAND(s) in position during installation. This is especially critical when installing on large diameter vertical pipes.

If possible, avoid installing the BAND over pipe defects. For rolled and welded pipe with longitudinal and circumferential welds, do not install the BAND over a circumferential weld. If it can be done without violating the other BAND orientation rules, align the BAND such that the longitudinal weld is near the fastener attachment rails. For spiral-welded pipe, avoid having the weld be near the fastener attachment rails.

An optional weld bead filler (elastomeric strip of material) is sometimes used to fill the gaps on either side of the longitudinal weld prior to installation of the BAND. Remove the paper strips covering the adhesive on the weld bead filler and attach the weld bead filler over the pipe seam weld. For particularly tall or wide weld beads, contact Customer Support to determine if the weld bead filler is recommended.

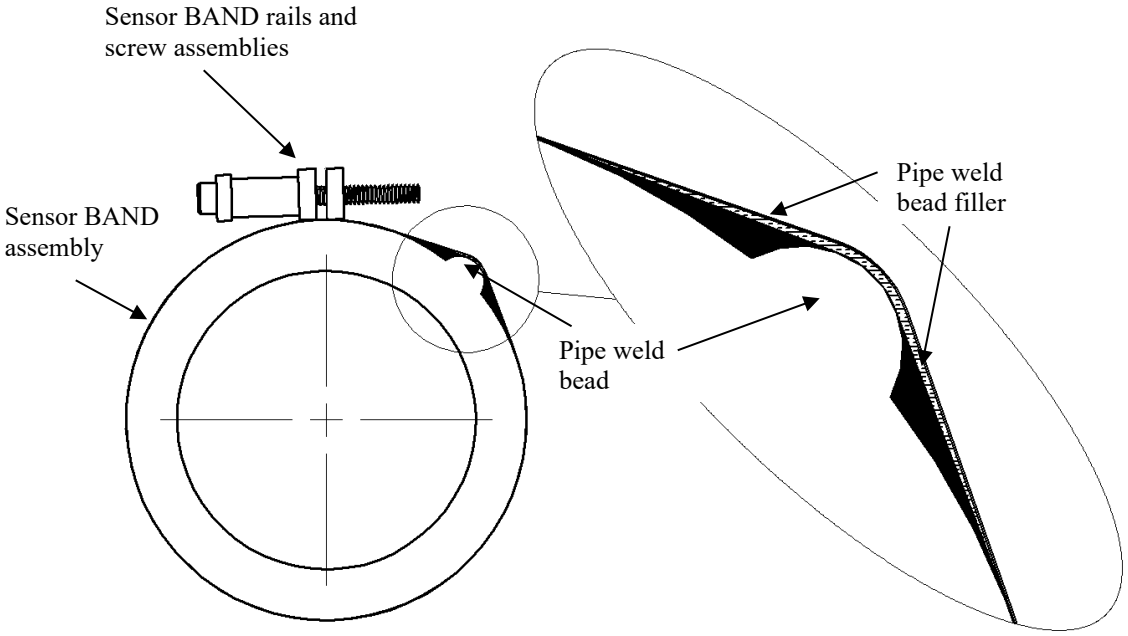


Figure 2-2: Weld Bead Filler

Sometimes a compliant layer (elastomeric material) is installed prior to the BAND. If the BAND was furnished with a compliant layer, wrap it around the process pipe. The ends of the compliant layer should be positioned at the longitudinal weld seam on the pipe (if there is one).

IMPORTANT: HD or SEGMENTED SENSOR BANDS MUST BE INSTALLED WITH THE FASTENER ATTACHMENT RAILS ON THE TOP OF HORIZONTAL PIPES

Note that for vertical pipe installations the orientation of the fastener attachment rails is arbitrary (though for dual BANDs where the BANDs are HD or segmented, the attachment rails of the 2 BANDs must be lined up). For horizontal pipe installations, the MODULE wants to be somewhere generally above the midline of the pipe (for convenience and to avoid performance issues related to condensation) and the BAND umbilical length may limit the possible fastener attachment rail locations as its position is optimized relative to pipe defects. However, the HD or segmented BANDs are specially designed such that their flow measurement accuracy in slurry flow (not in homogeneous fluid flow) is compromised if the fastener attachment rails are not positioned at the very highest point of the horizontal pipe (+/- 5°).

From knowledge of where the COVER is going to be installed, and the number of BANDs, mark the location(s) on the pipe where the BAND(s) needs to be installed.

Ensure there is no dirt or other foreign material on the BAND(s). Remove dirt or foreign matter using a clean cloth dampened with water.

Using those markings to position the first BAND on the pipe with the polyimide film (amber colored) against the pipe surface. If possible, orient the flow direction arrow on the BAND with the direction of flow within the pipe. **Note:** If this is not possible due to installation constraints, for example access to BAND fasteners, install opposite to flow direction. In that case, the TRANSMITTER must be re-configured for "reverse flow" during its set up as detailed in section 3.3.1.3.

Wrap the BAND around the pipe and slide the alignment pins on the attachment rail through their mating holes on the opposite attachment rail. Final positioning can be made after the screws have been started. **Note:** When installing the BAND keep in mind the requirement for MODULE's connector orientation as described in Section 2.3.6. If necessary, due to COVER installation constraints, wrap the sensor BAND over the weld seam.

Carefully start threading the screws into their screw holes (avoid cross threading) by using a hex driver until each screw is engaged about 2 turns. Once all screws are engaged make final positioning of the BAND with respect to pipe weld seam or desired orientation on the pipe.

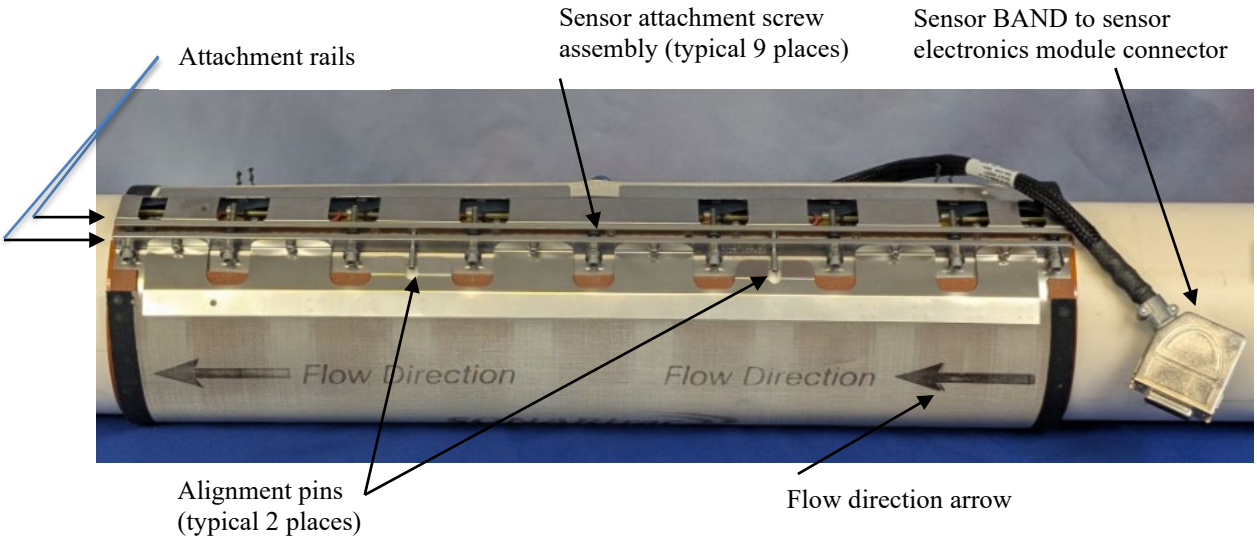


Figure 2-3: BAND Screw and Alignment Pins

If there is a second BAND to be installed (typical of larger diameter pipes) then install it in the same way, with the fastener attachment rails lined up and a space of 0.27” (6.86mm) between them. There is a tool provided for setting that space. It is CRITICAL that the 2 BANDs have their direction arrows pointing the same way and their umbilical cables exiting from the same side of the fastener attachment rails.

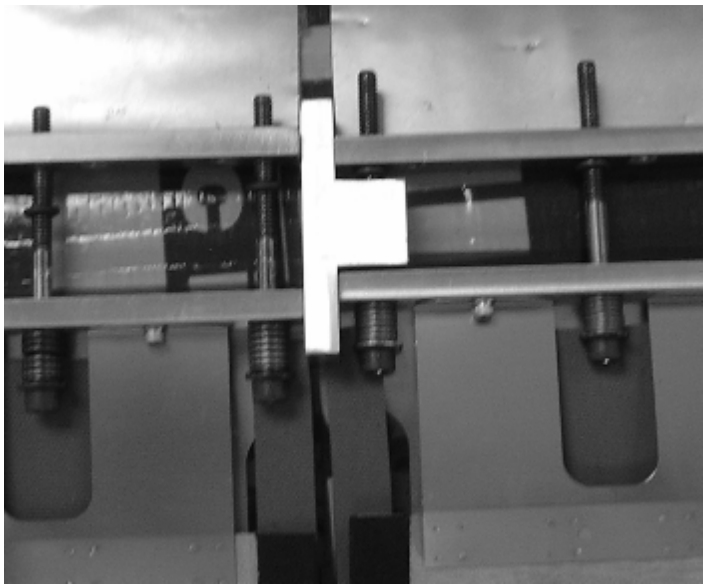


Figure 2-4: Temporary Spacer Tool Sets Dual-BAND gap

2.3.5.1 BAND Screw Tightening Instructions

The BAND screws use either a 7/64” (for #6 screw size) or 5/32” (for #10 screw size) hexagonal wrench (Allen key wrench). Refer to *Table 2-2* for size information. Start with the center most screw and tighten screws 3 - 4 turns at a time. **Important:** Alternate the sequence in which screws are tightened. Refer to *Figure 2-5* for the screw tightening sequence. **Note:** Repeat the tightening sequence only until the Belleville disc springs on the screws begin to compress. The BAND screw stack up assembly is illustrated in *Figure 2-6*.

Note: Ensure the Belleville washers do not stick to the screw threads.

The BAND screw size and number of Belleville washers can vary depending on sensor BAND size and pipe type.

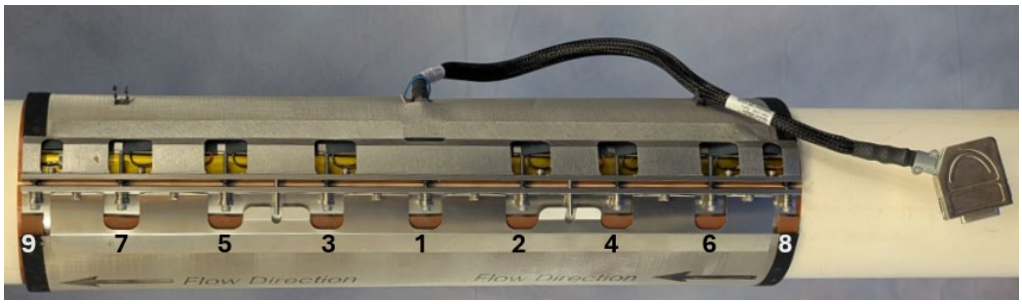


Figure 2-5: Sensor Band Screw Tightening Sequence

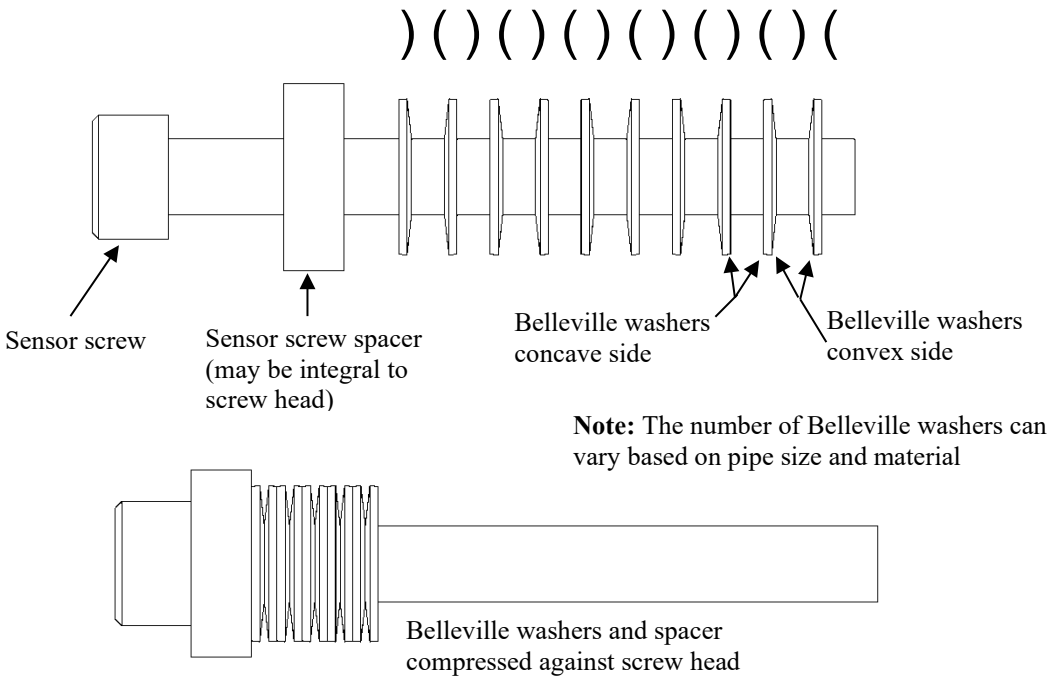
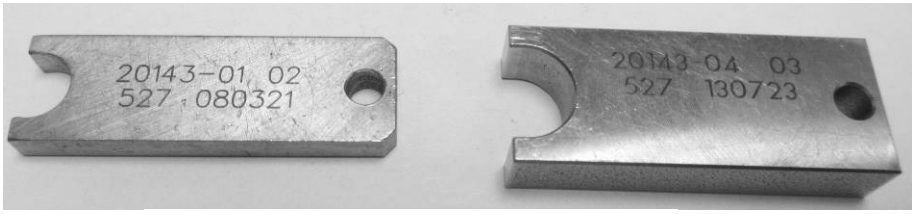


Figure 2-6: Sensor Band Screw Assembly

BAND Gap Gauge Tool P/N	Gap Size (Inch) ±.001	BAND		Belleville Washers			Socket Head Screw
		Pipe Diameter	Screw Assy Part Number	Number Of Washers	Stacked Free Height	Amount Of Compression	Hex Size
20143-01	0.165	2" - 4"	20592-01	10	0.23	0.065	#6 Screw, 7/64" Hex
20143-03	0.496	2" - 4"	20592-26	30	0.69	0.194	
20143-04	0.293	5" - 17"	20592-08	14	0.42	0.127	#10 Screw, 5/32" Hex
		18" - 36"	20592-06				
		38" - 60"	20592-06				
20143-08	0.627	5" - 17"	20592-12	30	0.9	0.273	#10 Screw, 5/32" Hex
		18" - 36"	20592-10				
		38" - 60"	20592-10				

Table 2-2: BAND Gap Tool Sizes

Further tightening of the screws is made while using the BAND gap gauge tool (shown below) furnished with the BAND. The gap gauge tool is used to set the compression on the Belleville washers referred to above. The gap gauge tool used is determined by BAND size and pipe material.



Most common sensor BAND gap gauge tools
P/N 20143-01 (left) and P/N 20143-04 (right)

Figure 2-7: BAND Gap Gauge Tool

Insert the BAND gap gauge tool over the Belleville washers on the middle sensor screw assembly and tighten the screw until it is snug but

the gap gauge tool can still be removed. *Figure 2-8* illustrates use of the BAND gap gauge tool. Alternate from screw to screw using the screw tightening sequence shown in *Figure 2-5*.

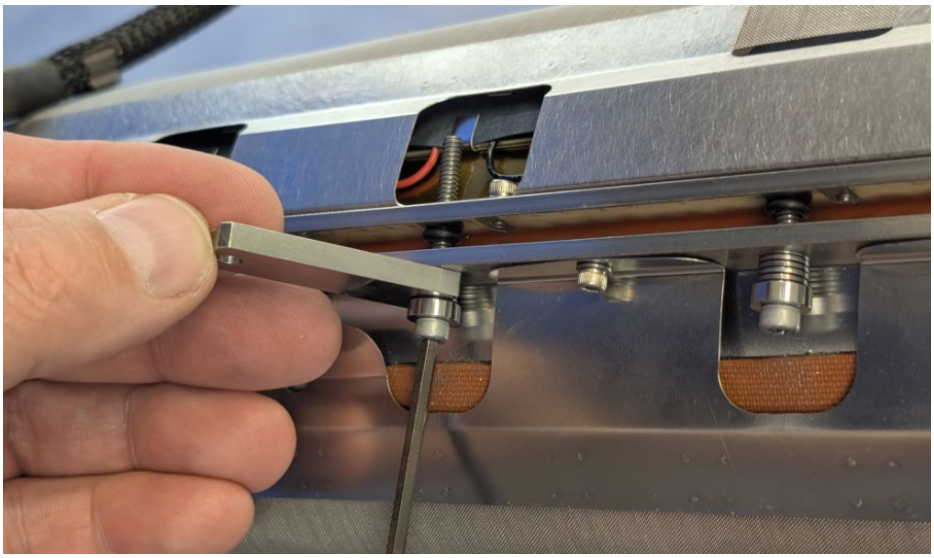


Figure 2-8: BAND Gap Gauge Tool Installed on Screw

Note: Ensure the gap gauge tool is perpendicular to the attachment rail to ensure proper tightness. Remove the tool, move to the next screw, and repeat the tightening on each of the screws.

Important: Tighten each screw once only. Do not retighten each screw using the BAND gap gauge tool.

Final BAND screw tightening is as follows:

A. For BANDs sized for 6" and smaller pipe:

1. Tighten screws #1 - 7 an additional one-half turn in the numbered sequence given in *Figure 2-5*. Do not tighten screw #8 & 9 (screws on either end of the BAND).

B. For BANDs sized for 8" and larger pipe:

1. Starting at screw #1 in *Figure 2-5*, tighten each screw an additional one-half turn in the given numbered sequence.
2. Once all nine screws have been tightened, tighten each screw an additional one-half turn in the given numbered sequence.
3. Once all nine screws have been tightened a second time, tighten screws #1 - 7 an additional one-half turn in the given numbered sequence.

C. For BANDs of any size installed on HDPE pipe

HDPE pipes are prone to increasing diameter with increasing temperature. The tightness of the screws should take into account the temperature at installation as well as the likely subsequent operating temperature range to prevent BAND breakage at high temperatures or BAND looseness and loss of sensitivity at low temperatures. The tightening advice above should be modified accordingly. For more guidance, contact Customer Support.

Attach the umbilical cable in the retaining clip on the top of the sensor BAND. The connector on this cable will attach to the MODULE connector as described later in the manual. The final BAND assembly is illustrated below.

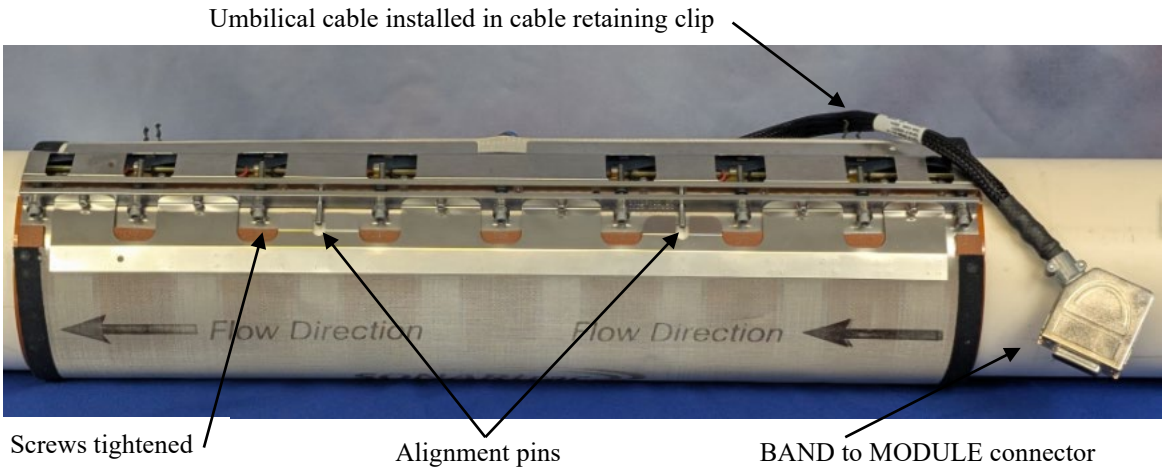


Figure 2-9: Installed BAND

	**CAUTION** **Over-tightening of fasteners may damage threads on the BAND. Under-tightening may affect SYSTEM performance. Always use the BAND gap gauge tool to ensure proper fit of the BAND.**
	**PRUDENCE** **Un serrage excessif des fixations peut endommager les filetages de la BANDE. Un serrage insuffisant peut affecter les performances du SYSTÈME. Utilisez toujours l'outil de jauge d'écart de BANDE pour assurer un bon ajustement de la BANDE.**

2.3.5.2 BAND Short Test

For performance reasons, the BAND is intended to be electrically isolated from the process pipe by the amber-colored polyimide film.

Use an ohm meter and verify the pipe is isolated from the BAND(s). Ensure there is no continuity between the BAND and the process pipe. If the BAND is shorted to the pipe, identify where the short is located and eliminate the short. For example, if a screw is shorting to a pipe weld bead, reposition the BAND, or file down the weld bead to eliminate the possibility of a short.

2.3.5.3 Mark Umbilical Cable Connectors of Dual-BANDs

Skip this section if there's only 1 BAND.

For the large diameter pipes with the 2 BANDs installed, look at the BANDs from a vantage point wherein the fastener attachment rails are at the "top" of the pipe (tilt your head if necessary). If the umbilical cables (which exit the BAND near the fastener attachment rails) are coming "toward you" (i.e. are exiting the BAND on "your side" of the fastener attachment rails), then the umbilical cable on the left is "A" and the one on the right is "B". If the umbilical cables (which exit the BAND near the fastener attachment rails) are going "away from you" (i.e. are exiting the BAND on "the other side" of the fastener attachment rails), then the umbilical cable on the left is "B" and the one on the right is "A". Use the adhesive labels from the small bag with the spacer tools to mark each connector appropriately.

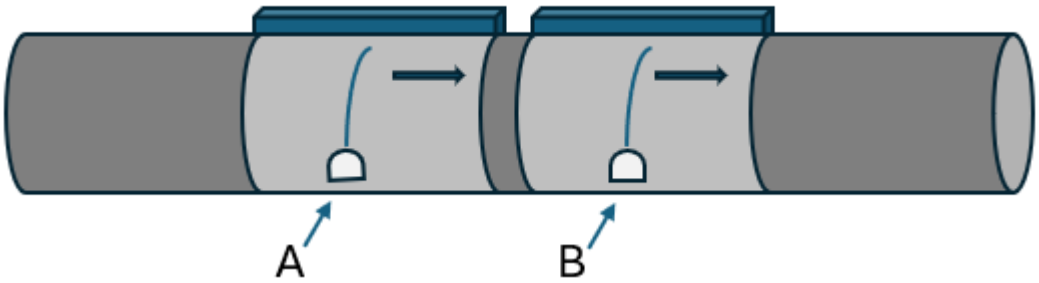


Figure 2-10: Dual Band Umbilical Identification

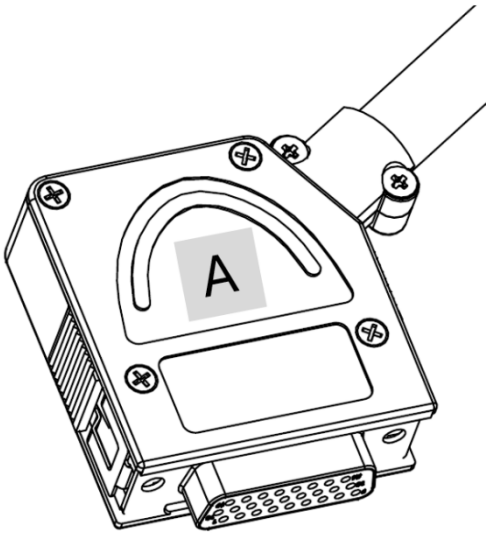


Figure 2-11: Dual Band Umbilical Marking

2.3.5.4 BAND Thermal Barrier Installation

The thermal barrier improves meter performance by minimizing time-varying temperature differences across the BAND. All thermal barriers include a slot for the BAND's umbilical cable and Velcro loops on each end for temporarily holding the D-sub connectors prior to pulling them through the access opening in the COVER to then attach them to the MODULE. When the thermal barriers are properly installed, those Velcro loops and the D-sub connector(s) will be near to the mounting rails (which should be at the top of horizontal pipes). Note that the orientation of the slot relative to the umbilical cable to achieve that proper installation varies with pipe size. Note that thermal barriers for large diameter pipes that require two BANDs will have two slots.

1. Align the slot(s) on the thermal barrier with the BAND umbilical cable(s) per *Figure 2-12* or *Figure 2-13*, below, according to the pipe size.
2. Wrap the thermal barrier over the BAND attachment rails.
3. Continue to wrap the thermal barrier around the BAND.
4. Seal at the Velcro strips and install the straps through the D-rings on the thermal barrier.
5. Retain the BAND umbilical cable(s) in the Velcro retention loop(s) on the end where the access opening in the installed COVER will be.

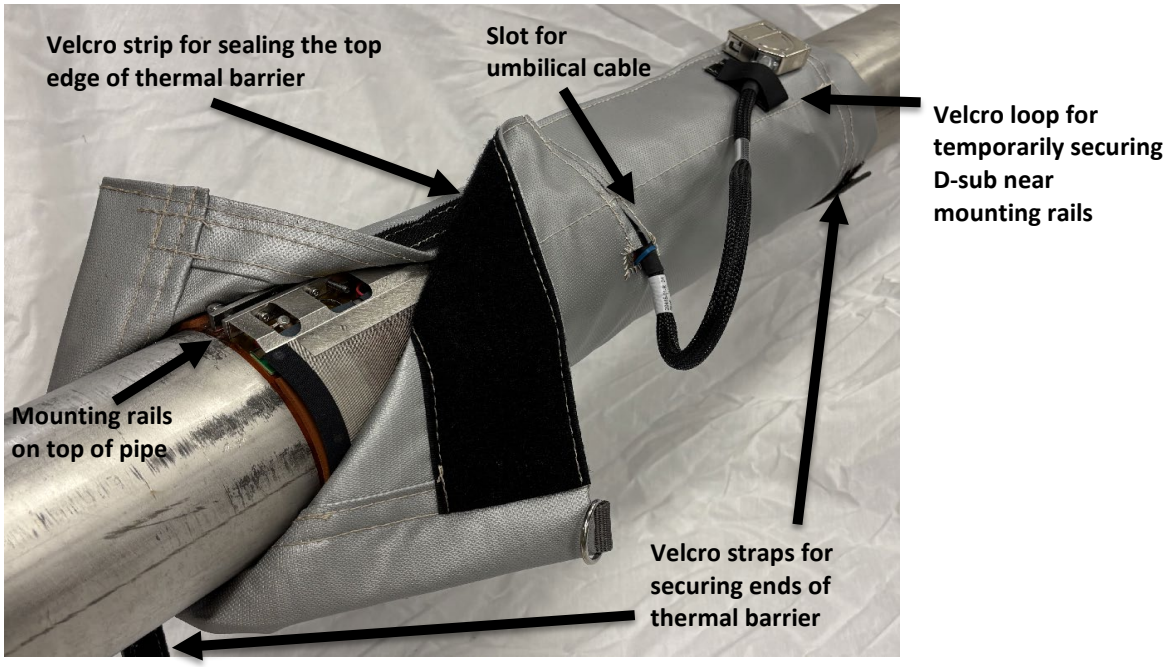


Figure 2-12: Thermal Barrier Installation over BAND - <6" and Dual-BANDs

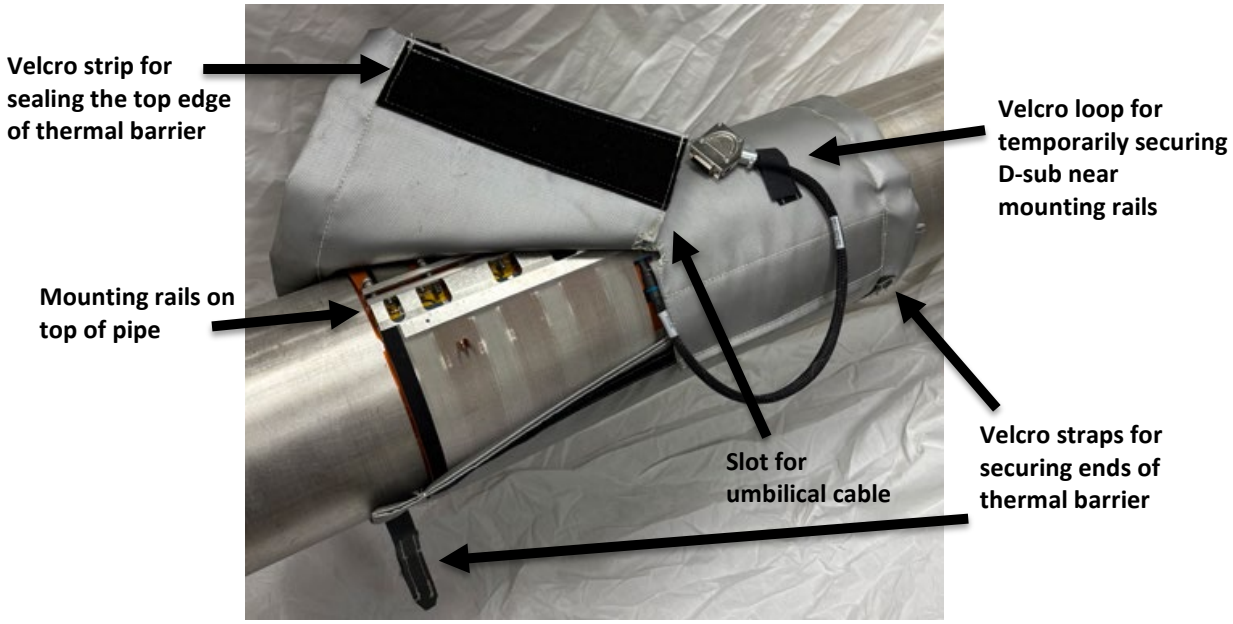


Figure 2-13: Thermal Barrier Installation over BAND - 6" to 30"

2.3.5.5 Install Y-cable for Dual BANDs

Skip this section if there's only 1 BAND.

With Dual-BAND SYSTEMs, a Y-cable assembly will have been provided.

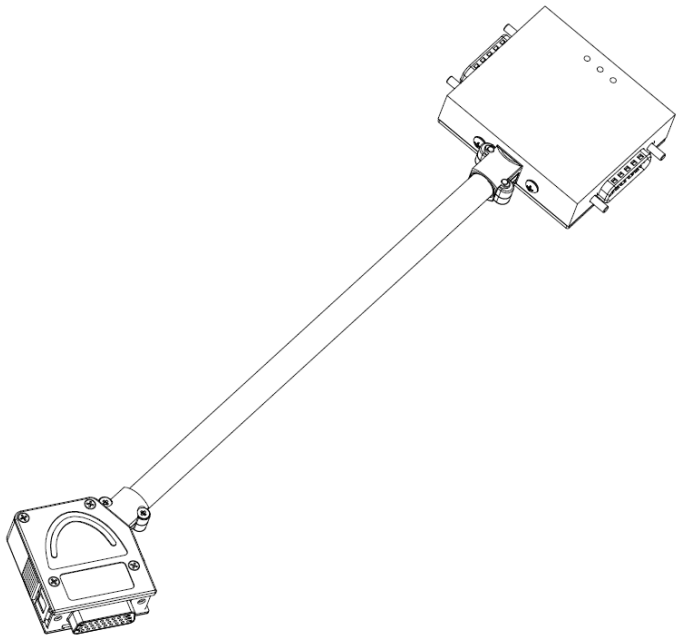


Figure 2-14: Y-cable Assembly

The Y-cable assembly is a small enclosure with 2 connectors – one marked "A" and the other marked "B" – along with a connectorized umbilical cable. The umbilical cable connectors of the two BANDS that were earlier marked with "A" and "B" should be connected to the similarly marked connectors in that enclosure. The connector of that connectorized umbilical should be retained by the Velcro straps nearest to where it will later be pulled through the opening in the COVER and connected to the connector in the bottom of the MODULE. For vertical installations, this should be the bottom-most Velcro location. See the instructional sheet included with the Y-cable assembly for how to route the three umbilicals and how to position and secure the Y-cable assembly so that it will best fit under the COVER.

2.3.6 COVER Installation

COVERs are made of fiberglass or stainless steel. The fiberglass COVERs are for smaller diameter pipes and are lighter and the clamshell halves are connected with tool operated latches and keepers. The stainless steel COVERs are for larger diameter pipes and are heavier and the clamshell halves are connected with bolts.

In both cases, for horizontal pipe installations, the COVER half with the MODULE should be the upper-most half of the clamshell. The length of the BAND's umbilical cable may prevent the MODULE from being at the highest point at the very top of the pipe, but the COVER should at least be oriented so that the MODULE is at or above the midline of the pipe.

The installation also requires separate clamps on the boot seals of the COVER to secure the seals on the two far ends of the mated clamshell halves to the pipe. For COVER sizes up to 6", that clamp is a Tee-bolt saddle clamp provided with the COVER. For pipe sizes greater than 6", that clamp is a length of stainless steel band with a pre-installed buckle fastener provided with the COVER which must be installed using a banding tool (BAND-IT® Model C00169, see www.band-it-idex.com, or equivalent) which is sold separately (CiDRA p/n 52511-01, or McMaster Carr p/n 5424K1).

CAUTION

Use of a BAND-IT® Model C00169 Banding Tool (or equivalent) is necessary for properly installing the stainless steel sensor covers. Failure to use this tool may void the warranty.

PRUDENCE

L'utilisation d'un outil de cerclage BAND-IT® modèle C00169 (ou équivalent) est nécessaire pour installer correctement les couvercles de capteur en acier inoxydable. Le fait de ne pas utiliser cet outil peut annuler la garantie.

The fiberglass COVERs are made only for standard ANSI pipe sizes but may be used on pipes and tubes with diameters between those standard sizes by using the next-larger fiberglass COVER size in conjunction with provided elastomer strips wrapped around the pipe to increase its diameter under the seal gaskets at the ends of the COVER. See further instructions below.

2.3.6.1 Diameters other than ANSI standard pipe sizes

Stainless steel COVERs are made to fit non-standard pipe sizes. This section of the manual is applicable only to fiberglass COVERs which are only made to fit standard ANSI pipe sizes. If the ordered SYSTEM acknowledged the tube size or the true non-standard pipe diameter, then it will have been delivered with lengths of adhesive-backed elastomer strips whose lengths and specially tapered ("skived") ends are custom-made for increasing the pipe diameter to accommodate the provided fiberglass cover.

Installation is as follows:

1. Clean the pipe/tube where the sensor head will be installed. The overall clean length should be at least 36 inches (91 cm).

2. Measure the overall length of the sensor cover from end seal to end seal and mark this distance on the pipe/tube.

3. Install the elastomer strips such that the outer edge of each strip aligns with the marks on the tube. Orient the elastomer strip so the paper covered adhesive will contact the pipe/tube. **NOTE:** For installation on vertically oriented pipes/tubes align the upper edge of the upper elastomeric strip ~1/8" (~3mm) above the line in step 2 above.

a. Remove the paper strips covering the adhesive.

b. Wrap the elastomer strip 3/4ths of the way around the pipe/tube. Pull it taut so it lies smoothly and evenly on the pipe/tube.

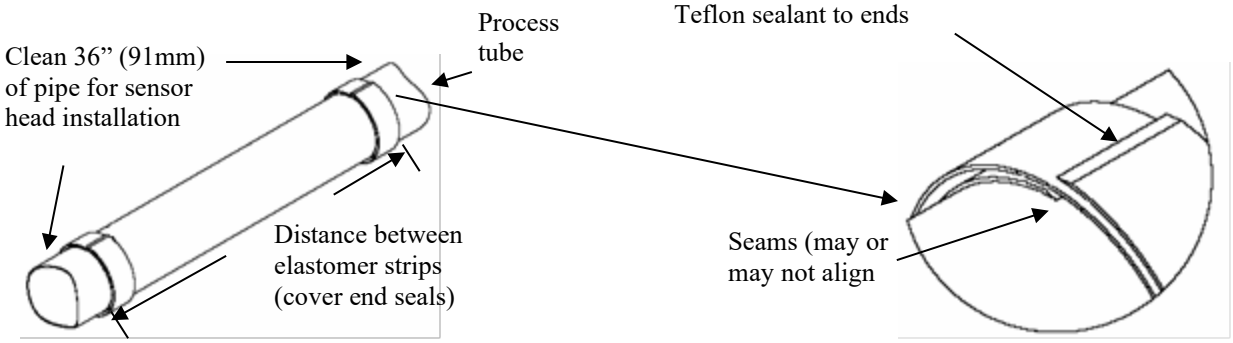
c. Apply a bead of the Teflon sealant (provided with the elastomer strip) to cover the top surface of the 2" (50mm) width of just the tapered end of the elastomer strip.

d. Continue to wrap the elastomer strip overlapping the previous layer, including that sealant-covered end.

e. Once the wrap is complete, apply a bead of the Teflon sealant to cover the top surface of the 2" (50mm) width of just the tapered end of the elastomer strip.

f. Install the second strip per the above steps.

Figure 2-15: Applying Elastomer Strips on Tubes and Non-standard Pipes



2.3.6.2 COVER Installation Procedure

Care must be taken during installation of the COVER to ensure the BAND’s umbilical cable does not become pinched between the COVER halves. If pinched, the problem may show up as a sensor failure during sensor tests and operation of the SYSTEM. This potential problem is most likely to occur in small size COVERs (<6 inch / <150 mm) due to the length and stiffness of the BAND cable.

It is strongly recommended that 2 or more persons be involved in COVER installations – especially for the heavier larger size COVERs, and especially for vertical installations.

There are two possible axial orientations of the top cover relative to the flow direction. Either the opening for the BAND umbilical is on the downstream end or on the upstream end. The SENSOR HEAD CABLE connector on the MODULE is on the opposite end from that opening and the cable exiting that right-angle connector will lay alongside that opening. For vertical installations, to avoid water ingress it is necessary that the cable connector point down. So, that opening in the cover wants to be on the lower end. For horizontal installations, there will probably be a preferred approach direction for the SENSOR HEAD CABLE and that should be taken into account. There are both “upstream” and “downstream” Velcro features in the thermal barrier to allow pre-positioning the umbilical cables such that they are accessible through the opening in the COVER. If the choice of COVER orientation is inconsistent with the earlier choice of umbilical pre-positioning, then re-position the umbilical before installing the COVER.

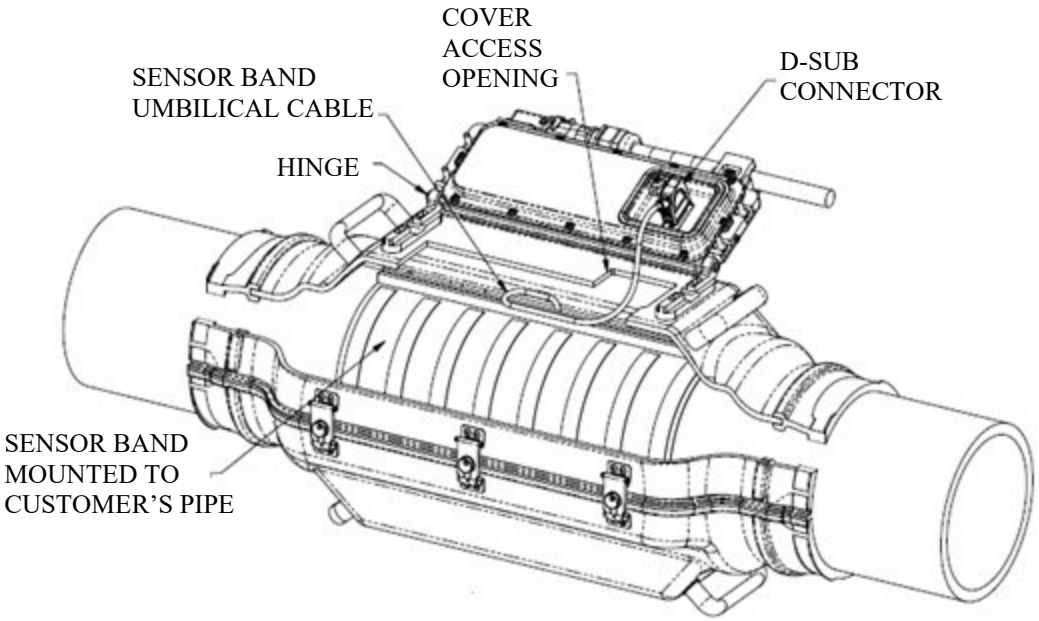


Figure 2-16: Breakaway View of Installed COVER

In some cases (typically fiberglass COVERs on pipes that are not standard ANSI pipe sizes) the COVER won't be sized exactly for the pipe OD (unlike the BAND – which MUST be) and instead will be oversized and require elastomer strips to be installed on the pipe to increase the effective OD to match the COVER size at the ends of the mated COVER clamshells and at their boot seals. Before attempting to install such COVERs, install the supplied elastomer strips at the correct locations and as described in 2.3.6.12.3.6.1 .

2.3.6.2.1 Horizontal Pipe Installation

COVER installation on horizontal pipes is as follows:

1. After the BAND(s) are installed, install the COVER's upper half (the half with the MODULE installed, or with the opening and the brackets for the MODULE if not installed) over the BAND(s) – generally centered on the BAND's rail. **Note:** Ensure the BAND umbilical cable's connector is accessible through the opening in the COVER underneath the MODULE. (If necessary, reposition COVER or cable connector.)
2. Install the COVER's lower half.
   a. For the fiberglass COVERs, hold the halves in place using the COVER's latches and strikes as the COVER halves are aligned.
   b. For the stainless steel COVERs, hold the halves in place with spring clamps or vise grips.
3. Align the COVER halves.
4. Secure the upper and lower COVER halves to each other.
   a. For the fiberglass COVERs, start at the center of the COVER and engage the latches and keepers using a ¾-inch wrench or socket to lock them together until all are attached.
   b. For the stainless steel COVERs, install and tighten the bolts at the flanges 1 – 2 turns. (The stainless steel COVER will have a fastener assembly consisting of a bolt with one washer and a serrated nut retained in the lower COVER flange.) Continue to tighten the bolts until the flanges bottom on the spacers integral to the flange and flange seal. This requires ~ 14.9 Nm (132 in-lb) of torque.
5. Install boot seal clamps
   a. For the fiberglass COVERs 6" and under that use the tee-bolt saddle clamp, wrap the tee-bolt saddle clamp around the boot seal. Locate the tightening bolt such that it is in-line with the MODULE on the upper cover half. Ensure the saddle clamp is located within the groove on the boot seal. Tighten the nut until the seal fits snug to the pipe. Repeat at the opposite end of the COVER.
   b. For fiberglass COVERs over 6", that use the band clamp, position the buckle on the band of the COVER so it is in line with the handles of the upper COVER half in the groove on the boot seal. Wrap the band around the boot seal and pass the end through the buckle on the band. Wrap the band around the boot seal a second time and pass it through the buckle. Pull the band taut and tighten the set screw to hold the band in place. **Note:** Ensure

the band is aligned within the grooves on the boot seal and the second wrap of the band is directly over the first wrap.

Install the BAND-IT® Model C00169 tensioning tool by inserting the band through the cutter bar and slide lock.

Note: This tool is asymmetric. The tool will pull in opposite directions when installed on opposite ends of the cover. The cutter handle (positioned either up or down) on the Model C00169 is located outboard with respect to the cover end, when the tool is properly installed. *Figure 2-17* illustrates proper installation of the tool.

Figure 2-17: BAND-IT® Model C00169 Tool Use

Verify the band is still aligned within the grooves on the boot gasket and over the first wrap of the band, and the band buckle is positioned in line with the COVER handle.

Loosen the set screw and then tension the band until the resistance on the tool handle is constant (i.e. the band does not slide easily through the buckle). The boot seal should be tight against the process pipe. Verify the band is in the boot seal groove. Tighten the band set screw to lock the band in place. The band will be dimpled by the set screw.

Figure 2-18: Boot Seal Clamp Tightened

Once the set screw has been fully tightened, loosen the tensioning tool and bend the tool and band up and over the

buckle. It is not necessary to cut excess band material (allows for re-tightening of the band if necessary). Place a reverse bend on the end of the band clamp as a safety measure using needle nose pliers. If pliers are not available, *F*igur*e 2-21* shows an example of bending the band strap over a second time with the edge directed back in towards the buckle.

Figure 2-19: BAND-IT® Tool Bending over Retaining Clip

Repeat the band installation procedure for the opposite end of the cover.

Figure 2-20: Band Clamp Final Installation

Figure 2-21: Alternative Band Clamp Final Installation

Note: Do not cut the end of the metal band.

c. For the stainless steel COVERs, apply a coating of the blue Joining Compound (comes in the Installation Kit) as shown in *Figure 2-22* onto the section of flange seal over the 2.35” (60mm) length where it covers the boot seal.

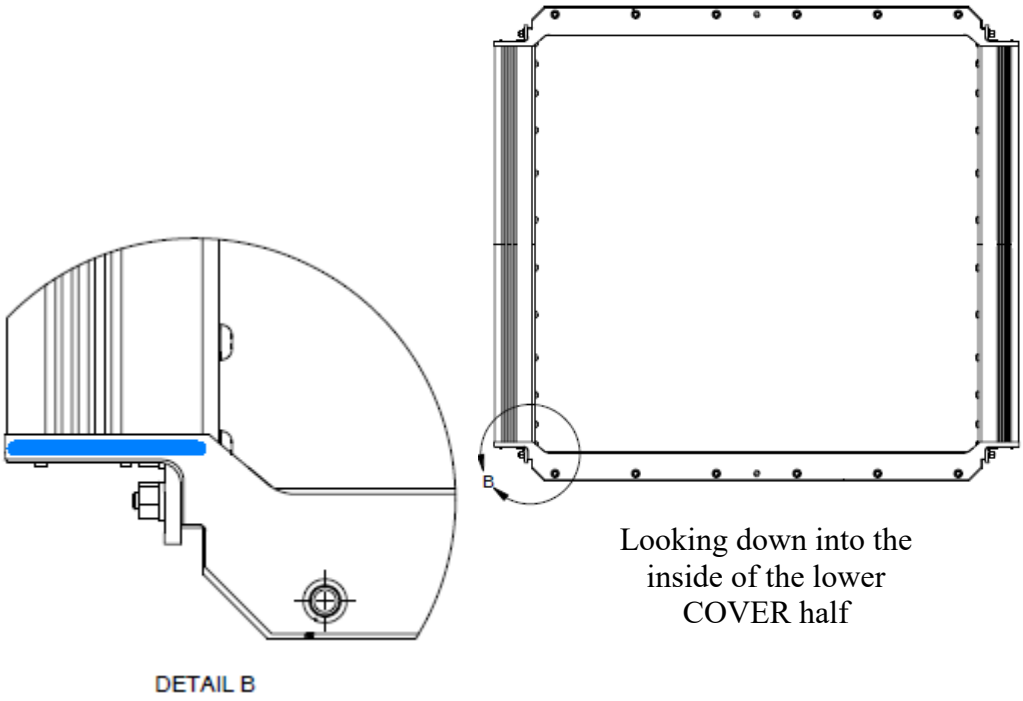


Figure 2-22: Joining Compound Applied to Seal of SS Cover

Do the same in the 3 other similar areas. Press the upper boot gasket and Joining Compound coated lower seal edges together.

Note that the band clamp installation instructions for the band clamp boot seals on the stainless steel covers are the same as the instructions for the band clamp boot seals for the fiberglass covers in “b”, above, with the exception of the requirement for 2 added splice protector plates on each end and also positioning the buckle over an existing seal protector plate.

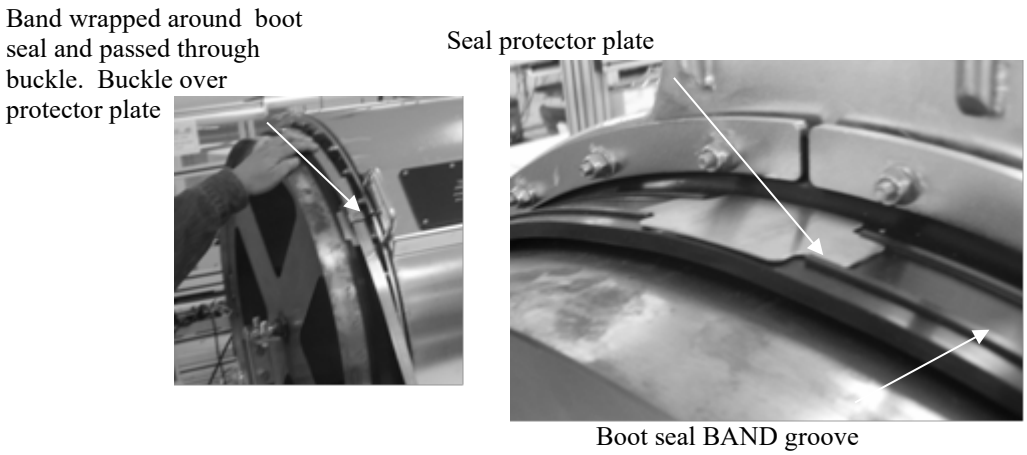


Figure 2-23: Boot Seal Band Installation

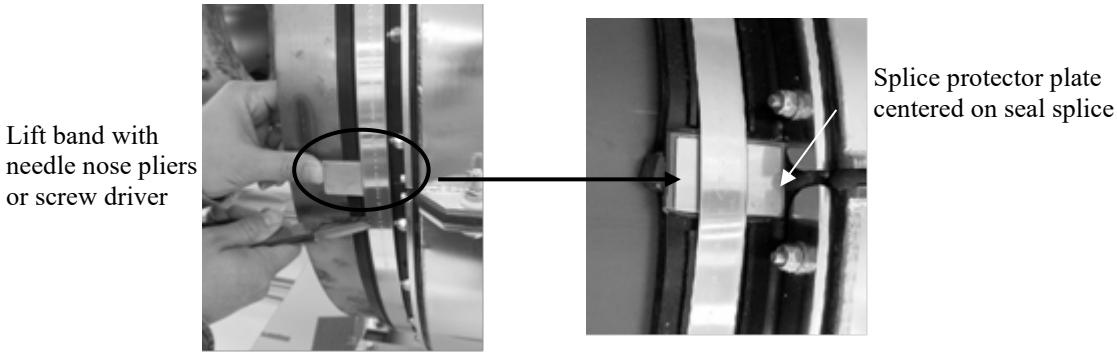


Figure 2-24: Splice Protector Plate Installation

When starting the process, position the buckle on the band over the seal protector plate located on the top of the upper cover outboard of the handles. **Note:** When installation is complete the buckle must be positioned on the protector plate to protect the seal from being damaged.

After looping the band through the buckle twice and before tightening the set screw, install the splice protector plates (centered on the seal splices) by lifting the band using needle nose pliers or a screwdriver, and slide the plates (2 per end) into position over the flange gasket. Pull the band taut. Tighten the socket head set screw on the band buckle just enough to keep the band in place but loose enough so the band will still slide through the buckle.

Continue with the rest of the band tightening process as in “b”, above.

2.3.6.2.2 Vertical Pipe Installation

The accuracy of the flow meter relies on assumptions of a full pipe and a uniform flow rate along the length of the meter. For vertical installations, these conditions are assured by choosing an installation location with the flow direction pointing up.

Vertical installations require 2 people. Vertical installation is much like horizontal pipe installation, but there is an additional MODULE orientation preference, and that is to have the MODULE connector for the SENSOR HEAD CABLE pointing down. For the other COVER clamshell half, the orientation should be such that the drain/vent is on the lower end of that half. Vertical installation is also trickier because both halves (not just the “bottom half”) needs to be supported during the mating of the COVER’s clamshell halves and the combined halves need to be supported during the operations to clamp their boot seals to the pipe. Note that the upper boot seal should be installed before the lower boot seal. Failure to provide adequate support during installation risks physical injury due to falling items and also risks damage to the equipment. Failure to properly install and tighten the components to the pipe such that the COVER later begins to slide down the pipe risks damage to the BAND.

Contact Customer Support for additional guidance on vertical installations.

2.3.6.3 Install MODULE on COVER

If the MODULE was installed on the COVER prior to the COVER being installed on the pipe, then skip this section. If the MODULE was not pre-attached to the COVER, remove it from its shipping box (a smaller box likely inside the larger box with the COVER). The MODULE connects to the COVER in two ways – (1) There are 4 retained bolts that are part of the MODULE that secure it to tapped holes in the mounting blocks that are part of the COVER; (2) There is a hinge assembly featuring 2 spring-loaded hinge pins that retains the MODULE onto the COVER even when those 4 retained bolts are not fastened. They allow the MODULE to be pivoted out of the way of an access opening in the COVER to allow the umbilical cable connector of the BAND to be attached to the mating connector in the bottom of the MODULE.

First tip one end of the MODULE to line up the spring-loaded hinge pin with the hole in the mounting block on one side and insert that hinge pin into that first mounting block. Then depress the spring-loaded hinge pin on the other end of the MODULE with your finger so that it can fit within the inside edge of the second hinge block. Then pivot that end of the MODULE until the spring-loaded hinge pin snaps into place in the hole in this second mounting block.

Should it ever become necessary to remove the MODULE from the COVER, first loosen the 4 retained bolts so that the MODULE is retained only by the spring-loaded hinge pins. Then depress one of the hinge pins with an appropriately thin tool by way of the through-holes in the hinge blocks and then pivot the DSE to free up that hinge pin. Then slide the other hinge pin out of the hole in the other mounting block.

Note that there is a gasket on the bottom of the MODULE for sealing around the access opening in the COVER. Prior to securing the MODULE to the COVER with the 4 bolts, assure that that gasket is undamaged and that it and the mating surface on the COVER are clean such that a good seal is assured.

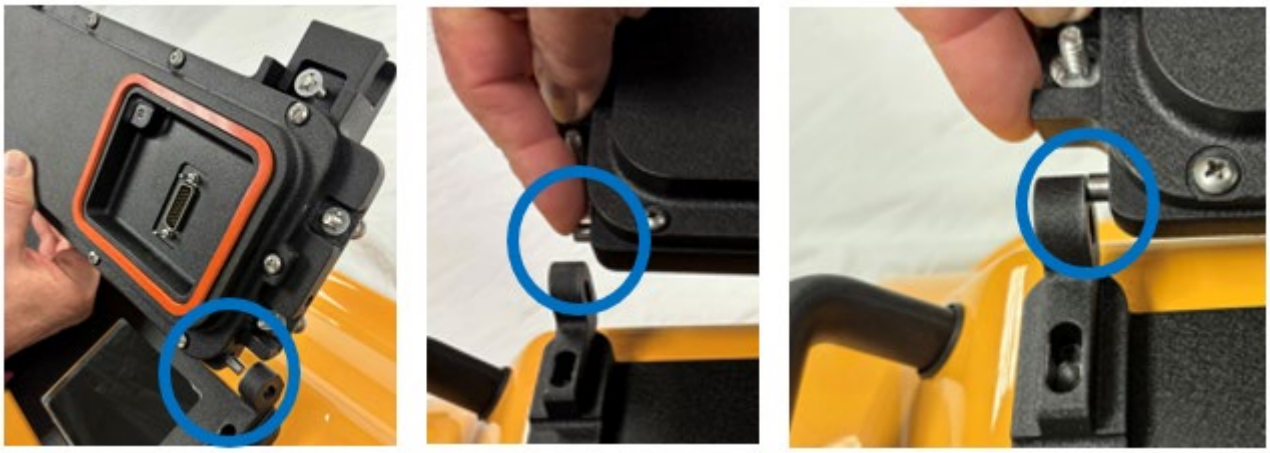


Figure 2-26: Installing the DSE MODULE on the COVER

Figure 2-25: Removing the DSE MODULE from the COVER

2.3.6.4 Adhere BAND label to MODULE

Take one of those Sensor Band Assembly labels discussed in Section 2.3.4, above, and adhere it to the MODULE in the location indicated by the arrow (just above the similarly sized MODULE model number label).

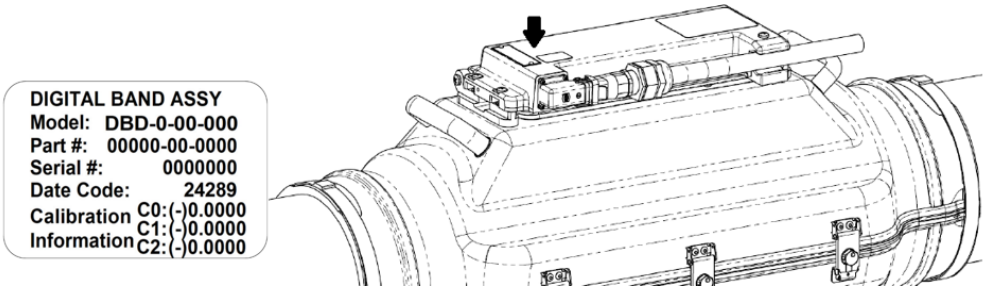


Figure 2-27: Adhere BAND Label onto MODULE just above the MODULE Label

2.3.6.5 BAND Umbilical Cable Connection

Loosen the 4 captive bolts securing the MODULE to the COVER. The MODULE should be retained by a hinge that allows the MODULE to be pivoted out of the way of an access opening in the COVER and to also expose the D-sub connector(s) on the bottom of the MODULE. Reach into the access opening and retrieve the D-sub end(s) of the BAND's umbilical cable(s). If the earlier instructions were followed, the D-sub connector end of the umbilical cable will be temporarily secured on the thermal barrier right inside the access opening where it can be easily freed from the Velcro and then plugged into the mating connector on the bottom of the MODULE. For pipe sizes 36" and under, 8-channel BANDs will have a single umbilical. For pipe sizes above 36", there will be two BANDs each with a single umbilical, but a Y-cable will combine those 2 umbilicals into a single umbilical to connect to the MODULE. Connect the umbilicals to the mating D-subs according to the markings on each as to which is the upstream versus downstream BAND.

Orient the D-shapes of the 2 D-sub connectors so that they will mate properly when pushed together. As they are pushed together, the Quicklock posts outboard of the male D-sub will enter the corresponding holes in the backshell with the female D-sub and when fully mated, the retention mechanism on both sides of the D-sub backshell will click into place as they lock into the notches in the Quicklock posts. The retention mechanism is shown in *Figure 2-28.*

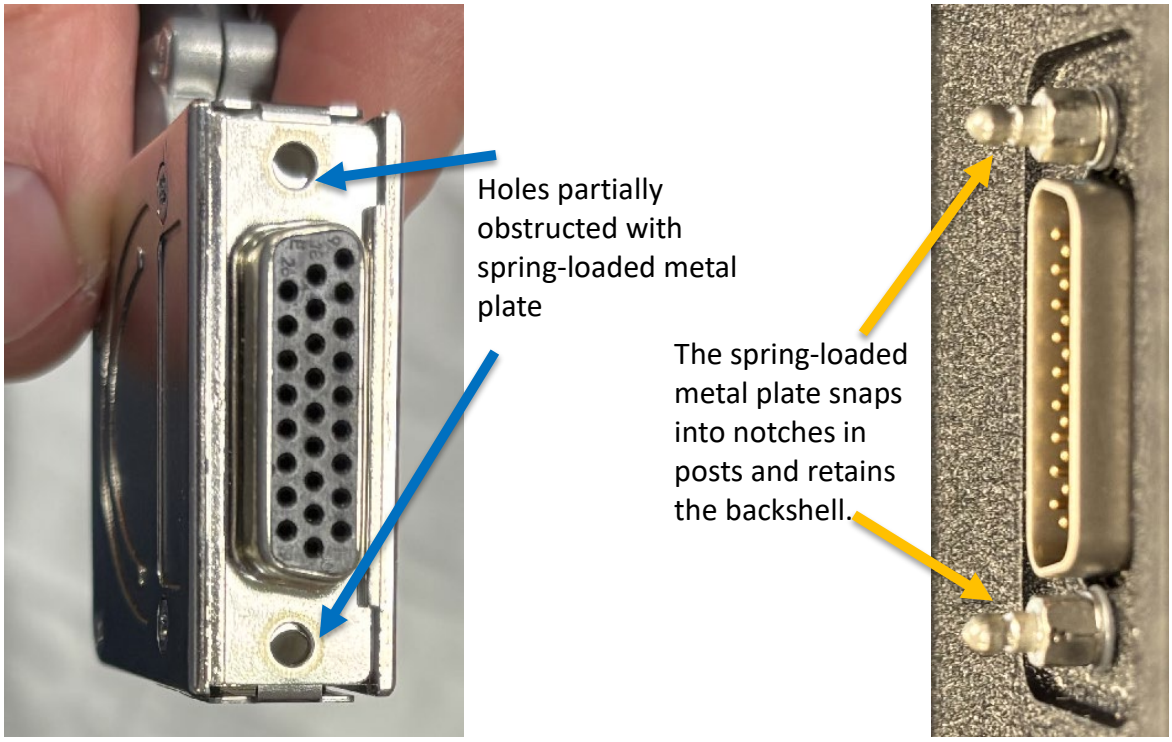


Figure 2-28: Mating of D-sub connectors

If it should become necessary to subsequently de-mate the D-sub connectors, push inward on both far edges of the D-sub backshell simultaneously near the edge closest to the mating connector to release the Quicklock posts so that the umbilical D-sub connector can be withdrawn. See *Figure 2-29.*

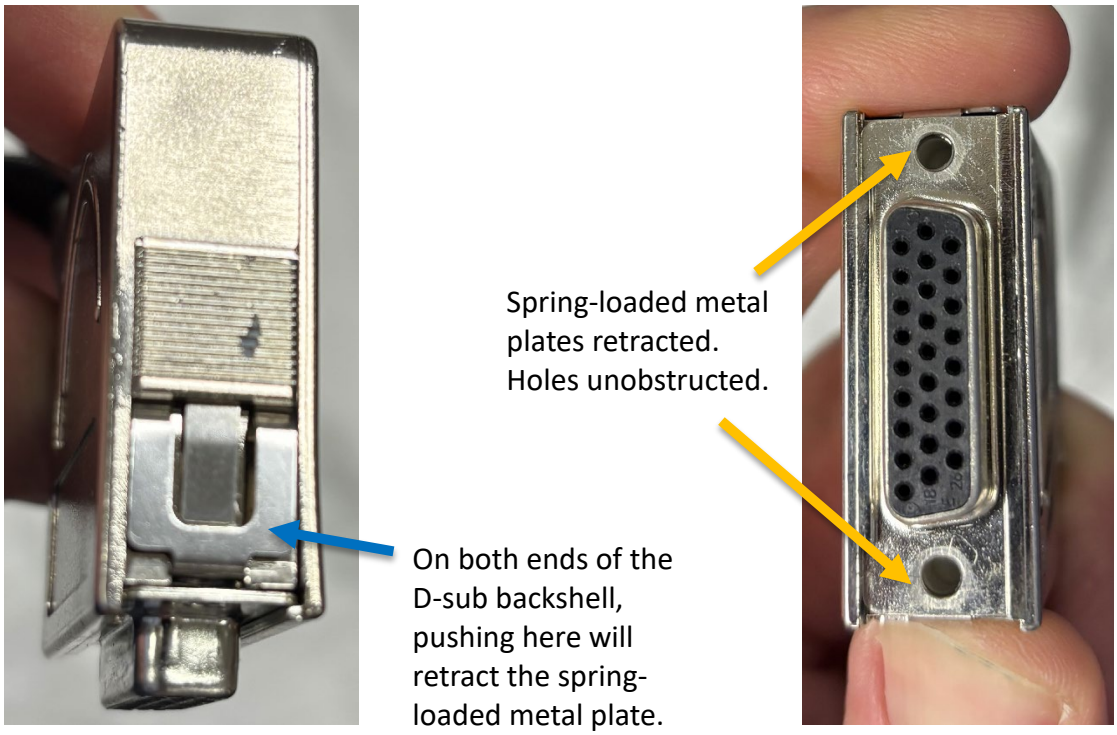


Figure 2-29: De-mating of D-sub connectors

FOR DUAL-BAND INSTALLATIONS, IT IS IMPORTANT THAT THE BANDS BE CONNECTED INTO THE PROPER D-SUBS OF THE Y-CABLE. THERE IS NO SOFTWARE CORRECTION FOR AN IMPROPERLY CONNECTED Y-CABLE.

After the BAND(s) are connected to the MODULE, re-tighten the 4 captive bolts to secure the MODULE to the COVER. It is necessary to fully tighten those bolts to compress the gasket on the bottom of the MODULE that environmentally seals around the access opening in the COVER. A torque of ~5.2 Nm (46 in-lbs) is required. A recess in the bottom of the MODULE prevents over-compressing the gasket.

2.3.6.6 Safety Issues of Improper SENSOR HEAD Installation

Failure to follow the instructions in the manual can lead to sub-optimal flow measurement performance or in some cases damage to the SENSOR HEAD.

There are virtually no ways in which improper installation of the SENSOR HEAD components could cause a safety hazard to personnel

(fire or electric shock) owing to the low voltages, current, and power going from the TRANSMITTER to the SENSOR HEAD.

2.4 SENSOR HEAD CABLE Installation

The SENSOR HEAD CABLE (from MODULE to TRANSMITTER) is used to transmit sensor signals & information and provides electrical power to the MODULE. Unarmored and aluminum-interlocked-armor cables are available. The weight of the unarmored and armored cables is nominally 175 and 320 lbs per 1000 ft (260 and 476 kg per km), respectively.

The SENSOR HEAD CABLE is furnished with a connector pre-attached to the MODULE end. Enough slack should be allowed at the SENSOR HEAD end to allow for connection/disconnection. The connector on the SENSOR HEAD CABLE will have a connector cover installed and retained with a lanyard. Leave this connector cover installed while the SENSOR HEAD CABLE is being laid and until it is time to connect it to the connector on the MODULE.

It is required that a sufficient length of SENSOR HEAD CABLE has been purchased to make the connection between the MODULE and the TRANSMITTER along the chosen path for laying the SENSOR HEAD CABLE and accounting for the approach directions and service loops and drip loops all in a single length. Splicing additional lengths of SENSOR HEAD CABLE to add to the length is not permitted. For Ordinary Locations, cables up to 500 feet long (152 meters) are available and will provide full performance. Contact Customer Support if longer cables are required.

2.4.1 Laying the SENSOR HEAD CABLE

When laying the connectorized SENSOR HEAD CABLE, put the connector end of the SENSOR HEAD CABLE nearest the MODULE and the exposed wire end nearest the TRANSMITTER. Provide for the bulk of the excess length to be at the TRANSMITTER end where it can be cut off, if required, but be certain to leave enough service length near the MODULE to account for the proper direction of approach, and the ability to install and uninstall the connector, and to clamp the SENSOR HEAD CABLE into the MODULE’s cable clamp without applying tension or twisting or side loads to the MODULE. Also, account for enough SENSOR HEAD CABLE to get to another cable clamping location not associated with the MODULE or COVER and not far from the MODULE

to prevent the weight or stiffness of the SENSOR HEAD CABLE from putting loads on the MODULE or its connector. Do not connect the SENSOR HEAD CABLE to the MODULE until after the SENSOR HEAD CABLE is fully laid and secured, including the securing of the TRANSMITTER end of the SENSOR HEAD CABLE and that end brought into the TRANSMITTER and the associated cable gland tightened.

Lay the SENSOR HEAD CABLE according to local electrical codes with consideration for any required use of cable trays or conduit, requirements for isolating cables carrying signals of different types, requirements for securing of cables at multiple locations, etc. The minimum bend radius of the unarmored Y67688 SENSOR HEAD CABLE is 5.6” (142mm), and that of the armored Y67689 SENSOR HEAD CABLE is 11.53” (293mm). When pulling the SENSOR HEAD CABLE, consider the maximum pulling tension. The maximum pulling tension (conductors only) of both the unarmored Y67688 and armored Y67689 SENSOR HEAD CABLE is 111 lbs (494 Newtons). Also, the temperature ratings of both the unarmored Y67688 and armored Y67689 SENSOR HEAD CABLE is 105°C (221°F), so don’t allow the SENSOR HEAD CABLE to contact anything (such as the process pipe) whose temperature can ever exceed that maximum temperature rating. Note that both the unarmored Y67688 and armored Y67689 SENSOR HEAD CABLE are type PLTC-ER (“exposed run”) marked for sun resistance, oil resistance, and direct burial.

At the TRANSMITTER end of the SENSOR HEAD CABLE, find a way to safely stow and secure the excess SENSOR HEAD CABLE length, if allowed. This end of the SENSOR HEAD CABLE is typically prepared for wiring into the terminals of the TRANSMITTER (jacket, fillers, and shields removed, and drain wires accessible). Those wires are ready to be cut shorter (if required), stripped, and inserted into terminals. If excess SENSOR HEAD CABLE length is required to be cut off, first take photos of the way that the SENSOR HEAD CABLE end was prepared so that the same can be done after the SENSOR HEAD CABLE is shortened. The unarmored SENSOR HEAD CABLE assemblies typically are shipped with a loose cable gland to be used at the center cable entry hole in the TRANSMITTER for the SENSOR HEAD CABLE, while the armored SENSOR HEAD CABLES are typically shipped with the cable gland already installed. If it is necessary to shorten the armored cable, it can first be cut to length with a hacksaw and then after removing the outer jacket for a length corresponding to the wire length to be exposed, use an armor cutter such as Roto-Split® to cut the armor near the new end of the outer jacket and then twist off the short length of exposed armor. Prepare the wires as before, then follow the gland manufacturer’s

instructions for installing the gland in the enclosure and the cable into the gland. If re-using the gland that the armored cable came with, it is p/n TMC075NB from CMP Products (www.cmp-products.com). For that gland, the installation instructions say to also remove 1" (25mm) of the outer jacket from the cut end of the armor. The SENSOR HEAD CABLE must enter the TRANSMITTER from the bottom and the SENSOR HEAD CABLE must be secured nearby to prevent pulling, twisting, and side loads being transmitted to the TRANSMITTER enclosure or to the wires in the terminals. Make sure that the glands are properly installed in the TRANSMITTER to maintain its Ingress Protection rating. Ultimately, the wires of the SENSOR HEAD CABLE get wired into certain TRANSMITTER terminals, but that is covered in section 2.5.6.3.

2.4.2 Connecting the SENSOR HEAD CABLE to the MODULE

When the SENSOR HEAD CABLE has been fully installed (and, ideally, when the power to the TRANSMITTER is off), then connect the SENSOR HEAD CABLE to the MODULE. Make sure that both connectors are clean and dry before mating. Align the key with the keyway, mate the connectors, and use the locking lever to latch it in place.

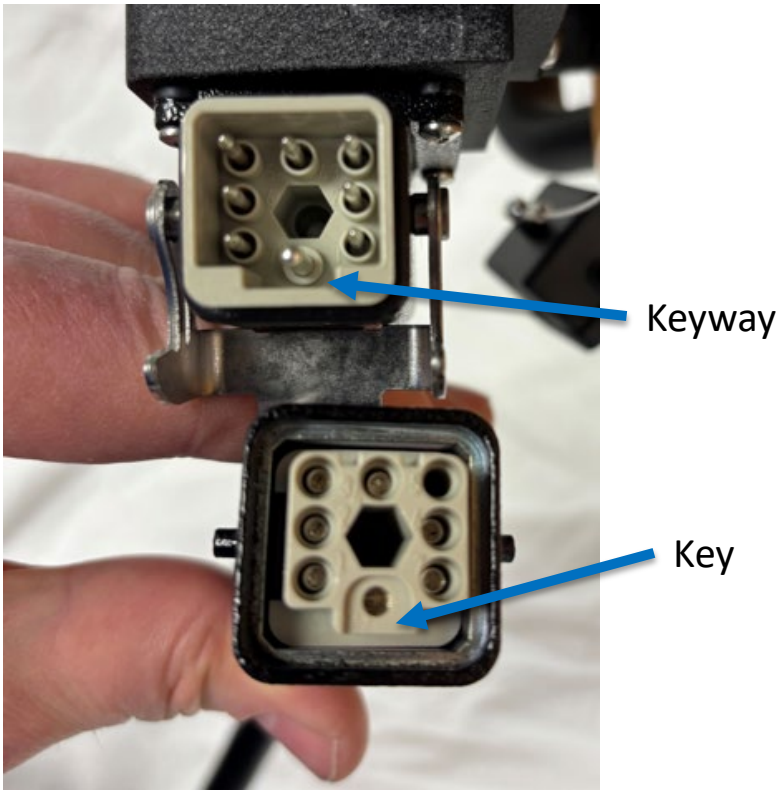


Figure 2-30: Keys and Keyways in SENSOR HEAD CABLE Connectors

After the connectors are mated, tighten the cable retention jaw on the side of the MODULE by turning the #2 Phillips head bolt on top until the SENSOR HEAD CABLE is snugly held, but not so tight that it is crushed. Note that if later it is necessary to disconnect the SENSOR HEAD CABLE from the MODULE, it may be necessary to first loosen the cable retention jaw before de-mating the connectors.

Secure SENSOR HEAD CABLE in the strain relief feature attached to the side of the MODULE. Using a #2 Phillips screwdriver, tighten the bolt for the movable jaw enough to grip the cable firmly without crushing it. This will help prevent the SENSOR HEAD CABLE from twisting or pulling on the connector.

Figure 2-31: Cable Strain Relief Jaw and Tightening Bolt on MODULE

Connector covers are provided on both the SENSOR HEAD CABLE and MODULE. Remove them prior to connecting the SENSOR HEAD CABLE to the MODULE and attach them to each other as shown in *Figure 2-32*. Use them to protect their respective connectors when the connectors are not mated. Make sure the insides of the connector covers are clean and dry before connecting them to the connectors.

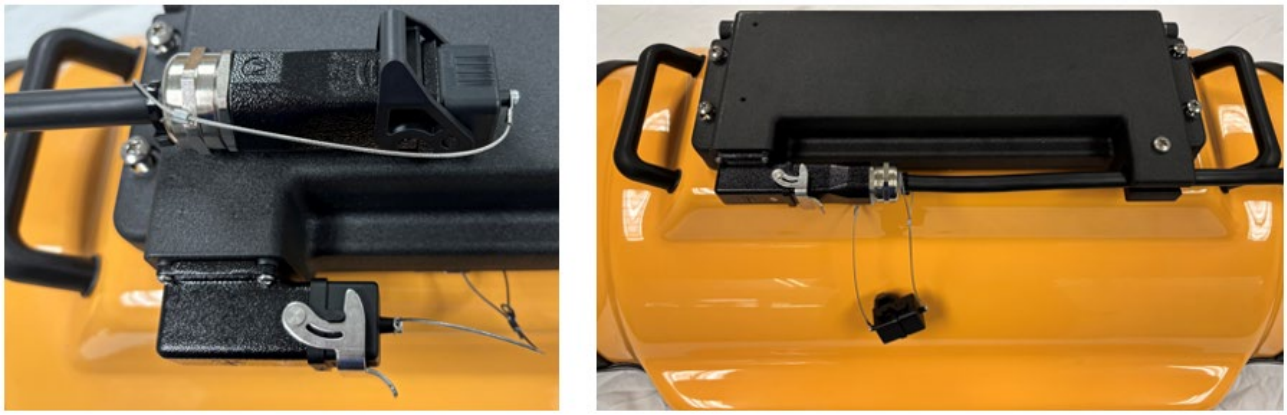


Figure 2-32: Use of Connector Covers – De-mated and Mated connectors

2.5 TRANSMITTER Installation

Do not apply power until the TRANSMITTER is fully installed and the wiring to all of the terminals (power and I/O) is complete and the sub-compartment covers over each set of terminal blocks is closed and secured. Disconnect power again prior to subsequent changes to the terminal block wiring.

2.5.1 Preparation

Prior to installing the TRANSMITTER, consider the available power, the ambient temperature, and whether it is to be wall mounted or pole mounted. If the markings on the TRANSMITTER received are not consistent with the conditions of the area in which it must be installed, contact Customer Support.

If this is an AC-powered TRANSMITTER, the SYSTEM installation should include a marked and appropriately rated switch or circuit breaker within close proximity of the TRANSMITTER and within easy reach of the operator. The function of this switch is to provide a safe means for power to be removed from the TRANSMITTER. The TRANSMITTER must not be installed in a position that makes it difficult to operate the switch or breaker.

An overcurrent protection device must be used in the SYSTEM in the lines powering the TRANSMITTER and should be chosen in accordance with local electrical codes based on the wiring and the load. The TRANSMITTER's Power Entry board includes replaceable 3.15A time delay fuses.

2.5.2 TRANSMITTER Power Requirements

The AC version of the TRANSMITTER can accommodate an input voltage of 100 – 240 volts AC, 50/60 Hz, and requires 25 watts of power.

The DC version of the TRANSMITTER can accommodate an input voltage of 18 – 35 volts DC and requires 25 watts of power.

The certification label on the right-hand side of the exterior of the TRANSMITTER enclosure specifies the allowed input voltage. A fuse sticker on the exterior of the cover over the terminal compartment for the power connections also indicates whether this is an AC or DC-powered TRANSMITTER. Applying AC power to a DC TRANSMITTER may cause permanent equipment damage.

2.5.3 TRANSMITTER Mounting Instructions

The TRANSMITTER should be mounted with the plane of the display oriented perpendicular to the ground and with the cable entry holes pointing down.

The TRANSMITTER is furnished with a Bulkhead (wall or panel surface mount) Installation Kit. An optional Pole Mounting Kit is also available.

The maximum available SENSOR HEAD CABLE length is typically 500 feet (152 meters). The SENSOR HEAD location and the actual SENSOR HEAD CABLE length limit the choices for TRANSMITTER location.

Select an installation location that allows for easy and safe access to the TRANSMITTER. Ensure the local ambient temperature range is within the operating temperature limits of the TRANSMITTER. Avoid locations with extreme vibration and locations that are subject to extreme water conditions (for example, direct hose-down).

2.5.3.1 Bulkhead Mounting

The TRANSMITTER is attached to the bulkhead or panel with user supplied 1/4-inch (M-6) fasteners through the four panel mounting feet on the TRANSMITTER.

2.5.3.2 Pole Mounting

The optional Pole Mount Kit is designed to allow for mounting the TRANSMITTER to poles up to 10-inch (254 mm) diameter and equivalent sized I-beams. (Additional lengths of clamps can be added for larger diameter poles and I-beams. Please contact your local distributor or Customer Support for more information.) The kit consists of two mounting rails, two worm-drive hose clamps, and fasteners. Each mounting rail has 4 sets of holes and 2 clevis pins, each clevis pin with a spring-loaded wedge for retention which can be depressed to remove the clevis pin and relocate it to a different hole.

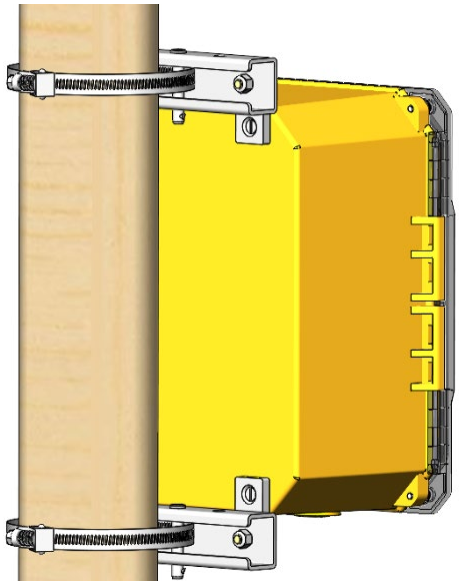
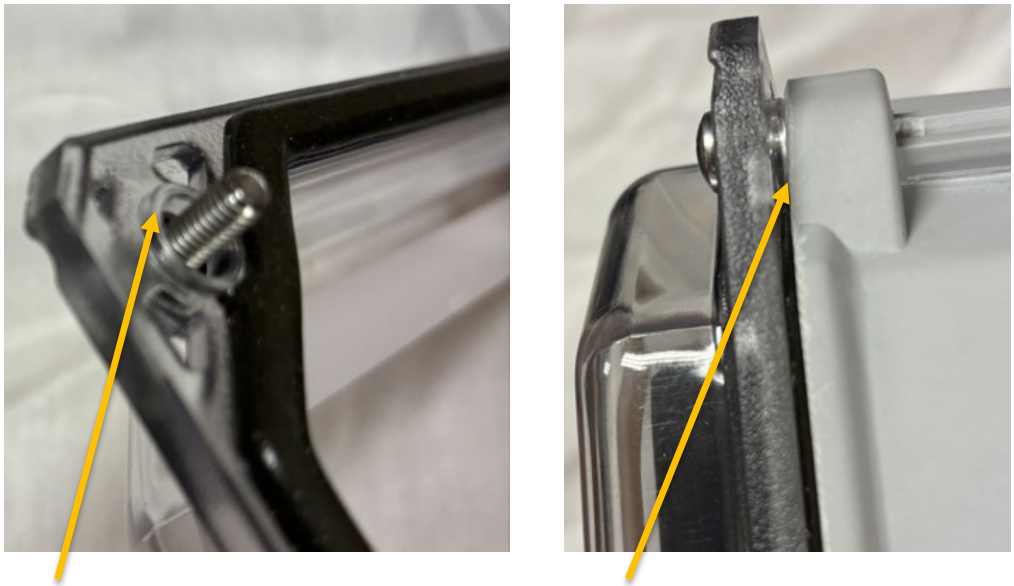


Figure 2-33: Pole Mount Kit

For each mounting rail, move the clevis pins to the inner-most or outer-most pair of holes according to pole diameter. Attach the mounting rails to the panel mounting feet using the 1/4-20 x 3/4” screws and locknuts supplied with the rails. Then for each mounting rail, slide one worm-drive hose clamp behind the pair of clevis pins, wrap the hose clamp around the pipe, and use the worm drive to tighten it onto the pole. Cut off unwanted excess hose clamp length.

2.5.4 TRANSMITTER Enclosure's Hinged Door

The TRANSMITTER's hinged door must be securely tightened in order to ensure a proper seal. The TRANSMITTER comes with 4 screws (retained with o-rings at the 4 corners of the door) for securely sealing the door. The TRANSMITTERs for use in Ordinary Locations also come with a loose pair of latches and an instruction sheet. The latches are installed by sliding the slot in the base of each metal latch up into the corresponding dovetail in each of the 2 beveled corners of the fiberglass TRANSMITTER enclosure furthest from the hinge. Those latches provide a means of pad-locking the enclosure. Use the 2 latches and/or the 4 sealing screws to securely seal the hinged door of the TRANSMITTER enclosure. If using the 4 screws, tighten as shown in *Figure 2-34* until the shoulders of the hinged door touch the corresponding corner flanges of the enclosure base (which sets the maximum compression of the door gasket). Avoid over-tightening. Apply a maximum of 2.3 Nm (20 in-lbs).



Molded-in shoulder around cover screw at corners of hinged transparent door of TRANSMITTER enclosure

Shoulder touching the corner flange of TRANSMITTER enclosure base

Figure 2-34: Using Screws to Secure TRANSMITTER's Hinged Enclosure Door

The TRANSMITTER enclosure door should be sealed in operation and also during any times other than those which require the door to be open

(e.g. for wiring to the terminal blocks or performing meter configuration via the keypad).

2.5.5 TRANSMITTER Enclosure Cable Entry

Power, sensor signal, and input /output signal cables enter the TRANSMITTER enclosure through cable entry holes with cable glands. The cable glands provide ingress protection for the cables. Always ensure they are fully tightened. *Figure 2-35* illustrates where each of the cable glands are installed.

All cable entries require cable glands, and any unused cable gland holes must be sealed with the gasketed hole plugs that came with the TRANSMITTER or equivalent plugs with IP ratings equal to or better than the IP rating of the TRANSMITTER.

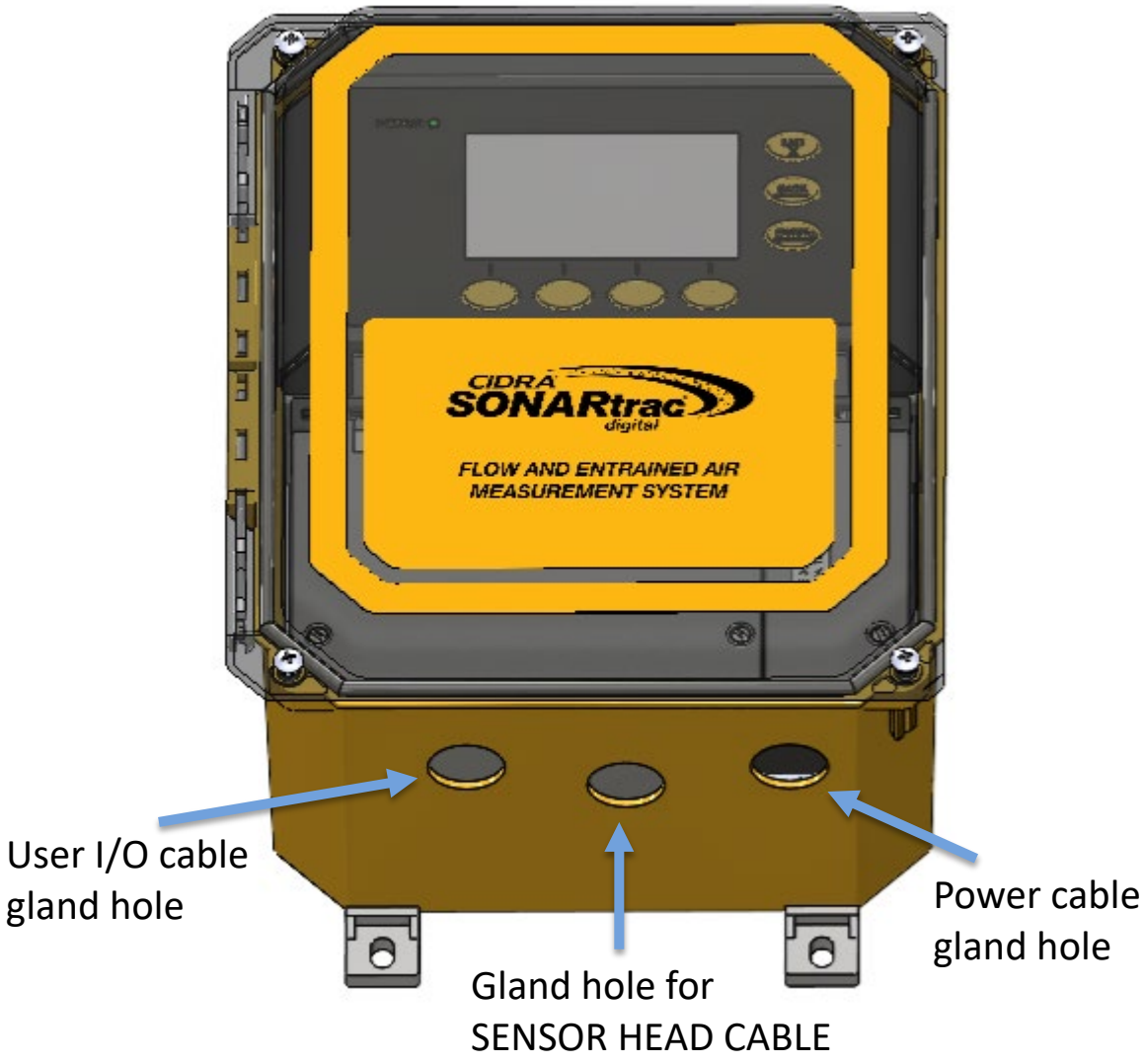
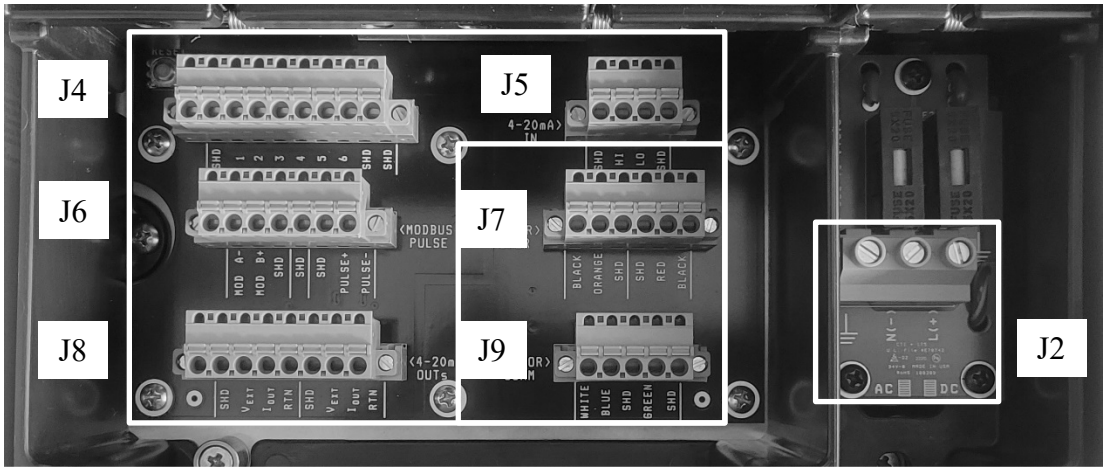


Figure 2-35: TRANSMITTER Enclosure Cable Gland Holes

2.5.6 TRANSMITTER Cable Connections



User I/O connections

Sensor I/O connections

Power connections

Figure 2-36: TRANSMITTER Terminals

Above is a picture of the lower portion of the TRANSMITTER with the polycarbonate door and the sub-compartment covers open. All terminal block terminals are numbered left to right. J2 is for the TRANSMITTER input power connections and is the only terminal block that is one-piece (not pluggable). J7 and J9 are the terminal blocks for the SENSOR HEAD CABLE (that goes to the MODULE). J5, J6, and J8 are the terminals for the base set of customer I/Os. J4 has the terminals associated with the optional and variable Modular Communications interface and its terminal functions vary with the installed Modular Communications board (if any).

It is recommended that all I/O cables used with these terminals be shielded with the shield grounded at the Transmitter end only. Terminals for connecting the drain wires to Earth (by way of the metal mounting plate) are provided in each terminal block.

2.5.6.1 Connecting wires to terminals

The mains power connections are through a one-piece, non-pluggable terminal block, J2, with screw terminals. It accepts wire from 0.2mm^2 to 4mm^2 (24AWG to 10AWG). Strip 8mm of insulation and twist the wire strands (and optionally use an 8mm long crimp ferrule) to control loose strands. Turn the screw counterclockwise a few turns to open the terminal. Insert the wire (or ferrule) and turn the screw clockwise and torque to 0.5 to 0.6 Nm (4.4 to 5.3 in-lb).

All of the other 6 I/O terminal blocks (J4, J5, J6, J7, J8, and J9) are 2-piece pluggable terminal blocks with spring-cage terminals that accept wire from 0.25mm^2 to 2.5mm^2 (24AWG to 12AWG). The two pieces are held together with a screw on each of the two mounting ears torqued to 0.3 Nm (2.7 in-lb). Strip 10mm of insulation and twist the wire strands (and optionally use an 8mm to 10mm long crimp ferrule) to control loose strands. Press down and hold the orange tab adjacent to the terminal to hold open the terminal. Insert the wire (or ferrule) and then release the orange tab.

With either terminal type, tug gently on wire after installation to ensure the wire is being well gripped by the terminal.

Route the wire neatly in the lower portion of the TRANSMITTER and secure with wire ties to keep the wires from getting pinched when the cover closes, and to separate the three groupings of wire from the three separate cable entry holes. Do not store excessive amounts of excess wire inside the TRANSMITTER.

When finished, close the hinged covers and secure them with the captive screws.

2.5.6.1.1 Tools

For the one-piece power entry terminal block, a 3/16” flat tip screwdriver with cabinet style tip is recommended for use with the screw terminals.

For the two-piece I/O terminal blocks, a 1/8” or 3.5mm flat tip screwdriver with cabinet style tip is recommended for both depressing the orange tab and for loosening/tightening the screws on the mounting ears.

2.5.6.2 TRANSMITTER Electrical Power Cable Installation

The ¾” NPT cable entry hole for the Electrical Power connections is the right-most hole. Use appropriate cabling (and with minimum 60°C temperature rating) and use a cable gland designed and certified for the cable type and diameter and for the hole size, and with equal or better temperature and IP ratings than the TRANSMITTER. Assure that the cable is supported near to but outside of the TRANSMITTER such that it is secured from pulling or twisting in the cable gland. Conduit (with the appropriate fittings) may also be used, but the conduit must be separately supported and not relying on the TRANSMITTER for support.

Wiring of the TRANSMITTER should always occur with the power OFF.

J2 is the terminal block on the Power Entry board and it has its own sub-compartment with a hinged and spring-loaded cover secured with a screw. It is tool-accessible so the electrical connections are intended to be made by an electrician or trained installer and subsequently not

intended to be accessible to Operators. For the DC TRANSMITTER powered by 18V-35VDC, these are not Hazardous Live voltages so it is not actually a shock hazard. The shock hazard applies to the AC-powered TRANSMITTER and is mitigated by that covered sub-compartment and, importantly, by a requirement that terminal J2-1 be tied to Earth Ground.

Make certain that the power source that is being connected is of the type (AC vs DC) and within the voltage range appropriate for the particular model of TRANSMITTER (check the electrical ratings on the certification label on the right-hand side of the exterior of the TRANSMITTER enclosure).

Take care in making the connections with the correct polarity. The right-most terminal (J2-3) is for (LINE) if AC, or (+) if DC. The middle terminal (J2-2) is for (NEUTRAL) if AC, or (-) if DC. The left-most terminal (J2-1) is for the protective earth connection. The protective earth connection MUST be made for the AC-powered TRANSMITTER for electric shock safety reasons and is highly recommended on the DC-powered TRANSMITTER for performance reasons.

Note that in AC power cords, the common wire color convention in the US is Black for Line and White for Neutral. In Europe the convention is Brown for Line and Blue for Neutral. Protective Earth is typically Green or Green with Yellow stripe.

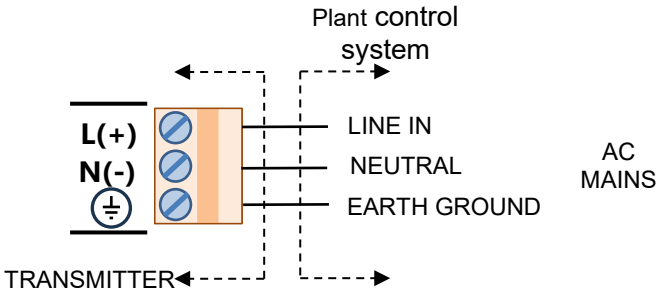


Figure 2-37: AC TRANSMITTER Power Connections

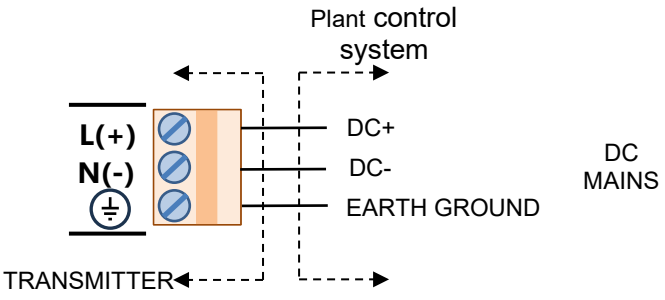


Figure 2-38: DC TRANSMITTER Power Connections

2.5.6.3 Sensor I/O connections

The ¾" NPT cable entry hole for the Sensor I/O connections (the SENSOR HEAD CABLE that goes to the MODULE) is the center hole.

The unarmored SENSOR HEAD CABLE is provided with a loose cable gland, whereas the armored SENSOR HEAD CABLE comes with a pre-attached gland at the TRANSMITTER end, and that gland includes a grounding ring with wire for grounding the gland and armor at the TRANSMITTER.

Whichever gland is used, be certain that it is the right type/size gland for the cable and the cable entry hole (sized for ¾" NPT) with appropriate ratings – including an IP66 or better rating. Be certain that it is properly and snugly installed and that the cable is separately strain-relieved in the vicinity of the TRANSMITTER to prevent pulling and twisting of the cable in the gland.

Terminal	Silkscreen	MODULE connector pin #	Function
J7 - 1	BLACK	1	Unspecified
J7 - 2	ORANGE	2	24V RTN
J7 - 3	SHD		Drain of 24V RTN
J7 - 4	SHD		Drain of +24V
J7 - 5	RED	3	+24V
J7 - 6	BLACK	4	Unspecified
J9 - 1	WHITE	7	RS485-Low
J9 - 2	BLUE	6	RS485-High
J9 - 3	SHD		Drain of RS-485
J9 - 4	GREEN	8	To Earth MODULE chassis
J9 - 5	SHD		Armor drain if armored cable

Table 2-3: Sensor I/O Connector Definition

The terminals for the SENSOR HEAD CABLE that goes to the MODULE are as follows:

J7-5 wrt J7-2 are the terminals that the TRANSMITTER uses to power the MODULE. J9-2 (Hi) and J9-1 (Low) are the terminals for the high-speed RS-485 bus between the TRANSMITTER and the MODULE. J9-4

is the terminal for a 16AWG grounding wire used to earth ground the metal enclosure of the MODULE by way of the TRANSMITTER.

In the standard SENSOR HEAD CABLE, the positive voltage (J7-5) is in its own twisted pair (with J7-6) and it is shielded with the drain wire going to J7-4. Similarly, the power return (J7-2) is in its own twisted pair (with J7-1) and it is shielded with the drain wire going to J7-3. Also, the RS-485 pair (J9-2, and J9-1) are in a twisted shielded pair with its drain wire going to J9-3. J9-5 is for earthing the armor of the cable if it is armored. The drain wire connections (J7-3, J7-4, and J9-3) do not connect to anything inside the MODULE such that the cable shields are intentionally grounded at one end only.

Note that J7-6 and J7-1 have no specific function in the Ordinary Location version of the *SONARtrac digital* system but should be connected as indicated in *Table 2-3* anyways.

Note that the MODULE Output Power defaults to the Enabled state and cannot be disabled from the front panel.

The silkscreen markings next to the terminals reflect the wire colors of the unarmored and armored SENSOR HEAD CABLE that is typically sold with the SYSTEM, but that doesn't necessarily preclude the use of other cables (see Customer Support).

2.5.6.4 Customer I/O Connections

The ¾" NPT cable entry hole for Customer I/O and Modular Communications inputs is the left-most hole. Use appropriate cabling and use a cable gland designed and certified for the cable type and diameter and for the hole size, and with equal or better temperature and IP ratings than the TRANSMITTER. Assure that the cable is supported near to but outside of the TRANSMITTER such that it is secured from pulling or twisting in the cable gland. Conduit (with the appropriate fittings and not relying on the TRANSMITTER to support it) may also be used. If no cable is used in this cable entry hole, then seal the hole with a certified hole plug (such as the one provided) with temperature and IP ratings equal to or better than that of the TRANSMITTER.

2.5.6.4.1 Analog Output connections

The TRANSMITTER has two 4-20mA Analog Outputs, ANA OUT #1 and ANA OUT #2. ANA OUT #1 also features a HART interface (if enabled). For each of those Analog Outputs, there are two wiring options. For one option, the current is supplied by a 24V supply inside the TRANSMITTER ("Internally Powered"). The other option is for the current to be supplied by the customer's 24V supply outside the TRANSMITTER (Externally Powered").

Internally Powered

The customer's cable effectively puts a current sense resistor (typically 250 ohms, but maximum 400 ohms) across J8-3 and J8-4 (for ANA OUT #1) or across J8-7 and J8-8 (for ANA OUT #2). The polarity is such that the voltage across the current sense resistor will be more positive on J8-3 (for ANA OUT #1) or on J8-7 (for ANA OUT #2). If using either of these outputs in Internally Powered Mode, the internal 24V supply must be enabled. Note that the internal 24V supply defaults to the enabled state and cannot be disabled from the front panel. Note that this internal 24V supply is isolated, but it is also shared between both Analog Outputs and the Analog Input.

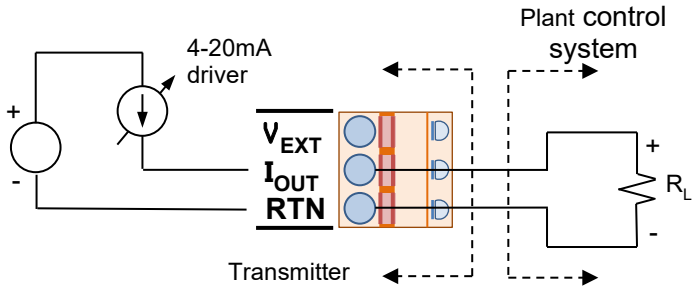


Figure 2-39: Internally Powered Analog Out

Externally Powered

The customer's cable effectively brings the customer's +24V supply output to J8-2 (for ANA OUT #1) or to J8-6 (for ANA OUT #2) and also has the return of their 24V supply going through a current sense resistor to J8-3 (for ANA OUT #1) or to J8-7 (for ANA OUT #2). The maximum current sense resistor in ohms is calculated as (V_{EXT} – 10V) / 0.021.

The remaining two terminal connections (J8-1, and J8-5) connect to the earthed chassis and can be used for drain wire connections.

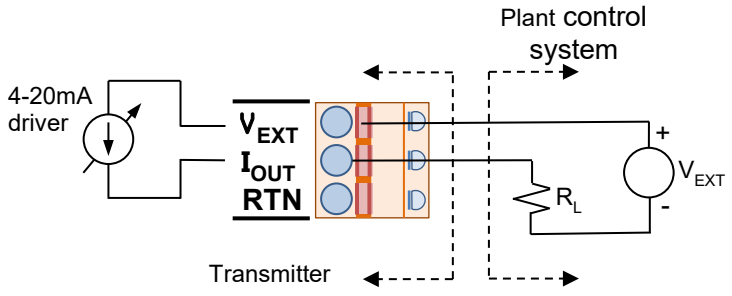


Figure 2-40: Externally Powered Analog Out

2.5.6.4.2 Analog Input connections

The Analog Input is a 4-20mA input which has only one connection method and that method uses the internal +24V supply. The +24V current comes out of J5-2 to the customer's two-wire 4-20mA transmitter. The other side of that 4-20mA transmitter brings current back into J5-3 where it is sensed by a 100 ohm current sense resistor. The internal +24V supply must be enabled for this Analog Input to function, but it defaults to the enabled state and cannot be disabled from the front panel. Note that this internal 24V supply is isolated, but it is also shared between both Analog Outputs and the Analog Input.

The remaining two terminal connections (J5-1, and J5-4) connect to the earthed chassis and can be used for drain wire connections.

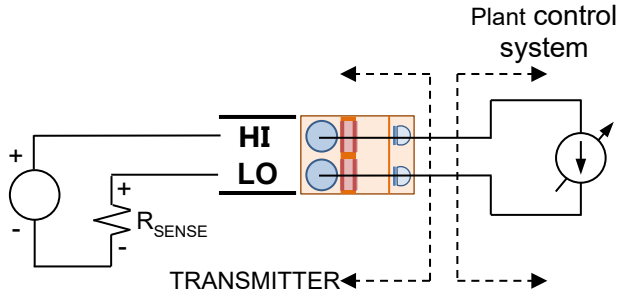


Figure 2-41: Analog In (Internally Powered)

2.5.6.4.3 Pulse Output connections

The Pulse Output is a normally-open solid-state relay between terminals J6-6 and J6-7. It can be configured for various low-going intervals representing a certain incremental volume (integrated flow rate) and its frequency can thereby indicate flow rate or the pulses can be counted to get a totalizer output. It can stand off 26VDC in either polarity, has roughly 10 ohm on-resistance, and will take up to 200mA. It is intended for IEC 61131-2 Type 1 interfaces. J6-5 is intended as a drain wire connection.

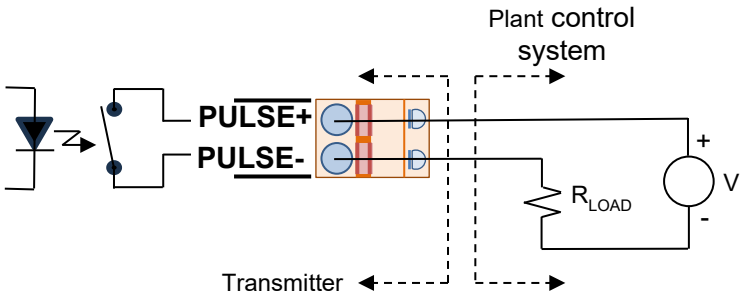


Figure 2-42: Pulse Output (Normally-Open)

2.5.6.4.4 Modbus connections

Not all TRANSMITTERS will have the Modbus interface enabled. Modbus will typically be disabled on TRANSMITTERS with any of the 3 Modular Comms options (Profibus DP, Foundation Fieldbus, or Profibus PA) or those with the HART interface enabled. The DTX-1 number on the smaller model number label on the right-hand side of the DTX-1 enclosure indicates which option is installed via the 2-letter field after the 3rd "-". "MB" means that Modbus is enabled To confirm whether the Modbus is enabled, see sub-menu *Info/Config*. If the Modbus interface is disabled, the J6-1 and J6-2 terminals, discussed below, will be non-functional for any RS-485 purpose.

The customer I/O Modbus connections are a 2-wire half-duplex RS485 bus on J6-2 ("MOD B+") and J6-1 ("MOD A-") with J6-3 intended for a drain wire connection. The A/B designations for the RS485 interface are notoriously confusing and inconsistently applied, so if it doesn't work initially, swap the J6-1 and J6-2 connections and try again. The RS-485 Analog Input, the internal 24V supply must be enabled. Note that parameters (baud rate, etc) can be set via the display/keypad, but that it is always RTU, not ASCII. There is no bus termination in the TRANSMITTER. See section 3.3.1.12 for additional Modbus information.

2.5.6.4.5 HART connections

Not all TRANSMITTERS will have the HART interface enabled. HART will typically be disabled on TRANSMITTERS with any of the 3 Modular Comms options (Profibus DP, Foundation Fieldbus, or Profibus PA) or those with the Modbus interface enabled. The DTX-1 number on the smaller model number label on the right-hand side of the DTX-1 enclosure indicates which option is installed via the 2-letter field after the 3rd "-". "00" means that HART is enabled, To confirm whether the HART is enabled, see sub-menu *Info/Config*. J8 is the terminal block for the HART connections. Use J8-2 and J8-3 if Externally Powered, or J8-3 and J8-4 if Internally Powered. Polarity is not important. If the HART interface is disabled, the J8 terminals will be non-functional for HART, but will still provide 4-20mA outputs. Contact Customer for further information on the HART interface.

2.5.6.4.6 Modular Communications connections

J4 is the terminal block for connections to one of the optional Modular Comms boards (if any). The DTX-1 number on the smaller model number label on the right-hand side of the DTX-1 enclosure indicates which option is installed via the 2-letter field after the 3rd "-". "DP" means

Profibus DP. “PA” means Profibus PA. “FF” means Foundation Fieldbus. Sub-menu *Info/Config* can also be used to determine whether the installed modular communication interface (identified as “Fieldbus”) is enabled. Detailed discussion of the Modular Communications options is beyond the scope of this manual. Contact Customer Support for further information on these interface options.

2.5.7 BAND Calibration Label

The BANDs are shipped with five calibration labels. The label lists the BAND part number, serial number, date of manufacture and three calibration factors. This information will be entered into the TRANSMITTER during setup.

Install the BAND calibration label discussed in section 2.3.4, above, on the inside of the door of the TRANSMITTER.

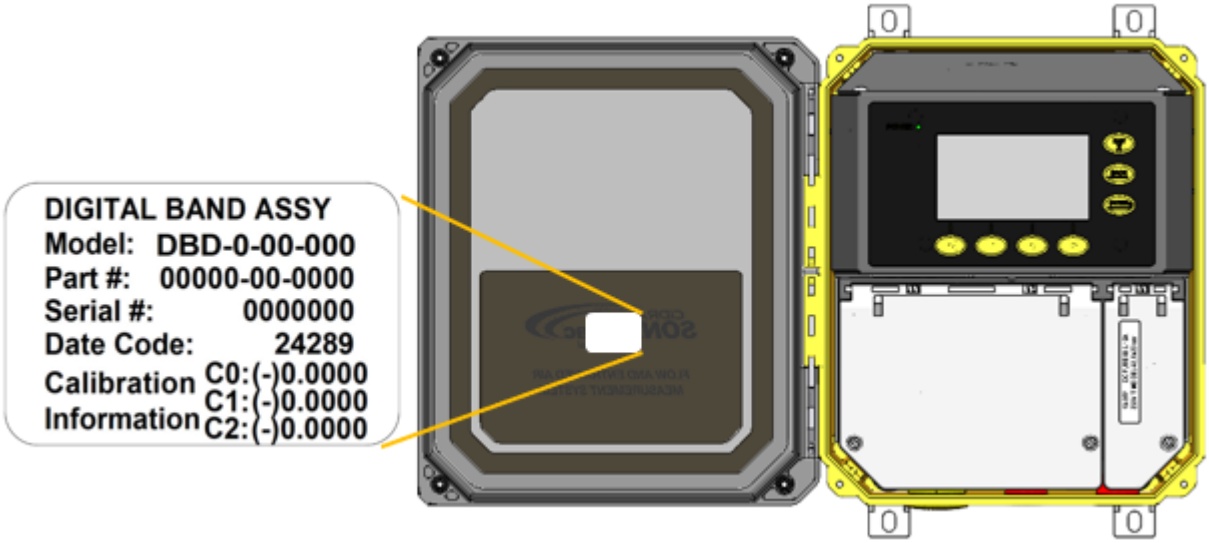


Figure 2-43: Adhere BAND Label to the Inside of the door of the TRANSMITTER

2.5.8 Safety Issues of Improper TRANSMITTER Installation

The main safety issues of improper installation of the TRANSMITTER are issues which compromise the IP rating of the enclosure, or issues involving improper wiring of the terminals. These issues can increase the risk of electric shock or fire. Note that there is no electric shock risk of the DC-powered TRANSMITTER which is neither powered by nor generates Hazardous Live voltages, and after installation the electric shock risk of the AC-powered TRANSMITTER is mitigated by the tool-accessible sub-compartment in which the mains terminal connections

are located and the earth-grounding of the metal chassis plate inside the TRANSMITTER's fiberglass enclosure. Note that wiring to the terminals should always be performed with the power OFF.

Improper wiring can include:

- Inadequately secured wires that can come out of their terminals. Loose wires can short to other wires or terminals.
- Secured wires with excessive insulation removed exposing the bare wire beyond the terminals. This increases the risk of electrical contact with personnel or with loose wires.
- Secured wires with insufficient insulation removed or inserted too far into the terminal such that the terminal clamps onto the insulation and creates an open or an intermittent connection.
- Secured wires installed in the wrong terminals. Care must be taken to avoid this. Depending on the miswire, the result could range from a safe but temporarily non-functional state to an unsafe state and/or permanent damage to the circuitry.
- Wire gauges or number of wires or type of wires inserted into a terminal that are outside the ratings of the terminal. Note that putting multiple wires in terminals is not recommended, but when the terminal's ratings permit it, extra care must be taken to assure that all wires are adequately secured.
- Applying voltages or currents that are beyond the ratings permitted by this manual.
- For the AC-powered TRANSMITTER, not assuring that the Protective Earth terminal is adequately tied to earth potential.

Compromise of the IP ratings of the TRANSMITTER enclosure can include:

- Failure to protect the TRANSMITTER from precipitation and dust EVERY time the enclosure cover is open (and failure to quickly clean it up and thoroughly dry it out– with the power OFF – if it ever gets polluted inside despite the attempt at protection).
- Failure to properly close the enclosure cover.
- Allowing foreign objects to be trapped in the gasket seals of the enclosure cover or allowing those seals to become damaged.
- Failure to use cable glands with the appropriate ratings (including IP ratings to maintain the IP rating of the enclosure) that are designed for the cable diameter and the cable entry hole diameter and which are properly installed with all their appropriate sealing components.
- Failure to use adequately rated hole plugs to seal unused cable entry holes. E.G. the TRANSMITTER is shipped with one light-colored plastic hole plug with gasket and backing nut that will maintain the IP rating if used in a hole not occupied by a cable/gland in the permanent installation. It is also shipped with

red (to attract attention to the fact that they are not for permanent use) press-in temporary shipping hole plugs in the two holes that are intended for the power connections to the TRANSMITTER and for the SENSOR HEAD CABLE. Those red temporary plugs have no IP rating and are expected to be discarded and not used in the permanent installation.

2.5.9 Applying power to the TRANSMITTER

Note that Mains power is only connected to the TRANSMITTER. The TRANSMITTER, in turn, powers the MODULE with low-voltage DC power via the SENSOR HEAD CABLE.

In general, there are two types of TRANSMITTER – those that accept only AC mains power (100-240VAC, 50/60 Hz) and those that accept only DC mains power (18-35VDC). Be sure that the applied mains power is the correct type for the TRANSMITTER. The marking label on the right side of the TRANSMITTER explicitly includes the allowed input voltage range. Additionally, the smaller label with the complete DTX-1 model number has a field after the 2nd hyphen showing either “DC” or “AC” to indicate which type of power it requires. As a further reminder, the fuse label on the hinged cover over the mains power terminals will also indicate whether it is an AC or DC powered DTX-1.

Perform a final inspection of the installation to verify connections as indicated above.

Verify the absence of condensation or frost inside the TRANSMITTER.

After a favorable inspection, apply power and verify that the display indicates normal operation. If there is no communication with the MODULE, the display will indicate “SENSOR FAILURE”.

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3 Equipment Configuration and Operation

3.1 Controls and Navigation

The following describes the use of the keypad and display to manually configure the SYSTEM – primarily via the keypad and a series of menus and sub-menus. An alternative way to configure the SYSTEM is by installing a Configuration file from a USB memory stick (utilizing the USB sub-menu, as described, below). Such Configuration file may be available from a saved Configuration of another near-identical SYSTEM installation, or one supplied by Customer Support (typically after analyzing data supplied to them from this meter). This can save time and/or allow configuration of rarely used parameters not otherwise accessible from the keypad/display interface.

3.1.1 Identification of Operating Controls

The TRANSMITTER's display and keypad controls used to set up and access the user input screens are illustrated in *Figure 3-1*.

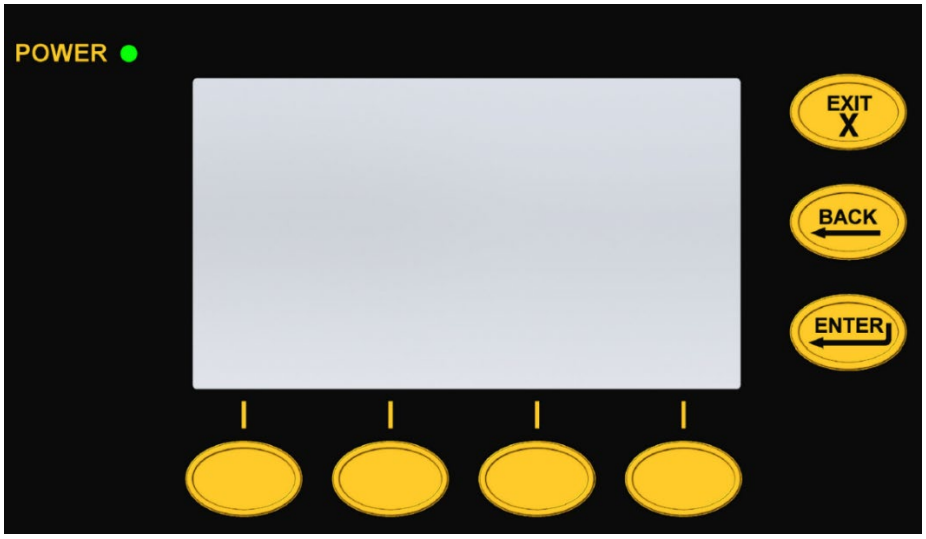


Figure 3-1: TRANSMITTER Front Panel Display and Keypad

There are 3 momentary keys on the right-hand side of the display with their function name written directly on them: EXIT, BACK, and ENTER. The names on those keys are suggestive of their function, but some (especially ENTER) have multiple situation-dependent functions which are clarified within the following instructions.

The 4 "soft keys" below the display with lines pointing up towards the display (used for navigating the menu structure – see section 3.2) have a varying set of uses, the instantaneous function of which will be indicated by the words or symbols shown on the bottom edge of the display next to those connecting lines.

Generally, there will be a color image of some type on the display which is the indication that the TRANSMITTER is powered. However, if the display is dark (backlight too low, or some sort of display failure) the Power LED at the upper left

can be used to distinguish between those possibilities and the more likely scenario of the TRANSMITTER not being powered.

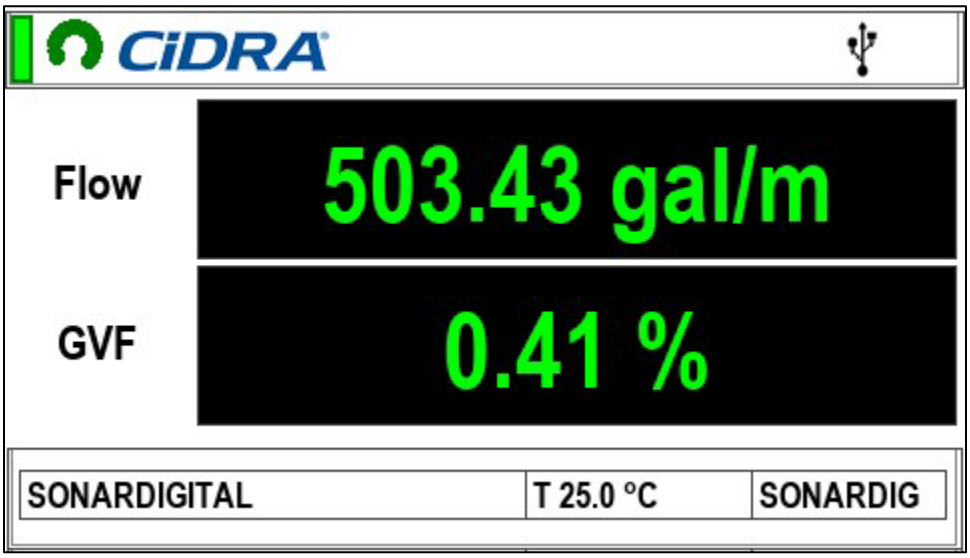


Figure 3-2: Operational Mode Display

The display has 2 distinct modes: the **Operational Mode** where the measured parameters are displayed and the **Menu Mode** where various system configuration parameters can be set. Shown above is the OPERATIONAL MODE Display. In the banner that includes an activity indicator, the CiDRA logo, and space for various logos representing the various digital communications interfaces. In this image, only the symbol for the USB bus interface is shown. Other possible logos are discussed below. The two main rows of the display ("Flow" and "GVF in this example) are any 2 of the set of 7 computed results (Flow Rate, Total, Speed of Sound, Gas Void Fraction, Total Liquid Flow, Velocity, or Band Temperature) – complete with choice of units - that can be user-configured to be displayed in either row. The information in the 3 sections of the bottom row are discussed further, below.

3.1.1.1 Digital Communication Interface Logos

Ethernet – The lighter color means that it's connected to an Ethernet bus. The darker color means that it's being communicated with.

USB bus - Means that the USB-C connector is connected to a USB bus.

USB Memory Stick - Means that a USB Memory Stick has been detected on either the USB-A or USB-C connector. Note that this logo will be hidden by the USB bus logo if there is a simultaneous USB-C bus connection.

Profibus PA - The lighter color means that the board is detected and the software key enabled. The darker color means that it is also being powered by a connected bus.

Profibus DP - The lighter color means that the board is detected and the software key enabled. The darker color means that bus traffic is also detected.

Foundation Fieldbus - The lighter color means that the board is detected and the software key enabled. The darker color means that it is also being powered by a connected bus.

Modbus - Means that bus traffic is detected. Will not appear if the software key is not enabled.

HART - Means that bus traffic is detected. Will not appear if the software key is not enabled. Even if the software key is enabled, will not appear on TRANSMITTERS that have Profibus PA or Foundation Fieldbus.

3.1.1.2 Rotating Activity Indicator

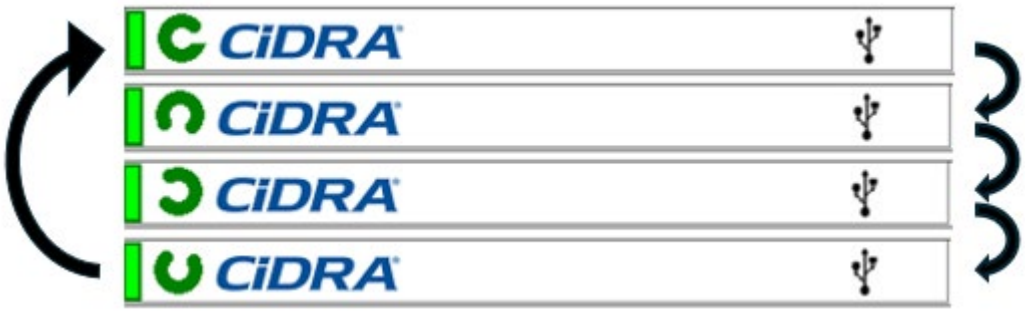


Figure 3-3: Rotating activity indicator at upper left of Operational Mode Display

At the upper left is an indicator that is constantly rotating clockwise to indicate that the meter is in normal operation.

3.1.1.3 Cycling Diagnostic Information

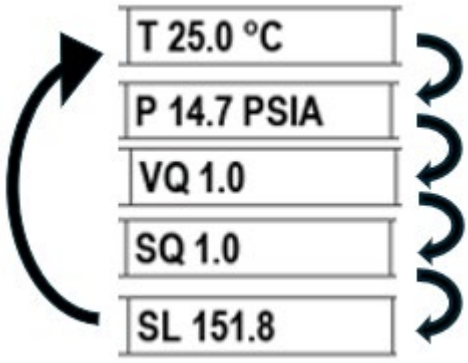


Figure 3-4: Sequence of diagnostics displayed at bottom of Operational Mode Display

In the center of the bottom ribbon of the Operational Mode Display is some immediate diagnostic information that continuously cycles through in this order:

"T" and "P" are the process temperature and pressure - which are either constants entered by the user or are configured by the user to be dynamically updated by remote 3rd-party sensors via one of various means.

"VQ" and "SQ", are the flow Quality and SOS Quality, respectively. As discussed later. they are numbers typically between 0 and 1 with larger numbers indicating a higher level of confidence in the computed parameter.

"SL" (aka "SPL") is an estimate, in dB, of the level of raw acoustic signal in the pipe.

NOTE: These 5 cycling parameters are the default state (if you perform a reset to defaults), though various subsets (or NO parameters) are selectable instead, but not via the front panel.

3.1.1.4 Fixed Identification Information

Unique identifiers can be shown on the display in addition to or in lieu of the identifiers etched into the optional tag.

In the lower-right of the display ("SONARDIG" in *Figure 3-2*) is a label referred to as "Short Tag" which is user-settable to any distinguishing name or number the user would like to label the TRANSMITTER as (up to 8 characters) by using sub-menu *Basic/System*. For those TRANSMITTERS with enabled and functional HART interfaces, this same parameter is also settable in sub-menu *Comms/HART*. Similarly, in the lower left of the display ("SONARDIGITAL" in *Figure 3-2*) is a label referred to as "Long Tag". It has the same function and is settable in the same sub-menus as "Short Tag", but it can be up to 40 characters long. Note that the location for "Long Tag" is shared with the Status messages, so if there are any Status

messages indicating other than normal operation, the “Long Tag” will not be displayed.

Note that resetting to defaults (section 4.1.1) will reset these tags to “SONARDIG” and “SONARDIGITAL”.

3.1.1.5 Status Messages and Warning Displays

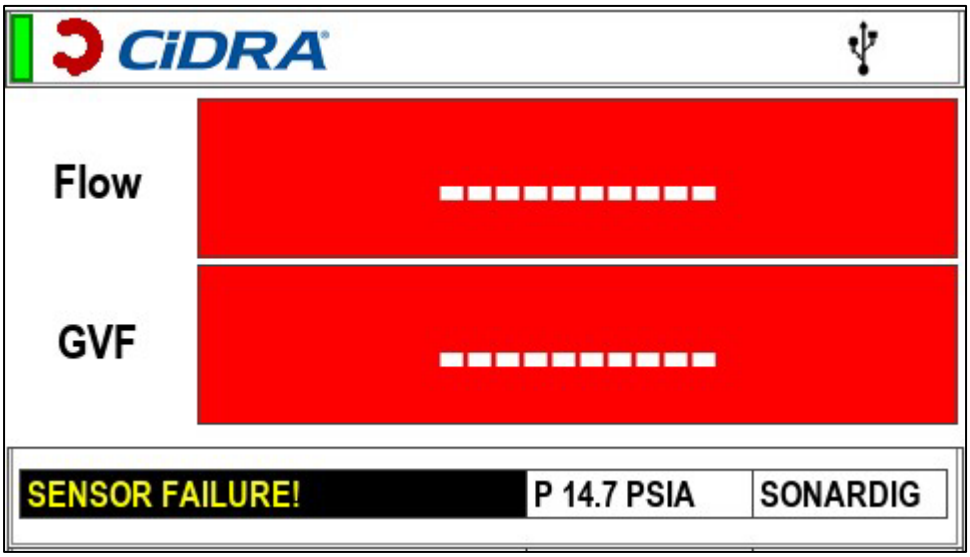


Figure 3-5: Operational Mode Display when Sensor communication is lost

The image above is a warning display that appears if communication is lost between the TRANSMITTER and the MODULE for any reason. The green rectangle in the upper left will turn yellow or red if there is a problem with the voltages or currents associated with powering the MODULE. For details, see the right-hand column of Page 2 of the *Diag/Voltage*s sub-menu. If this warning display appears or the rectangle is not green, verify that the connector between the SENSOR HEAD CABLE and the MODULE is properly connected, and that the wires at the SENSOR POWER and SENSOR COMM terminal blocks in the DTX TRANSMITTER are properly installed. If these fault indications persist, contact Customer Support.

Note that the Status message, “SENSOR FAILURE!”, hides the Long Tag in the lower left of the display. Other Status messages can also appear there, though typically not in combination with the red background. The meaning of the Status messages should be self-explanatory, so a list of all possible Status messages is not provided here.

3.1.2 Menu Mode Navigation

The purpose of this section is to explain how to navigate the menus and sub-menus of Menu Mode to do basic configuration of the SYSTEM and basic diagnostic tests. Since there are a lot of sub-menus and they will evolve with future software revisions, the fundamental training that is required is how to navigate them. The examples below may differ from the menus and sub-menus seen on your TRANSMITTER, but the navigation rules are the same.

The sub-menus, themselves, are largely self-explanatory. The bottom 2 rows of each sub-menu typically show the unabbreviated name of the highlighted parameter and the minimum and maximum values permitted for numeric inputs or the list of possible selections for non-numeric inputs. Also, the factory default value or selection is indicated.

The top-level menu structure is shown in *Figure 3-19*.

3.1.2.1 Entering Menu Mode – The ENTER, BACK, and EXIT keys

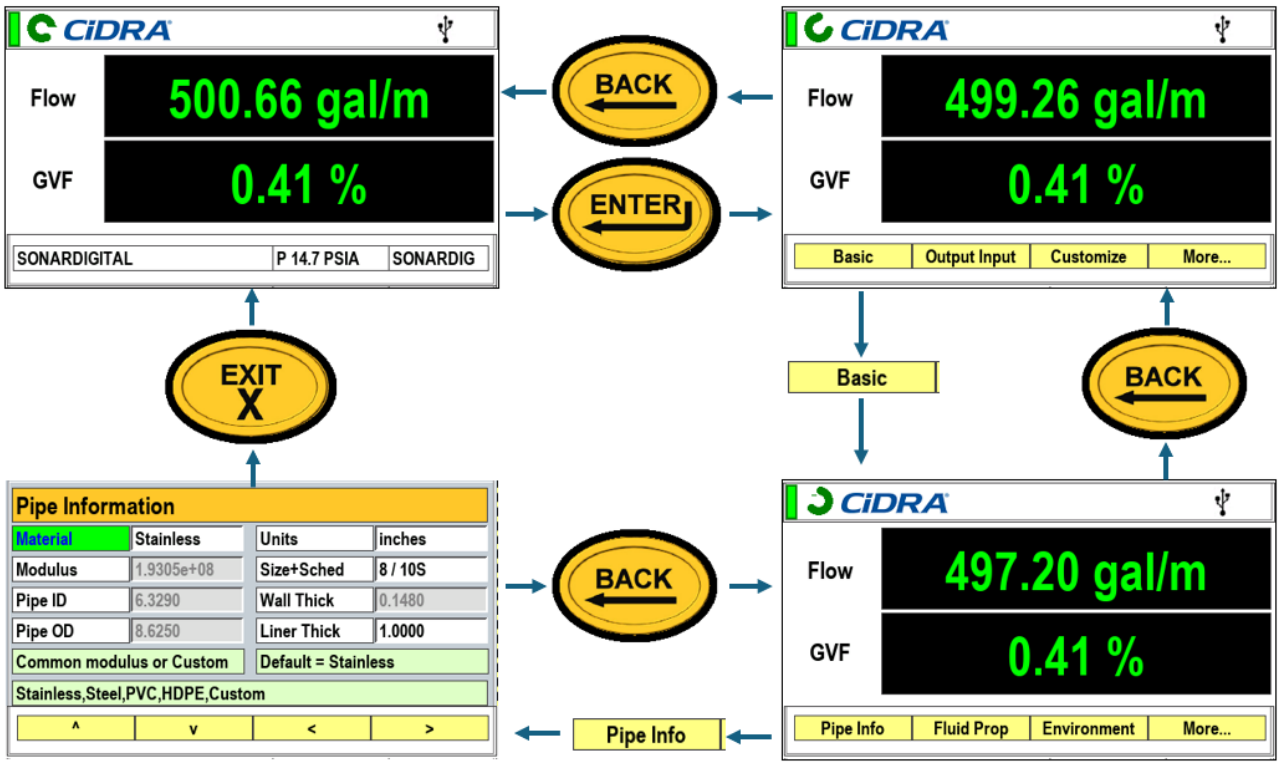


Figure 3-6: Use ENTER, BACK, and EXIT keys to find sub-menus in Menu Mode

Pressing the ENTER key (or any of the 4 undefined soft keys under the OPERATIONAL MODE display) transitions from OPERATIONAL MODE to the top level of menus in MENU MODE. Going down to sub-menus requires pushing the Soft Key under the sub-menu name. The BACK key moves back to the next-higher menu level (or back to OPERATIONAL MODE if already at the top menu level). At any level of MENU MODE, the EXIT key brings you all the way back to OPERATIONAL MODE.

3.1.2.2 Use of the MORE soft key

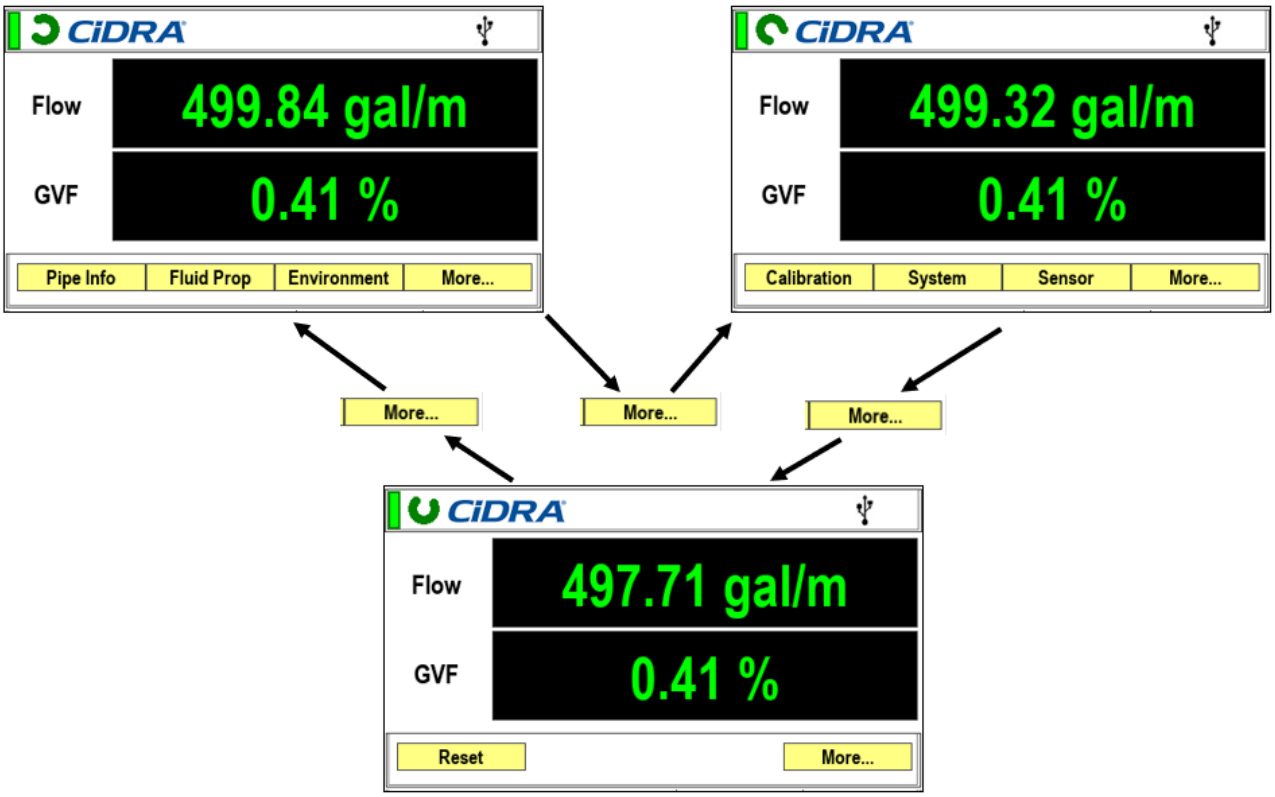


Figure 3-7: Use MORE key to see additional sub-menu options

For Menu or Sub-menu levels that have more than 4 sub-menus, the right most soft key will be “More…” and pressing that key will show the additional sub-menus at that level on one or more screens in a circular fashion.

3.1.2.3 Use of the DOWN and UP arrow soft keys to select parameters

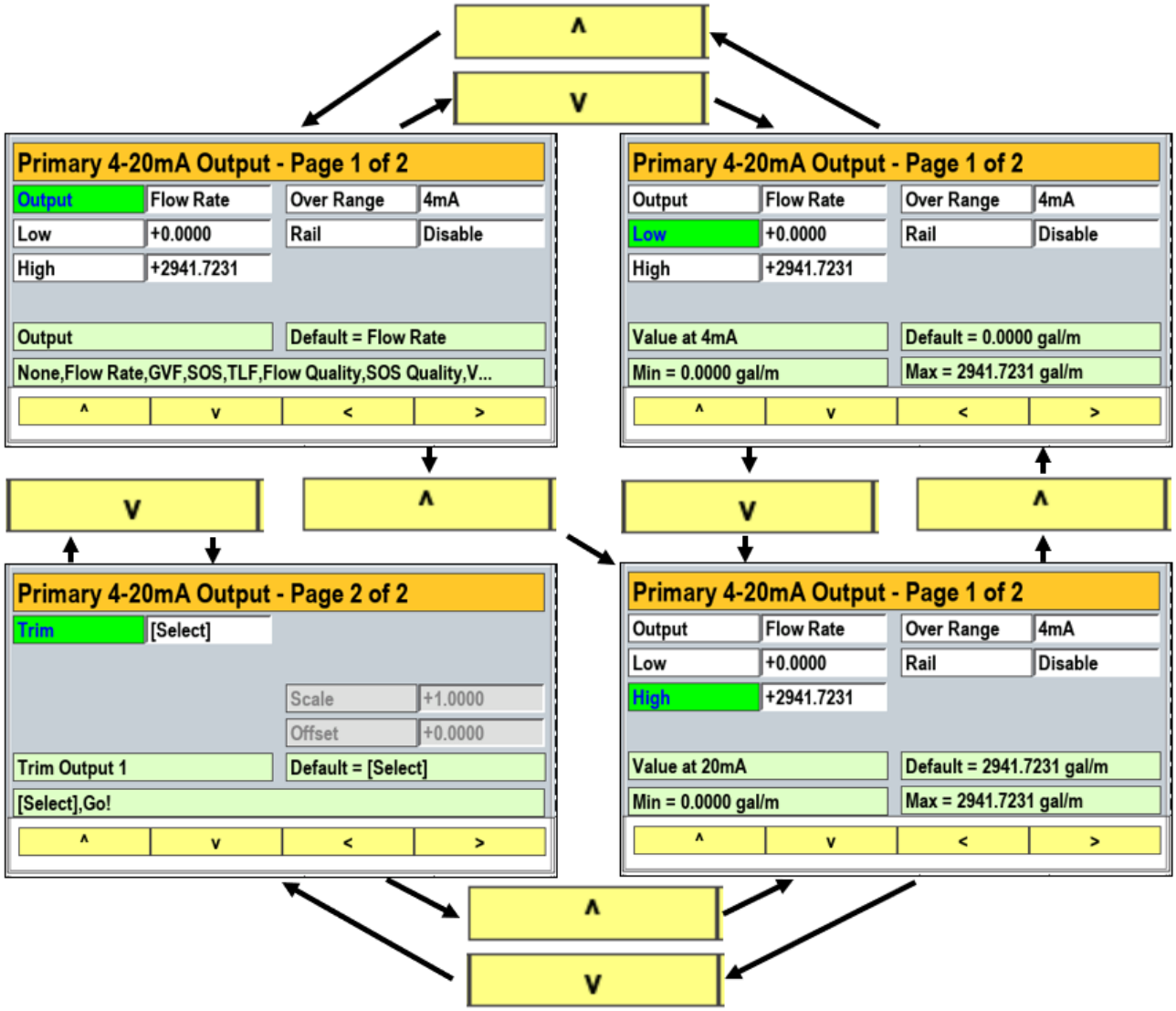


Figure 3-8: Use DOWN and UP arrows to select parameters from different rows/pages

Once at the sub-menu level, use the down arrow soft key to move the cursor (indicated by a green background) down a column of entries (and the up arrow soft key to move up that column) even jumping to the next page on multi-page sub-menus. Note that if you up arrow at the top of the first page, it moves the cursor to the bottom of that page. Similarly, if you down arrow at the bottom of the last page, it moves the cursor to the top of that page.

3.1.2.4 Use of the RIGHT and LEFT arrow soft keys to select parameters

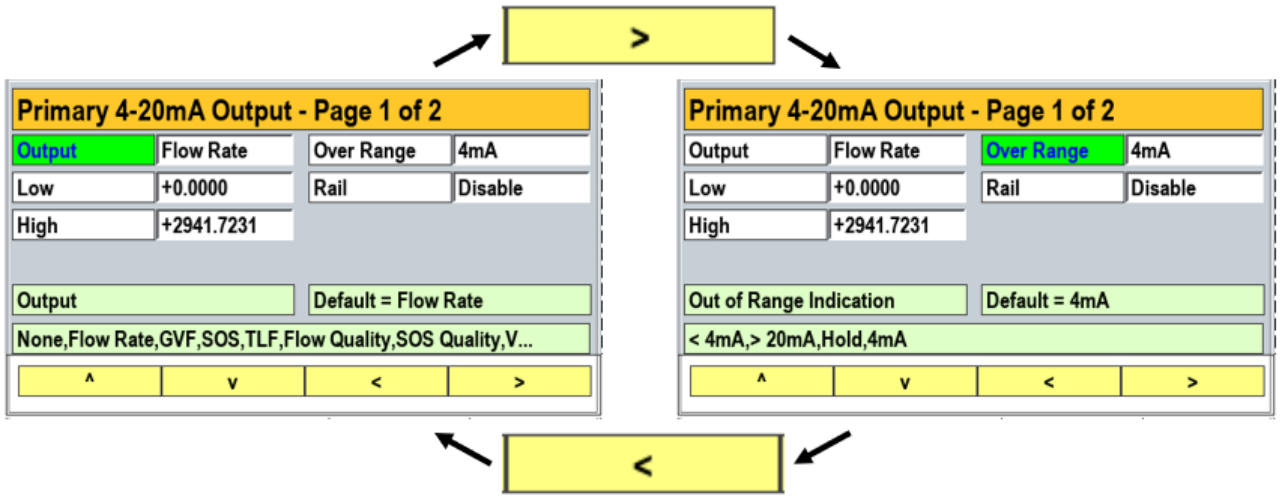


Figure 3-9: Use RIGHT and LEFT arrows to select parameters from either column

The right arrow and left arrow soft keys can be used to move the cursor (indicated by a green background) to select parameters from the right-hand versus left-hand columns.

3.1.2.5 Editing the selected parameters that use selection lists

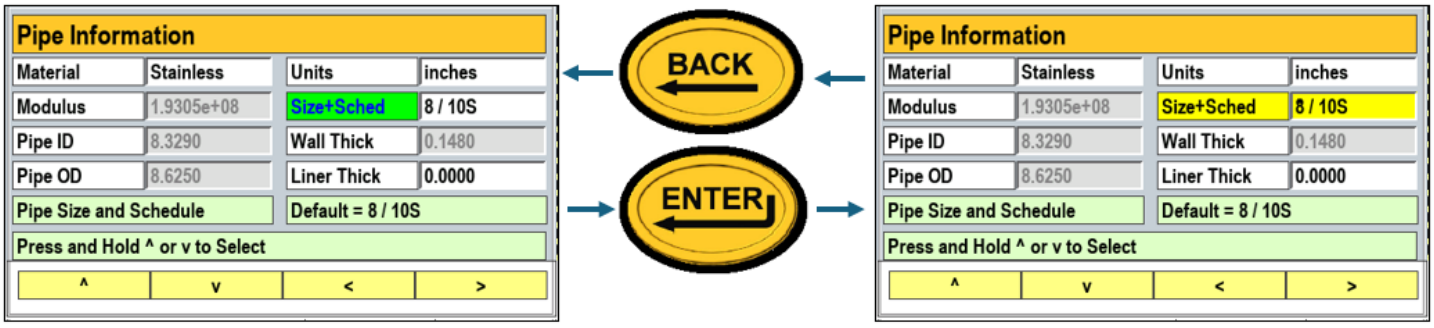


Figure 3-10: Press ENTER to enter a Selection List

background), press ENTER to highlight the entry window to its right. [The highlighting of the “Size+Sched” box went from green to yellow as that of the “8 / 10S” box to its right went from white to yellow.] The BACK key can also be used to undo an ENTER if you decide that you don’t want to edit that parameter after all.

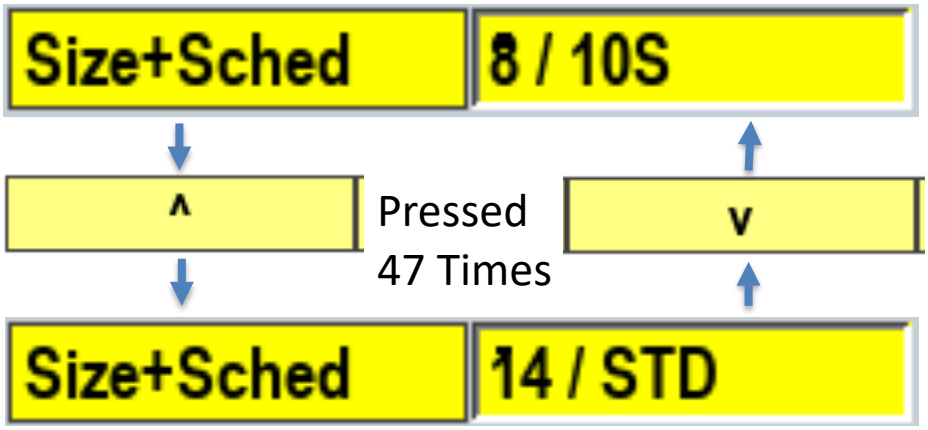


Figure 3-11: Use of UP arrow and DOWN arrow to make a selection from a list

With the entry window highlighted in this selection-type entry window, make a selection by using the up arrow or down arrow soft keys. Some lists of selections are VERY long (like this one) and as a convenience, just holding down the up arrow or down arrow soft key allows rapidly moving through those long lists.

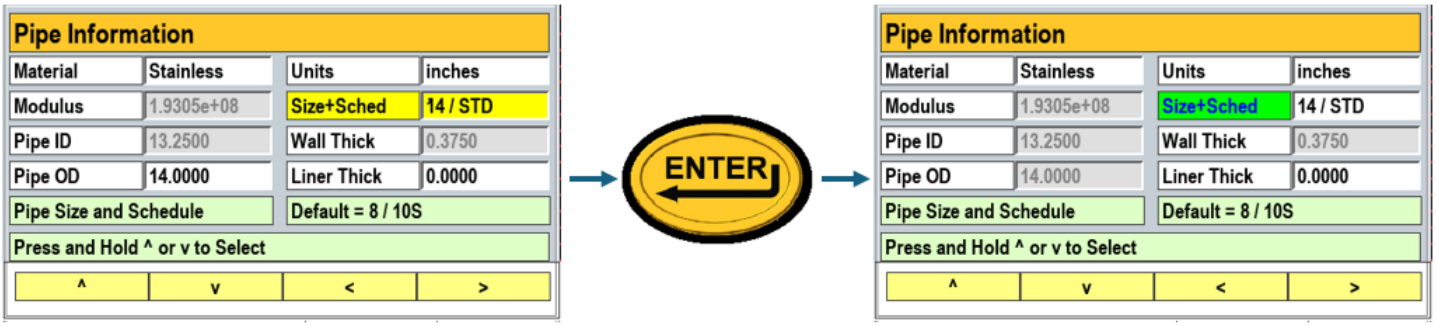


Figure 3-12: Press ENTER to lock in the selection

When the desired selection is highlighted, then press ENTER to lock it in. The entry window is then no longer highlighted. Sometimes (such as with this parameter), making a new selection for the parameter will change the values of other parameters as well. In this case, Pipe ID, Pipe OD, and Wall Thick all changed accordingly (and their new values were shown as the selection was changed even before they were locked in).

3.1.2.6 Editing the select parameters that use numeric entries

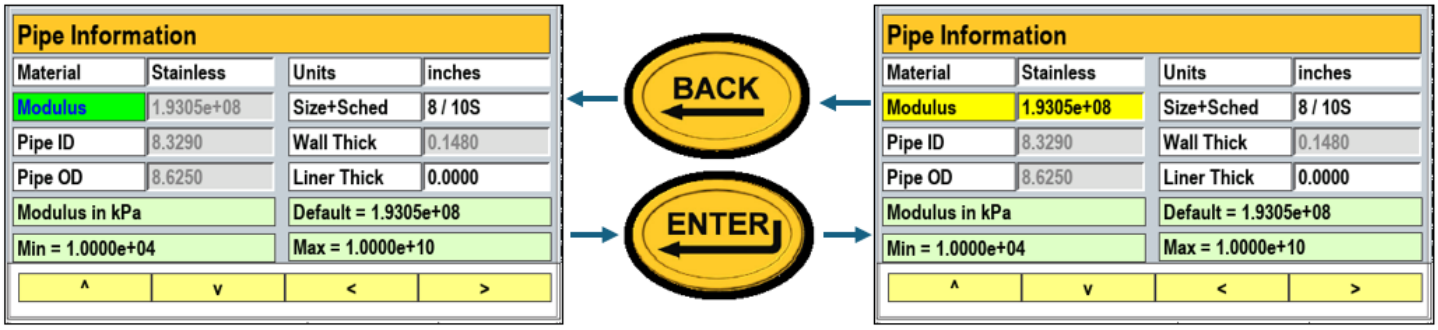


Figure 3-13: Editing using Numeric Entries

For parameters with numeric entries, after selecting the parameter, press ENTER to highlight the numeric entry edit box.

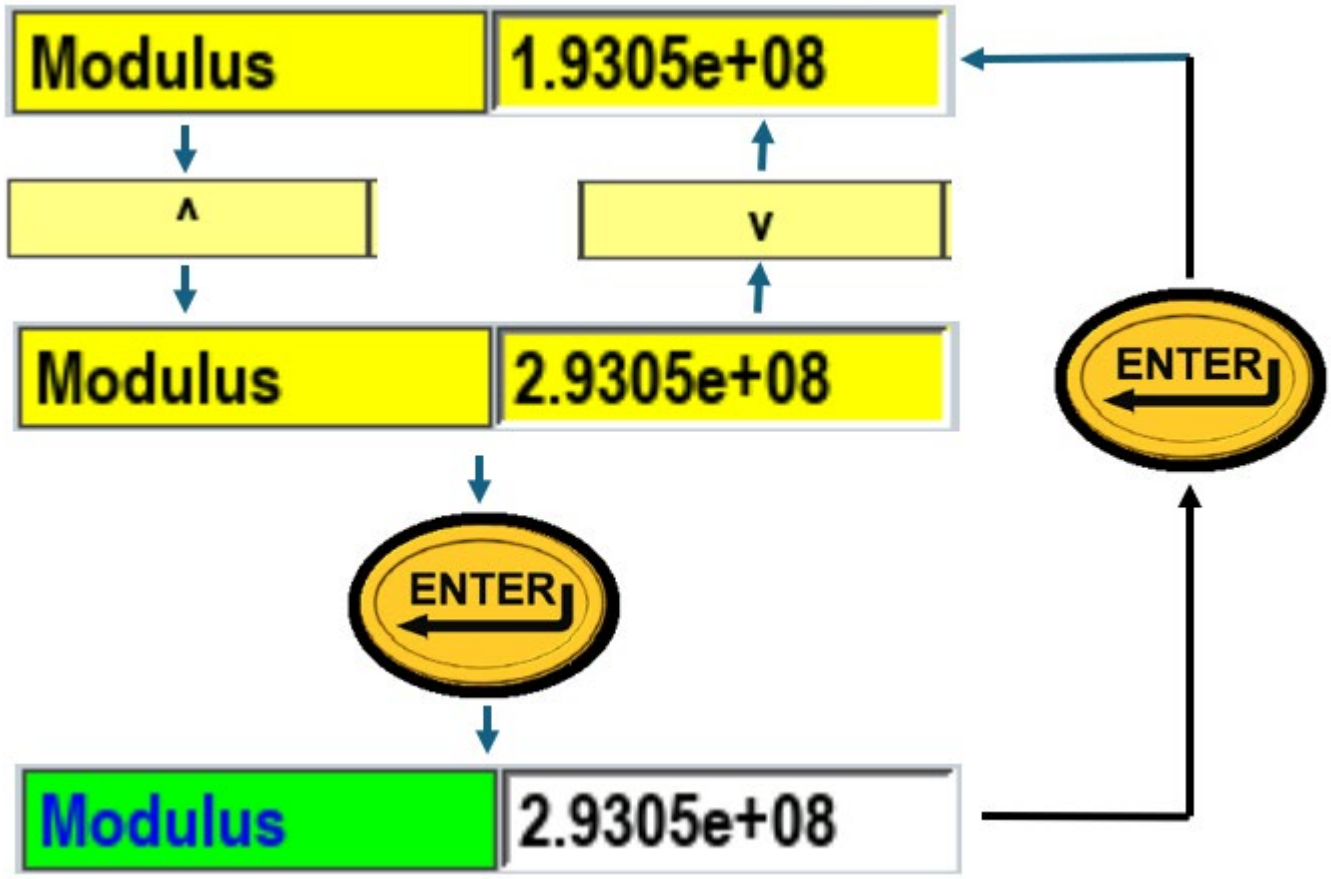


Figure 3-14: Use of UP and DOWN arrows to Change Numbers

The blinking cursor will start on the first digit. The right arrow and left arrow can be used to move the cursor to other digits. For each digit to be modified, use the up arrow to increase or down arrow to decrease the value to the desired value before moving to another digit and doing the same. Once the number is set to the intended new value, then press ENTER to lock it in. At that time the numeric entry box will no longer be highlighted. Note that in the example shown above, the blinking cursor was on the first digit.

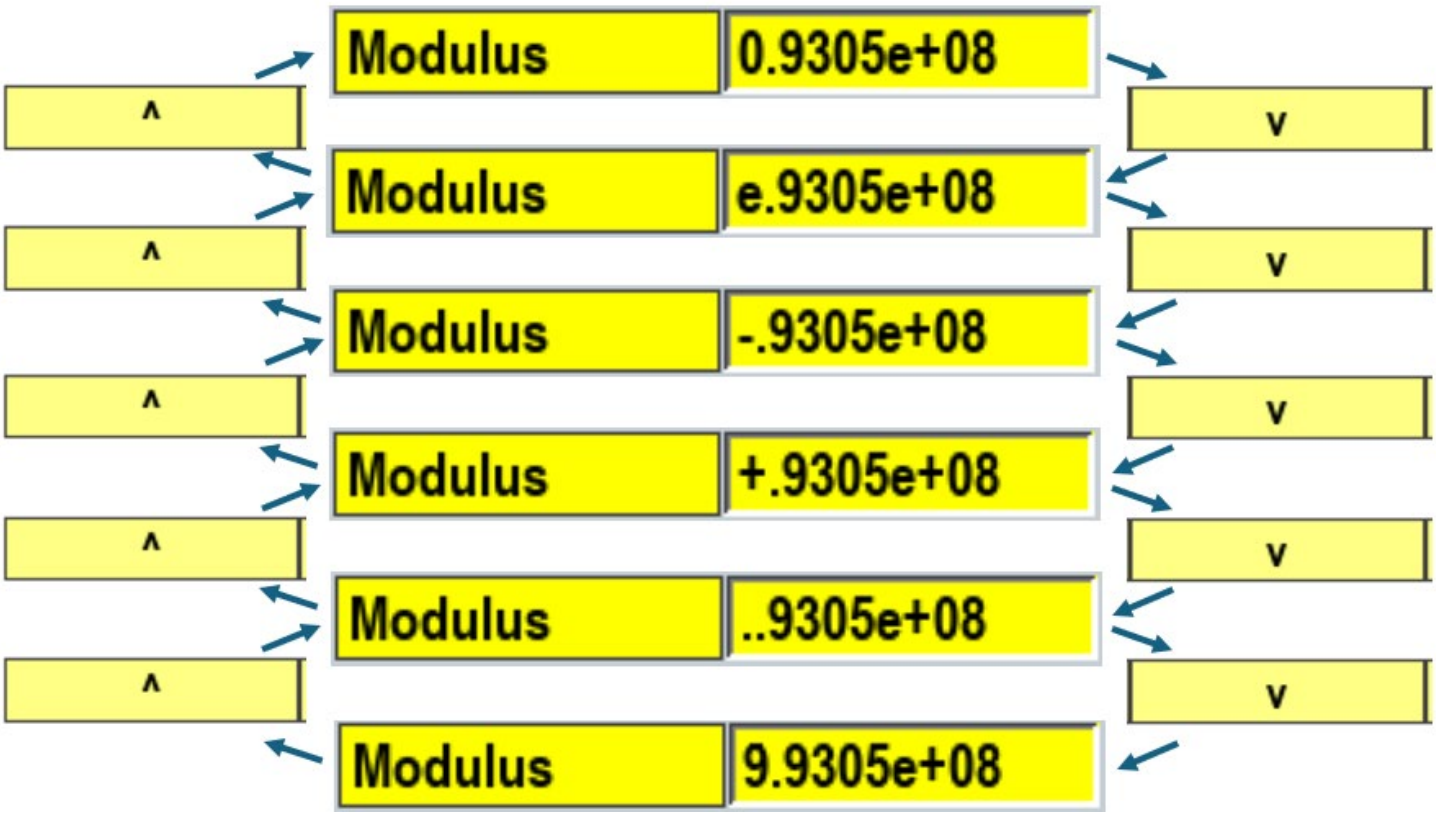


Figure 3-15: Use of UP and DOWN arrows to Change Numbers and Symbols

The options for using the up arrow (or down arrow) are a circular list that in addition to numbers 0 through 9 includes a decimal point, plus sign, minus sign, and exponent (“e” for multiplication by factors of 10). To increment from, say “9.43” to “10.4”, you must change the “9” to a “1”, then move the cursor to the right and change the decimal point to a “0”, then move the cursor to the right again and change the “4” to a decimal point, then move the cursor to the right again and change the “3” to a “4”. Creating a non-sensical character sequence (e.g. 2 successive decimal points) and then pressing ENTER will result in an error message and the value being restored to its pre-edited value.

3.1.2.7 Using parameters that begin processes like Tests and RESETs

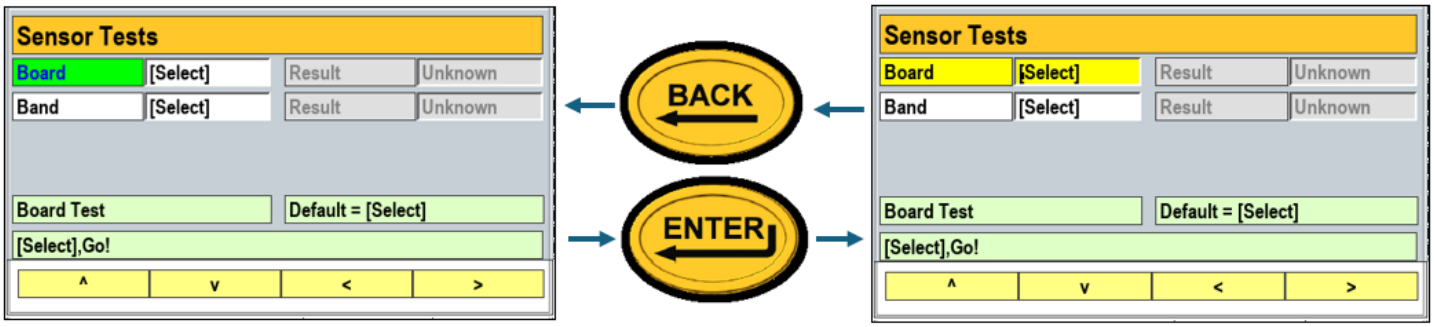


Figure 3-16: Starting TESTs and RESET Operations - ENTER

For Self-tests such as this Sensor Board test (which tests just the MODULE electronics and not the BAND) and certain RESET functions, press ENTER after selecting it to highlight the entry window.

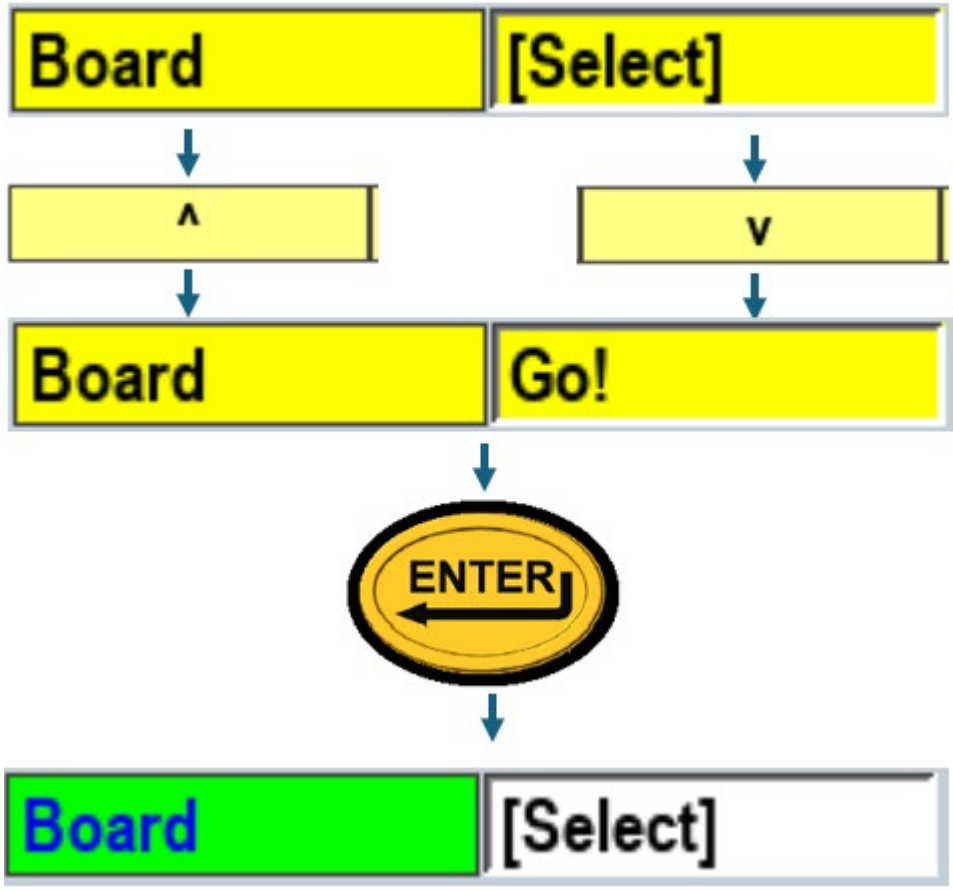


Figure 3-17: Starting TESTs and RESET Operations - GO

Then use the up arrow or down arrow soft key to select “Go!”. Then press ENTER to start the process. There may be various pop-up screens that require pressing ENTER again to continue. When done, the display again just has the test or action highlighted.

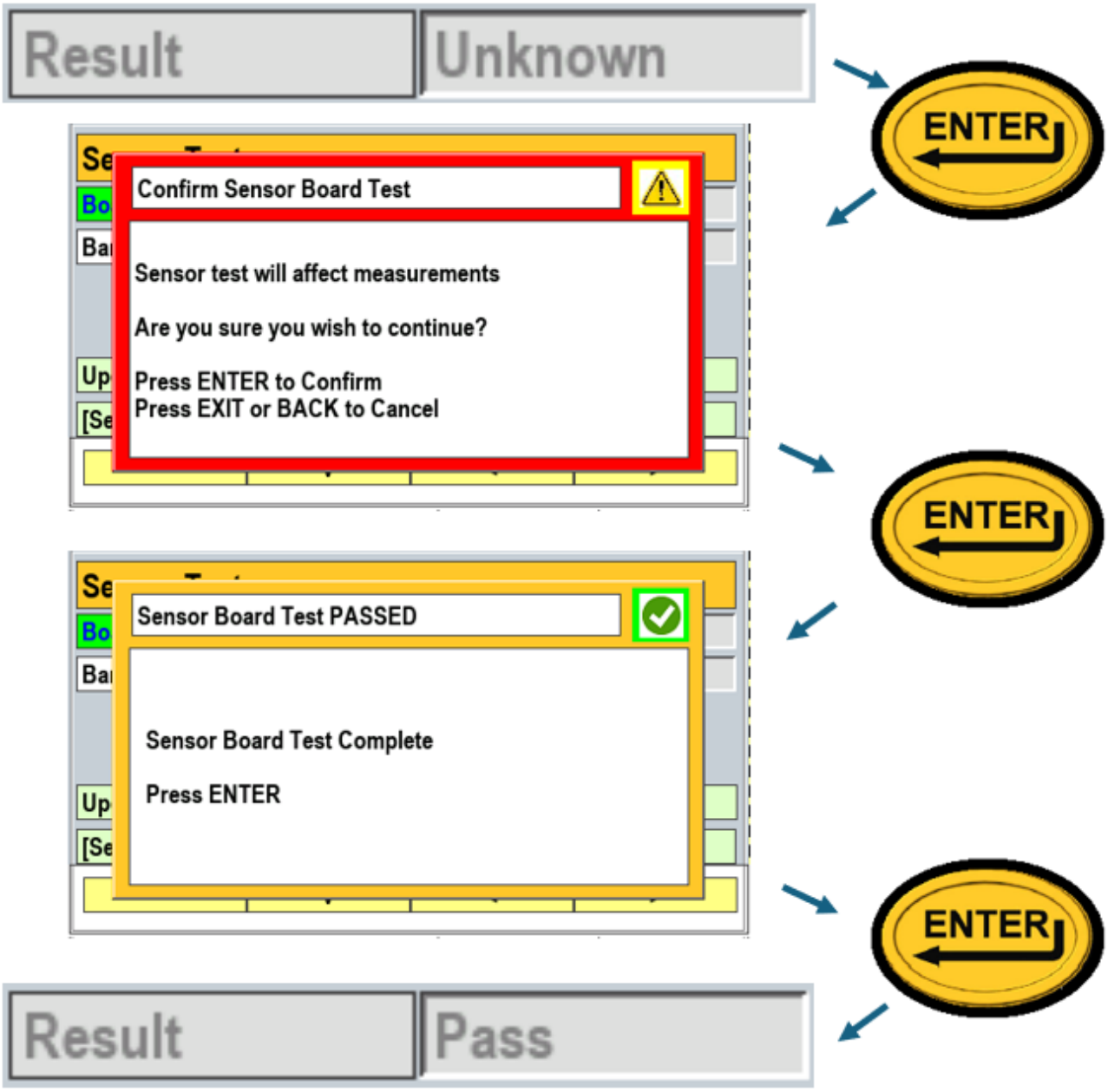


Figure 3-18: Pop-ups and Test Results

When running certain self-tests or RESETS (the example, above, is taken from the previous Sensor Board test example), pop-up messages warning of possible negative effects of continuing may pop up, giving you an option of not continuing. Also, other pop-ups telling you the results of the test (including which specific parts, if any, of the tests failed) may occur and require pressing ENTER again after you have read it. In some cases (like this one), the Result of the last time the test was performed will be indicated in the column on the right.

3.2 Menu Structure

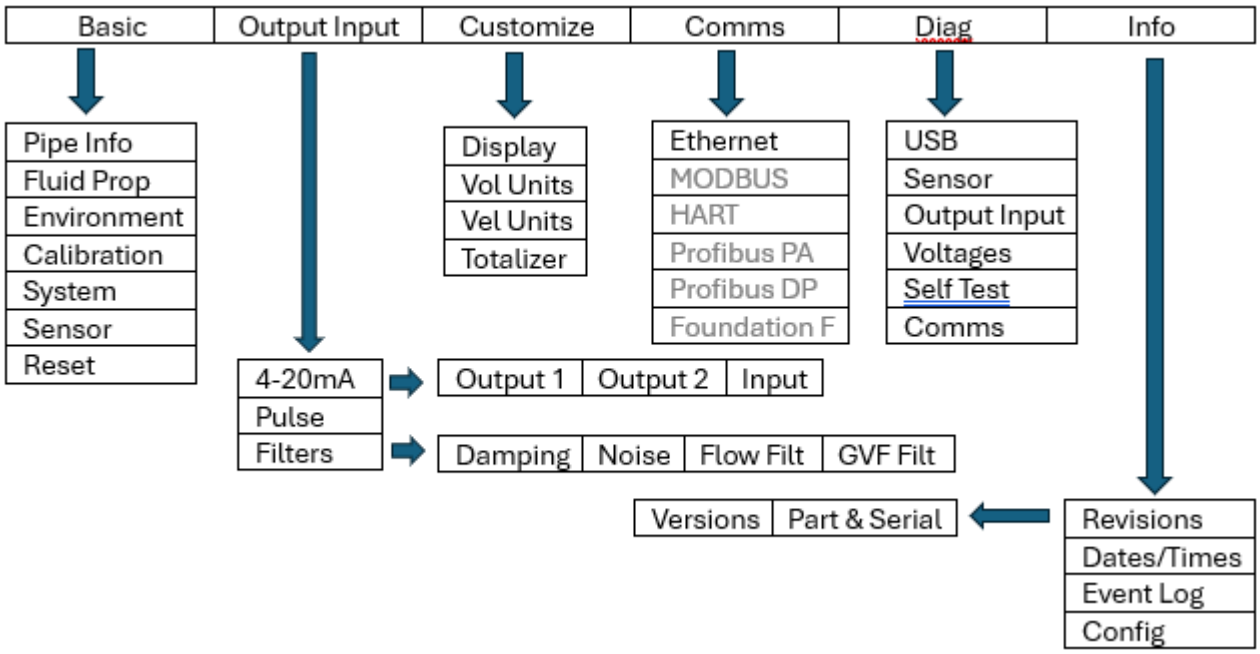


Figure 3-19: Menu Structure

In the menu structure, above, the 6 categories across the top are the top-level menus. The down arrows from each point to the sub-menus that appear when selecting those menus. The subsequent right or left arrows indicate an even lower level of sub-menu for some of the sub-menus. By selecting the lowest sub-menu, one or more screens of configuration or diagnostic parameters will be displayed according to the sub-menu which can be navigated as described earlier. In the subsequent discussions, a shorthand notation will be used to identify the sub-menu being discussed. For example, "*Info/Revisions/Versions*" is the shorthand for the sub-menu in the bottom-center of the Menu Structure, above, and describes how that submenu is reached by selecting the "Info" menu, then its "Revisions" sub-menu, then ITS "Versions" sub-menu.

Basic – Primarily includes configuration sub-menus for configuring the measurement system. Also, setting the date/time. Also, the resetting of everything that can be reset – except the TRANSMITTER itself. Also, some diagnostic info about the Sensor levels.

Output Input – Primarily includes configuration sub-menus for configuring the analog inputs and outputs (if used). Also, the trim procedures for the analog outputs.

Customize – Primarily concerns configuration sub-menus for configuring the layout of the display and for the units used both by the display and the other outputs. Also, includes configuring the Totalizer (if used).

Comms – Primarily includes configuration sub-menus for the communication interfaces: Ethernet, Modbus, HART, Profibus PA, Profibus DP, and Foundation Fieldbus. Note that the last 5 of those 6 interfaces are printed with a lighter shade of font to indicate that those sub-menus will not exist in every TRANSMITTER. In fact, typically there will only be Ethernet and one other sub-menu displayed, and the sub-menus not displayed will reflect that those interfaces are not available.

Diag – Includes sub-menus with diagnostic information (e.g. analog voltages, communication error counts), also self-tests, and USB memory stick operations (e.g. collecting diagnostic information and raw data or installing custom settings or new firmware versions).

Info – Includes sub-menus with static information about the system (e.g. firmware and hardware versions), also an event log (e.g. a time-stamped record of power on/off events and uses of the USB memory stick). Includes the sub-menu to identify which features in the software have been enabled.

Note that even SYSTEMs with model numbers that don't support GVF will typically have sub-menus for configuring the GVF-related parameters and drop-down lists that include GVF-related output options. In those situations, those drop-down list options will not work and the GVF-related configuration parameters will be ignored. Even for SYSTEMs with model numbers that DO support GVF, if the GVF-related functions (GVF, SOS, TLF) are not being used, then it is not necessary to configure the GVF-related parameters.

3.3 Operation

When not being configured or in a test mode and the Operational Mode display of *Figure 3-2* is present with the symbol in the upper-left corner rotating, the meter is running and computing flow and/or GVF results at a typical rate of once per second. There is a startup time of up to 25 seconds before the first in-range flow rate will be reported. Rated accuracy is not achieved until the system has thermally equilibrated – approximately 30 minutes after power-ON.

3.3.1 System Configuration

Initial configuration should be performed before the SYSTEM is an active part of the plant's control loop. Subsequent adjustment of the configuration should start with notifying Control Room Personnel because those adjustments will potentially affect the SYSTEM outputs during and/or after such adjustments.

3.3.1.1 Configuring the pipe

In sub-menu *Basic/Pipe Info*, pipe dimensions may be selected from a list of common Size+Schedule or Size+SDR pipe sizes or entered numerically as pipe diameter and wall thickness in inches or millimeters. Note that the Size+Sched and Size+SDR lists are not exhaustive and are in sequential order of nominal pipe size, but not necessarily in numerical order of wall thickness and include multiple separate names for pipes with identical dimensions (e.g. STD and SCH 40). Also, the Size+SDR list can only be used if the Material of the pipe is selected to be HDPE. Continuously holding down the up-arrow or down-arrow is an alternative to the many individual clicks it would take to get through the long lists. Tubing, thick-walled pipe, metric pipe, and non-standard pipe will need to have their dimensions entered numerically. If there is a pipe liner, the liner thickness must be entered. The GVF equations do not account for the effects of the pipe liner, so the GVF accuracy is reduced for lined pipes.

Parameter "Pipe ID" is what the meter will use to convert linear velocity to volumetric flow rate, so for volumetric flow measurement accuracy, it must be set correctly – either directly set or indirectly set as a result of entering the correct "Pipe OD", "Wall Thick", and "Liner Thick" values. For unlined pipe, "Pipe ID" is the inside diameter of the pipe. For lined pipe, "Pipe ID" is the inside diameter of the lining. Make certain that "Pipe ID" is correct before leaving this sub-menu.

For GVF, both the Pipe OD and the wall thickness must be set correctly. The Modulus must also be correctly set for GVF, but Modulus is not used in the flow calculation. The Modulus of some common materials can be selected automatically by selecting from the Material drop-down list, or it can be entered numerically by selecting "Custom" from the Material list.

The menu either calculates the Pipe ID or the Pipe OD from the other entered parameters. It will never calculate wall thickness or liner thickness based on entered Pipe OD or Pipe ID. There are clues to which calculation it is going to perform (described below), but it can do unexpected things such as increasing the calculated Pipe OD in response to an entered increase in the Liner Thickness. It is safest to follow one of the following 6 entry sequences.

A) If you know the OD of the pipe, the wall thickness, and the liner thickness, enter them in this order:
    a. Pipe OD
    b. Wall Thick (Enter the wall thickness of the unlined pipe)
    c. Liner Thick

B) For lined pipe if you know the ID of the liner, the wall thickness of the unlined pipe, and the liner thickness, enter them in this order.
    a. Pipe ID (Enter the ID of the liner)
    b. Wall Thick (Enter the wall thickness of the unlined pipe)
    c. Liner Thick

C) For lined pipe, if you know the ID of the pipe without the liner, the wall thickness of the pipe, and the liner thickness, enter them in this order.
    a. Pipe ID (Enter the calculated result of the actual Pipe ID of the unlined pipe less 2x the liner thickness)
    b. Wall Thick (Enter the wall thickness of the unlined pipe)
    c. Liner Thick

D) If you know the ANSI pipe size and schedule of the pipe, you can look for it in the Size+Sched dropdown list (so long as it's not an HDPE pipe). Note that for lined pipe, the Pipe ID displayed after your selection will be the ID of the liner. Enter the parameters in this order.
    a. Liner Thick
    b. Size+Sched (Select one from the drop-down list and then press Enter)

E) If you know the Size and SDR of the pipe, select it from the Size+SDR drop-down menu. The only way to access the Size+SDR menu is to select Material type HDPE. If you only care about flow measurement and not GVF, then you can just use the HDPE Material selection and its default Modulus. If you care about GVF and the pipe is not HDPE and/or the default modulus for selecting HDPE is not accurate, then you will not be able to use the Size+SDR drop-down menu and will instead need to enter the dimensions numerically either from a table or from having previously written down the dimensions from the HDPE Size+SDR drop-down list. Note that making a selection in the Size/SDR menu and then changing the Material type to something other than HDPE will switch back to the Size+Sched menu and change your pipe dimensions. If using the Size+SDR menu, enter the parameters in this order.
    a. Liner Thick
    b. Size+SDR (Select one from the drop-down list and then press Enter)

F) If you've begun the entry process by using the Size+Sched or Size+SDR dropdown list and want to tweak the values from those that resulted from that selection, the safest thing to do is to decide which of Pipe ID or Pipe OD that you DON'T expect to change, do the tweaks to Wall Thick and/or Liner Thick as desired, then if your parameter changed unexpectedly, re-enter numerically that recorded value for that Pipe ID or Pipe OD parameter. If you change Pipe OD or Pipe ID, expect the other of those two parameters to change accordingly.

If the background color for Pipe ID and Pipe OD numeric entries is different, then the parameter with the lighter-colored background will be held constant while the parameter with the darker-colored background will be recalculated when you change Wall Thick or Liner Thick. If you make a selection from the drop-down lists of either Size+Sched or Size+SDR, then both Pipe ID and Pipe OD will have the darker-colored background and it will be unclear which parameter will be held constant and which will be recalculated. If you then select the parameter (Pipe ID or Pipe OD) that you want to be held fixed, and click Enter twice (once to jump to the mode wherein it can be numerically entered and a second time to lock in that value without changing it) then that parameter's background will change to the lighter color.

3.3.1.2 Configuring the pipe contents

In sub-menu *Basic/Fluid Prop*, the only parameters necessary for volumetric flow rate are the dynamic viscosity and the specific gravity (the density in g/cm^3) of the liquid or slurry. The default values are those of pure water at 1 atmosphere (14.7psia, 101.325kPa) and 25°C (77°F). For a fluid other than pure water or to reflect different conditions, the dynamic viscosity and specific gravity will need to be entered numerically – which, for Specific Gravity, requires first changing the fluid entry in the right-hand column to "Custom".

To measure GVF, the additional parameters needed are the Speed of Sound of the bubble-free liquid or slurry, the Gas Constant of the gas and the Ratio of Specific Heats for the gas. Sub-menu *Basic/Fluid Prop* allows for the entering of the Speed of Sound of the bubble-free liquid or slurry. The default value is that of pure water at 1 atmosphere (14.7psia, 101.325kPa) and 25°C (77°F). For a fluid other than pure water or to reflect different conditions, the Speed of Sound of the bubble-free liquid or slurry will need to be entered numerically - which requires first changing the fluid entry in the right-hand column to "Custom". There is no ability to change via the front panel the Gas Constant of the gas and the Ratio of Specific Heats for the gas. The gas defaults are those for dry air (21% oxygen, 78% Nitrogen,0.93% Argon, 0.04% Other – primarily Carbon Dioxide: percents by volume) at 1 atmosphere (14.7psia, 101.325kPa) and 25°C (77°F). Specifically, the default Gas Constant is 287J/(kg*K) and the default Ratio of Specific Heats is 1.4. If alternate values for Gas Constant and Ratio of Specific Heats are desired because the bubbles in the fluid are other than dry air or to reflect different temperature and pressure conditions, contact Customer Support for assistance in setting those values.

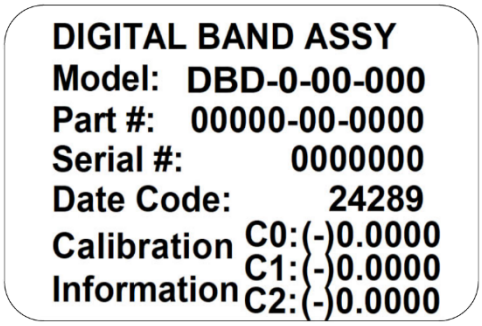
An additional parameter for improved accuracy of GVF measurement is the "polytropic exponent" which is a parameter related to the assumed bubble size distribution. The default assumption is that the polytropic exponent is equal to the

Ratio of Specific Heats (the so-called “isentropic case”, which is an assumption of bubble sizes on the larger end of the spectrum). This parameter cannot be changed via the front panel. If there is reason to change the polytropic exponent, contact Customer Support.

Also, for GVF, the pressure and temperature of the fluid need to be entered either as constants or linked to either the 4-20mA input or to one of the digital busses for dynamically updated values. Altitude is required to relate a gauge pressure to an absolute pressure. To make these selections, go to sub-menu *Basic/Environment* – where you can also select the units for temperature and pressure. The options there are “Fixed” (in which case just enter a constant pressure and/or temperature on this same sub-menu); “4-20mA Input” (which requires configuring the 4-20mA input on sub-menu *Output Input/4-20mA/Input* per the instructions in section 3.3.1.5, below); “MODBUS” (which requires writing to the Modbus registers as defined in section 3.3.1.12, below); or “Protocol” (which means by way of one of the Modular Communications options which requires a level of configuration of Profibus DP, Profibus PA, or Foundation Fieldbus which is beyond the scope of this manual – see Customer Support).

3.3.1.3 Configuring the BAND(s)

The BAND is delivered with a small plastic bag of adhesive labels that includes information that must be entered as configuration parameters. In previous steps in this manual, there were recommendations about where to adhere those labels so that the information could be found to enter into the TRANSMITTER at this configuration step.



There should be one such label on the MODULE, another on the side of the TRANSMITTER, and three spare labels left from the original 5 that were in the small plastic bag. Some BAND information is also found on a label on the BAND’s umbilical cable next to the D-sub connector.

At sub-menu *Basic/Calibration*, enter the 3 calibration coefficients (C0, C1, and C2) from that label (not the zeroes in the example label shown above) into the TRANSMITTER. They are used for Reynold’s number correction of flow rate. Like other flow meters, this meter’s accuracy claims are based on certified test facilities’ tests using water. The calibration’s validity holds for other homogeneous Newtonian fluids and slurries over the same range of Reynold’s numbers. These calibration coefficients are not used to correct the SOS or GVF measurements.

At sub-menu *Basic/Sensor*, enter the BAND serial number. Note that if there are two BANDs for a large-diameter pipe, it doesn't matter which serial number is entered.

The BANDs have arrows painted on them indicating the assumed flow direction. At sub-menu *Basic/Sensor*, the configuration parameter for the actual flow direction needs to be entered as "forward" if the flow is in the direction of the arrow or "reverse" if not. If unsure whether the BANDs are oriented the right way, you may need to initially experiment with this configuration parameter after the normal flow conditions are established in the pipe to see which is the correct setting.

NOTE: The sensor spacing of the 8 sensors on the pair of BANDs on the large diameter pipes is double that of the spacing for smaller pipes with single BANDs and that special spacing needs to be configured in the TRANSMITTER firmware for proper operation, but there is no way to configure it via the keypad. **CONTACT CUSTOMER SUPPORT FOR HELP IN CONFIGURING THE FIRMWARE FOR SYSTEMS WITH TWO BANDS.**

IT IS IMPORTANT THAT THE BANDS BE CONNECTED INTO THE PROPER D-SUBS OF THE Y-CABLE. THERE IS NO SOFTWARE CORRECTION FOR AN IMPROPERLY CONNECTED Y-CABLE.

3.3.1.4 Configuring the Gain

Sub-menu *Basic/Sensor* is where the Gain of the electronics in the MODULE can be set according to the signal levels of the sensor BAND. Those signal levels vary with pipe parameters and flow rate. The selection box "Gain Option" has 3 choices: "Auto Gain", "Manual", and "One Time". If "Auto Gain" is selected, then the "Gain" row below it will change to say "Auto Gain" and will show the gain that is currently being applied but will be grayed out to prevent manually setting the gain. The meter will automatically change gains according to changes in the signal levels. When a gain change occurs, it may cause a disturbance in the computed flow – though in most cases the disturbance will be small and possibly undetectable. If this is unacceptable, then the gain can be set manually – which is the default state.

Choosing "Manual" from the "Gain Option" selection box allows a selection from the "Gain" box, below, of one of 7 fixed Gain levels. The manual Gain level selection should be made at a time when the flow rate is typical and should be chosen such that the min and max signal levels are in the range of +/-2000 to +/-8000 (full-scale is +/-32768). The "One Time" selection is a one-time function that for only a short time allows the "Auto Gain" function to select the Gain, accordingly, but then revert to "Manual" after the Gain is selected.

On the right-hand side of the first page of the *Basic/Sensor* sub-menu is a summary of the largest Max and smallest Min of all 8 channels. This can be used when manually selecting a fixed Gain. On the following 2 pages of the sub-menu are the individual channels' Mins and Maxes which can be used, diagnostically, to see if there is an errant sensor channel behaving differently from the rest.

3.3.1.5 Configuring the 4-20mA Analog Outputs and Input

Analog Outputs – Configure each of the two separately

Use the sub-menu corresponding to the Analog Output being configured: *Output Input/4-20mA/Output 1* or *Output Input/4-20mA/Output 2.*

For the two 4-20mA Outputs, if used, on the first page of the sub-menu select the parameter that it is outputting, and what the 4mA and 20mA levels correspond to in the units of that parameter.

The “Over Range” parameter determines what current to output when the SYSTEM is unable to make a valid measurement. Options include: 4mA (default), less than 4mA, greater than 20mA, or to hold the output current of the last valid measurement.

The “Rail” parameter has 2 options: Disable (default) or Enable. In “Disable”, an otherwise valid measurement outside of the range covered by the 4-20mA output current range will result in the output current as selected by the “Over Range” parameter, above. In “Enable”, an otherwise valid measurement that would otherwise report in excess of 20mA will report 20mA, while measurements that would otherwise report less than 4mA will report 4mA.

On the second page of the sub-menu, the output can also be trimmed to make it match the actual output current as measured by the customer’s equipment. When the “Trim” function is launched, pop-up windows with step-by-step instructions will appear.

Analog Input

In sub-menu *Output Input/4-20mA/Input*, the 4-20mA Input, if used, the parameter that was selected to be linked to that 4-20mA Input (when sub-menu *Basic/Environment* was configured) will be shown in brackets at the top of the sub-menu page. The units shown in parentheses with the “Low” and “High” parameters will be the units that were selected in sub-menu *Basic/Environment*. Select what values of that parameter the 4mA and 20mA currents correspond to. Since there is no “Trim” function for the Analog Input, any desired trimming must be incorporated into the assignment of the values corresponding to 4mA and 20mA. Also, choose whether to enable a one pole low-pass filter for that input, and what time constant to use with it. The defaults are “Disable” and tau equals 30 seconds.

3.3.1.6 Configuring the Pulse Output

For the Pulse Output, if used, will have the units that were selected in sub-menu *Customize/Vol Units*. Use sub-menu *Output Input/Pulse* to select the parameter to associate with the pulse output, the multiplier of those units, and the cutoff below which there will be no output pulses. There are 5 choices for pulse width ranging from 1 to 500 milliseconds. There is a limitation of a maximum 50% duty cycle output, so the pulse width choice limits the maximum pulse rate to 5 choices between 500 and 1 pulse per second which is reflected in the maximum possible parameter value shown at the top of the right-most column.

3.3.1.7 Configuring the Filters

Measurement Filters (Flow and GVF)

There are two types of filter available for application to the flow and GVF measurements, and both are based on a single-pole low-pass filter ($1-e^{-t/tau}$).

A Damping filter with a constant tau is available. The default is enabled with a tau of 6 seconds, but it can be disabled or the tau changed from the keypad. Sub-menu *Output Input/Filters/Damping* includes the controls for both Flow and GVF.

The Noise-Reduction ("NR") filter has a variable tau depending on how much the current un-filtered measurement differs from the previous filtered measurement. A piecewise linear function of tau versus that difference can be configured for 2 cases, "Low", and "High". *Figure 3-21*, below, shows tau versus that difference for the NR filter and for the Damping filter. The NR filter defaults to disabled and Low, but it can be changed to enabled and also to High from the keypad and can be enabled either with or without the Damping filter also being enabled. The purpose of the NR filter is to aggressively smooth the flow measurement readings in the condition of unchanging or slowly changing flow rate, but to allow a more rapid reaction to significant rapid changes in the flow rate than would otherwise be achievable with a fixed tau. Sub-menu *Output Input/Filters/Noise* includes the controls for both Flow and GVF. The shape of the Low and High curves is changeable, but not from the keypad. Contact Customer Support if customization of those curves is required.

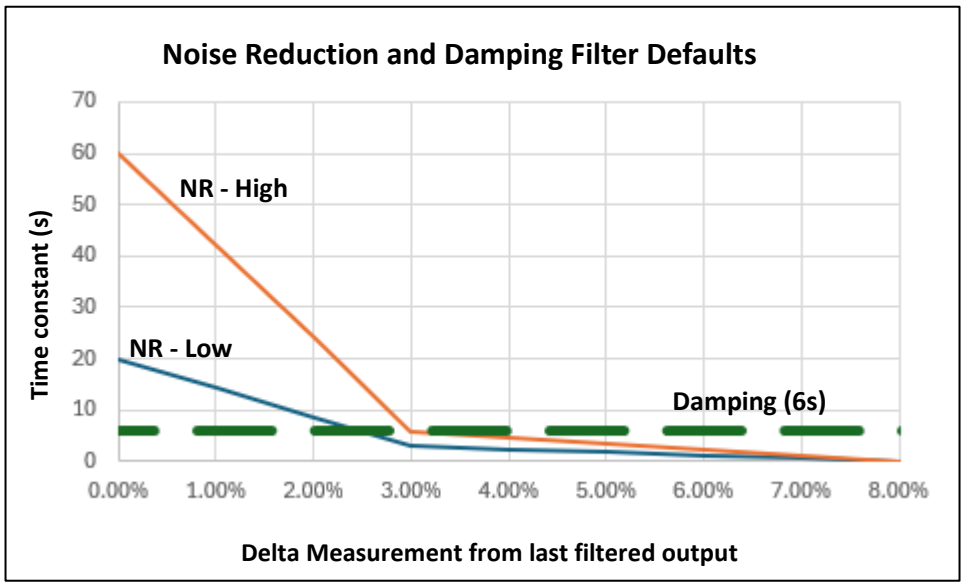


Figure 3-21: Noise Reduction and Damping Filter Defaults

Quality Filters (Flow and GVF)

The SYSTEM measures flow by sensing and interpreting the acoustic signals caused by the moving fluid. Those signal levels decrease as the flow decreases. The SYSTEM can't measure flow all of the way down to zero flow. The SYSTEM must also reject interfering acoustic noise signals (pumps, valves, vibration, other) which presents a varying degree of challenge depending on the amplitudes and frequency content of those noise signals. A parameter called "Quality" is calculated along with each measurement and gives an indication of the signal-to-noise level of the acoustics after processing. It is typically a positive number between zero and one (but "-1.0" indicates an inability to calculate the flow measurement, and "-2.0" indicates extremely low sensor signal levels). The low signal level threshold is determined by the minimum SPL setting which cannot be changed from the front panel (contact Customer Support for further information). The calculated measurement "Quality" must exceed a minimum threshold for the flow or GVF measurement to be considered valid. This minimum threshold Is factory set and is not adjustable from the front panel. A Quality Filter function is enabled by default to deal with low Quality in a phased way such that for short-duration episodes of low Quality, the SYSTEM first continues to report the last value with acceptable Quality for a while, and if the flow measurement Quality again becomes acceptable soon enough and consistently enough, then to resume reporting current flow measurements. Else, it eventually goes to the No Flow state (display showing "---"). One of the main purposes for this Quality filter is to address the situation of no fluid flow wherein without this filter, random non-zero flow measurements might be reported due to non-flow-related acoustic signals detected by the BAND. There is a separate but similar Quality filter for GVF with the same default settings. Both of these Quality filters default to Enabled and they can be disabled from the keypad but it is recommended that they remain enabled. There are multiple parameters that affect the particulars of the operation of the Quality filters when enabled and it is recommended that they not be changed from their defaults without first consulting with Customer Support. With the default parameters, the SYSTEM will respond to low Quality measurements by holding the most recent good Quality measurement for between 2 and 10 samples – depending on the pattern of good and bad Quality measurements – before either going into the No Flow State or resuming the display of current good-quality measurements. 4 sequential bad Quality measurements will quickly put it in the No Flow State. Once in the No Flow State, 4 sequential good quality measurements are required before it resumes outputting current good-quality measurements. Though the default filter settings are the same, the Flow and GVF Quality filters can be configured separately (with parameters on 2 pages) via these sub-menus: *Output Input/ Filters/Flow Filt* and *Output Input/ Filters/GVF Filt*. Contact Customer Support if the behavior of the Quality Filters requires changes from the default settings.

3.3.1.8 Configuring the Date/Time

Use sub-menu *Basic/System* to set the time, the date, and the date format of the local clock. This local clock is used for the time stamps in all of the snapshot files. Note that the local clock has battery backup so it will not reset when power is removed from the TRANSMITTER. However, it has no time reference external to

the TRANSMITTER so it does not automatically correct for daylight savings time, and it will tend to drift somewhat over time.

3.3.1.9 Configuring the Display

Use sub-menu *Customize/Display* to custom configure the display as to what parameter is displayed on either of the first 2 rows. Choices include “Flow Rate” (which assumes a liquid with no bubbles); “TLF” (True Liquid Flow is the flow rate of just the liquid after removing the measured volume of the bubbles); “Velocity” (the linear velocity of the fluid flow rather than the volumetric flow rate); “SOS” (Speed of Sound of the liquid/gas mixture at process conditions); “GVF” (Gas Void Fraction of the liquid/gas mixture at process conditions – derived from SOS and various entered parameters); “Total” (the Totalizer sum of the flow measurements – Flow Rate, or TLF – since the last time that the Totalizer was reset to zero; see Totalizer configuration, below); and “Band Temp” (the temperature of the thermistor on the sensor BAND on the OD of the pipe which is an approximation of the temperature of the fluid in the pipe). Note that TRANSMITTER models that do not include the GVF-related software will not permit choosing the following options: “TLF”, “SOS”, or “GVF”. Note that a valid SOS/GVF measurement is required to produce a TLF value.

On sub-menu *Customize/Display,* the display brightness can be reduced (the default is 100% brightness).

There is a self-test for the display that generates color bars. It is found at sub-menu *Diag/Self Test* where it’s called “Screen”.

To Write Protect the configuration of the Display (and all of the other configurations) go to sub-menu *Basic/System* and look for “Protect”. It defaults to “Disable”. When changed to “Enable” it prevents any of the previously configured parameters from being changed. An error message will pop up if an attempt is made to change a parameter. Changing the Write Protect option back to “Disable” will again allow parameters to be changed. Consider Enabling “Protect” after all of the configuration is complete as a means to prevent unintentional changes to the configuration. However, note that when Protect is Enabled, it does not prevent the installation of a new configuration file via USB stick – which configuration file might also include disabling the Protect feature.

Also, in sub-menu *Basic/System* under “Undetermined” is the ability to select how the system treats “Undetermined” values (computed Flow or GVF values that are outside of the allowed range, or values with an associated Quality below the minimum Quality threshold). There are 2 options: “Bad” (default) or “Zero”.

	“Bad”	“Zero”
Display	“---"	0
Data History	NaN	0
4-20mA Outputs	Over Range	0
HART	NaN	0
MODBUS	NaN	0

Table 3-1: "Bad" versus "Zero" for "Undetermined"

Note: NaN is the code for “Not a Number”

Notes re: 4-20mA outputs:

- Over Range - means the output current as defined by the 4-20mA output configuration parameter named “Over Range” as set, above.
- 0 - this means the non-zero mA current for whatever the 4-20mA output configuration parameters equate with the parameter value being zero

3.3.1.10 Configuring the Units

Use sub-menu *Customize/Vol Units* to select the units used for volumetric flow rate. In the top row of each column, selecting “Custom” will allow editing the other 3 corresponding rows – if required.

Use sub-menu *Customize/Vel Units* to select the units used for velocity and Speed of Sound.

3.3.1.11 Configuring the Totalizer

The Totalizer function integrates the flow rate to give total volume. If used, it must be configured. In sub-menu *Customize/Totalizer* there is a choice of which flow rate to use (“Flow Rate” assumes no bubbles; “TLF” is True Liquid Flow and uses the measured Gas Void Fraction to remove the bubble volume from the reported volumetric flow rate), what units to convert the integrated flow to (with a multiplier option), and the specification of a Low Cut value of the instantaneous measured flow rate below which (if Enabled – default is Disabled) not to add to the total. Go to sub-menu *Basic/Reset* to reset the Totalizer to zero.

3.3.1.12 Configuring the Modbus interface

Not all TRANSMITTERS will have the Modbus interface enabled. Modbus will typically be disabled on TRANSMITTERS with any of the 3 Modular Comms options (Profibus DP, Foundation Fieldbus, or Profibus PA) or those with the HART interface enabled. To confirm whether the Modbus is enabled, see the sub-menu *Info/Config*. If the Modbus interface is disabled, the J6-1 and J6-2 terminals will be non-functional for any RS-485 purpose.

The Modbus interface, if used, must first be configured. This can be done from the sub-menu *Comms/MODBUS.* Set the bus Address, Baud Rate, Data Width, Parity, and Stop Bits in consideration of the other devices sharing this bus. The “Swap” setting is discussed, below. Note that the Modbus interface is always RTU, not ASCII.

The Modbus register addresses are all odd and 16-bits wide. For reading and writing 32-bit hexadecimal numbers, those odd addresses are inclusive of the next even address. The Input registers contain 32-bit floating point numbers that use both registers. The Holding registers must be written to as 32-bit Long Integers, but the resulting setting is based only on the 16-bit value in the (first) odd-numbered address. Hence, writing that 32-bit Long Integer must be done in a way that puts those critical selection bits into the odd-numbered address.

Modbus uses a “big-Endian” representation (wherein the first 8-bit byte of each 16-bit word is treated as the most-significant byte), and there is no way with this product to change that to “little-Endian” instead. In “big-Endian” representation, writing the 32-bit hexadecimal number 0x12345678 to the odd Modbus register address results in “1234” in the odd address and “5678” in the following even address. However, there is an option to do a word swap that puts “5678” in the odd address and “1234” in the even address. There is a selection parameter in the *Comms/MODBUS* sub-menu called “Swap” and identified as “32 Bit Register Set”. The options are “MS Reg First” (default) and “LS Register First”. Selecting “LS Reg First” will put the least-significant 16-bit word in the odd register address and the most-significant word in the next even register address. With this background information and knowledge of the settings of the other devices sharing the bus, select the appropriate setting for the ”Swap” parameter.

In-depth discussion of the Modbus interface and the full set of registers is beyond the scope of this Basic manual.

Diagnostics for the Modbus interface can be found on the first page of the sub-menu *Diag/Comms.*

To reset the counters in the Modbus diagnostics, go to sub-menu *Basic/Reset.*

The Modbus interface defaults to a power-Enabled state and even if not used cannot be disabled from the front panel.

*Table **3-2*** shows the most commonly used Modbus registers.

Table 3-2: Basic Modbus Registers

	Address	Size	Type	Value	Description	Notes
Modbus Input Registers (Read-Only)	7601	2	Float	Display VF	Flow Rate as it appears on the LCD.	See Note 1.
	7609	2	Float	Display TLF	TLF as it appears on LCD.	See Note 1.
	7605	2	Float	Display GVF (%)	GVF as it appears on LCD.	See Note 1.
	7603	2	Float	Display SOS	SOS as it appears on LCD.	See Note 1.
	7003	2	Float	Velocity (ft/s)	Measured flow rate in ft/s without any filtering applied.	
	7019	2	Float	TLF (ft/s)	Measured TLF in ft/s without any filtering applied.	
	7017	2	Float	GVF (%)	Measured GVF in %.	
	7011	2	Float	SOS (ft/s)	Measured SOS in ft/s without any filtering applied.	
	7023	2	Float	Velocity Filtered (ft/s)	Filtered Flow Rate in ft/s	
	7233	2	Float	TLF Filtered (ft/s)	Filtered TLF	
	7027	2	Float	GVF Filtered (%)	Filtered GVF in %.	
	7025	2	Float	SOS Filtered (ft/s)	Filtered SOS in ft/s	
	7007	2	Float	VF Quality	Measured flow quality.	
	7015	2	Float	SOS Quality	Measured SOS quality.	
	7615	2	Float	VF Totalizer	Total Flow.	
	7619	2	Float	TLF Totalizer	Measured total TLF.	
	7039	2	Float	Pressure	Pressure as used in calculation of GVF in configured units.	
	7041	2	Float	Temperature	Temperature as used in calculation of GVF in configured units.	
	7143	2	Float	Band Temperature	Temperature measured by the sensor BAND.	
Modbus Holding Registers (Read/Write)	3107	2	Long Int	Temperature Units	Selects units used for input of 'SOS Process Temperature' degrees.	0 = C, 1 = F
	3109	2	Long Int	Pressure Units	Selects units used for input of 'SOS Process Pressure'.	0 = PSIg, 1 = kPAg, 2 = BARg
	3019	2	Long Int	Volume Units	Selects units used to display and log flow volume.	0 = m^3, 1 = l, 2 = gal, 3 = m, 4 = ft, 5 = iga, 6 = ft^3, 7 = user
	3027	2	Long Int	Time Units	Selects units used to display and log flow time.	0 = d, 1 = h, 2 = m, 3 = s, 4 = user
	3035	2	Long Int	SOS Units	Selects units used to display and log SOS.	0 = ft, 1 = m
	3049	2	Long Int	Totalizer Units	Selects units used to display and log total flow.	0 = gal, 1 = m3, 2 = ft3, 3 = l, 4 = VF_VOL_UNITS
	3053	2	Long Int	Totalizer Multiplier	Selects totalizer multiplier.	0 = 1, 1 = k, 2 = M

Note 1: Will be set to QNAN when not displayed and in “Bad Reading” mode. Will be set to zero (0) if in “Zero” mode for undetermined value.

Note that for parameters VF, GVF, SOS, and TLF, each has 3 Modbus parameter option prefixes: Display, Filtered, and <blank> (meaning Raw). The Raw and Filtered values are in specific unchangeable units (ft/s for rates or % for GVF) and are numbers if it is possible to calculate a number. The Filtered values differ from the Raw values in that they have the user-selected filters applied – and include Reynolds number corrections for VF and TLF. The Display parameters reflect what the DTX-1 TRANSMITTER display is reporting, including other than numeric values if they are out of range or if the associated Quality is low (see the "Undetermined" selection in section 3.3.1.9), and does so in whatever units the user has selected in *Customize/Vol Units* and *Customize/Vel Units* (see section 3.3.1.10).

3.3.1.13 Configuring the HART interface

Not all TRANSMITTERS will have the HART interface enabled. HART will typically be disabled on TRANSMITTERS with any of the 3 Modular Comms options (Profibus DP, Foundation Fieldbus, or Profibus PA) or those with the Modbus interface enabled. To confirm whether the HART is enabled, see the sub-menu *Info/Config*. If the HART interface is disabled, the 4-20mA Analog Output #1 (terminals J8-2, J8-3, and J8-4, as defined in section 2.5.6.4.1) will still provide a 4-20mA output, but will not communicate via HART.

The HART interface, if used, must first be configured. This can be done from the sub-menu *Comms/HART.*

In-depth discussion of the HART interface is beyond the scope of this Basic manual. See Customer Support for further information and DDL (Device Description Language) files.

Diagnostics for the HART interface can be found on the second page of the sub-menu *Diag/Comms.*

To reset the counters in the HART diagnostics, go to sub-menu *Basic/Reset.*

Keep in mind that only the 4-20mA Analog Output 1 has the HART functionality.

Note that for TRANSMITTERs with the optional Foundation Fieldbus or Profibus PA interface (DTX model numbers that include "-FF-" or "-PA-") even if the HART interface is enabled, the HART interface cannot actually be used.

3.3.1.14 Configuring the Ethernet interface

Note that the Ethernet interface is for diagnostic purposes and will typically only be used for short times by Service personnel and typically only with special CiDRA software tools. It implements a proprietary protocol that is not described in this manual and does not have the option of an industry-wide protocol such as Modbus TCP. If used, it must first be configured. This can be done from sub-menu *Comms/Ethernet.*

Diagnostics for the Ethernet interface can be found on the sixth page of the sub-menu *Diag/Comms* under "TCP/IP".

To reset the counters in the Ethernet diagnostics, go to sub-menu *Basic/Reset.*

3.3.1.15 Configuring the Profibus PA interface

The optional Modular Comms interfaces that are not part of the basic SYSTEM are beyond the scope of this manual. Their configuration is typically done by the customer's Host system and doesn't require configuration via front-panel of the DTX-1. See Customer Support for additional information and for the DDL (Device Description Language) files.

To check whether the Modular Communications interface is enabled, use sub-menu Info/Config (in which it will be identified as "Fieldbus").

Diagnostics for the Modular Comms interface can be found on the fourth page of the sub-menu *Diag/Comms* under "Modular I/O".

To reset the counters in the Modular Comms diagnostics, go to sub-menu *Basic/Reset.*

That said, if the TRANSMITTER has the appropriate board installed and the Fieldbus feature key enabled, there will be a sub-menu *Comms/Profibus PA*. In that sub-menu, there is a status parameter called "Power". If it says "Power OFF", that means that it is not connected to a powered bus and will not be functional. If it says "Power ON", that means that it detects that it is connected to a power bus, but it doesn't mean that there is any activity on that bus (essentially the same information as is embedded in the darker of the 2 Profibus PA logos on the Operational Mode display).

3.3.1.16 Configuring the Foundation Fieldbus interface

The optional Modular Comms interfaces that are not part of the basic SYSTEM are beyond the scope of this manual. Their configuration is typically done by the customer's Host system and doesn't require configuration via front-panel of the DTX-1. See Customer Support for additional information and for the DDL (Device Description Language) files.

To check whether the Modular Communications interface is enabled, use sub-menu Info/Config (in which it will be identified as "Fieldbus").

Diagnostics for the Modular Comms interface can be found on the fourth page of the sub-menu *Diag/Comms* under "Modular I/O".

To reset the counters in the Modular Comms diagnostics, go to sub-menu *Basic/Reset.*

That said, if the TRANSMITTER has the appropriate board installed and the Fieldbus feature key enabled, there will be a sub-menu *Comms/Foundation F*. In that sub-menu, there is a status parameter called "Power". If it says "Power OFF", that means that it is not connected to a powered bus and will not be functional. If it says "Power ON", that means that it detects that it is connected to a power bus, but it doesn't mean that there is any activity on that bus (essentially the same information as is embedded in the darker of the 2 Foundation Fieldbus logos on the Operational Mode display).

3.3.1.17 Configuring the Profibus DP interface

The optional Modular Comms interfaces that are not part of the basic SYSTEM are beyond the scope of this manual. Their configuration is typically done by the customer's Host system and requires little to no configuration via front-panel of the DTX-1. Note that there are 3 versions of Profibus DP: V0, V1, and V2 (successively more complex, but backwards compatible). The TRANSMITTER supports version V1. See Customer Support for additional information and for the DDL (Device Description Language) files.

To check whether the Modular Communications interface is enabled, use sub-menu Info/Config (in which it will be identified as "Fieldbus").

Diagnostics for the Modular Comms interface can be found on the fourth page of the sub-menu *Diag/Comms* under "Modular I/O".

To reset the counters in the Modular Comms diagnostics, go to sub-menu *Basic/Reset.*

That said, if the TRANSMITTER has the appropriate board installed and the Fieldbus feature key enabled, there will be a sub-menu *Comms/Profibus DP*. In that sub-menu, there are 2 possible configuration actions (change the bus address, or reset the Transmitter's Profibus DP interface to defaults), and 5 status parameters. If the parameter called "Status" indicates "Active", then that conveys the same information as the darker of the 2 Profibus DP logos on the Operational Mode display.

3.3.2 Performing Self-tests

These tests can be done as part of the initial commissioning to see if everything is OK, or for diagnostic purposes later to confirm a fault and to fault-isolate, or post-repair to verify that the SYSTEM has been returned to functionality.

The "Board" test is a test of the electronics in the MODULE and doesn't require a functioning (or even an attached) BAND. The "Band" test involves a test of both the BAND and the electronics in the MODULE. If the "Board" test passes and the "Band" test fails, it points to a BAND failure. If there is a USB memory stick installed in the TRANSMITTER when either test is run, then at the end of the test there will be an option to save the test results to the USB stick. Those test results may be of value to Customer Support in diagnosing problems. Both of these tests can be found in sub-menu *Diag/Sensor.*

The tests of the Analog Outputs allow them to be commanded to a defined state regardless of the flow or GVF measurements so that their functionality can be independently confirmed using external test equipment. The tests for both 4-20mA Analog Outputs and the Pulse output can be found in sub-menu *Diag/Output Input.*

The test of the 4-20mA Analog Input is an indication of the current in milliamperes being measured by the TRANSMITTER and that can be compared with a current

measurement using external test equipment to confirm functionality. The tests for the 4-20mA Analog Input can be found in sub-menu *Diag/Output Input.*

Note that all of these Self Tests are disruptive and interfere with the normal reporting of measured flow and GVF.

3.3.3 Checking Status

Diagnostic Voltages

At sub-menu *Diag/Voltages* there are 2 pages of TRANSMITTER diagnostic voltages followed by 2 pages of Sensor diagnostic voltages. For a summary status of those 2 sets of voltages, sub-menu *Diag/Self Test* has “Sys Volts” and “Sen Volts” that, when run, will report a summary Pass/Fail result.

During commissioning, a review of the diagnostic voltages is advised (those out of range will be highlighted in red). For most parameters in sub-menu *Diag/Voltages*, when highlighted, the bottom row will show not only the Min and Max pass/fail criteria, but in parentheses it shows the Min and Max values (since they were last reset) for parameters that are fluctuating. As indicated at the top of the menu, pressing “Enter” with the cursor on any of the values will reset the Min/Max values to the current reading for all of them. There may be a period of several seconds after pressing Enter during which the value zero is displayed in parentheses before the value is refreshed with the latest reading. Note that these are also diagnostic parameters associated with troubleshooting in conjunction with Customer Support.

Note that if the MODULE is not connected, all of the Sensor diagnostics on pages 3 and 4 will be reported as zero. If the MODULE is connected, but the BAND is not connected, the Band Temp (which is the temperature at a thermistor on the BAND) on page 4 will be reported as a temperature below -50C and will have a red background to indicate a failure. It will also cause the “Sen Volts” test of sub-menu *Diag/Self Test* to fail.

Event Log

At sub-menu *Info/Event Log*, there is a time-stamped listing of events such as power ON/OFF and use of the USB stick. It is a large circular buffer that can hold a lot of data in a long list of consecutive pages. That buffer can be cleared by using sub-menu *Basic/Reset*. Also, sub-menu *Info/Dates/Times* is a one-page summary of the Event log containing the most recent time stamps for 8 types of events.

Software/Hardware version info

Sub-menu *Info/Revisions/Versions* contains firmware version numbers for the firmware in the TRANSMITTER and the Sensor.

Sub-menu *Info/Revisions/Part & Serial* contains software part numbers and some hardware part number and serial number information.

3.3.4 Use of USB Memory sticks

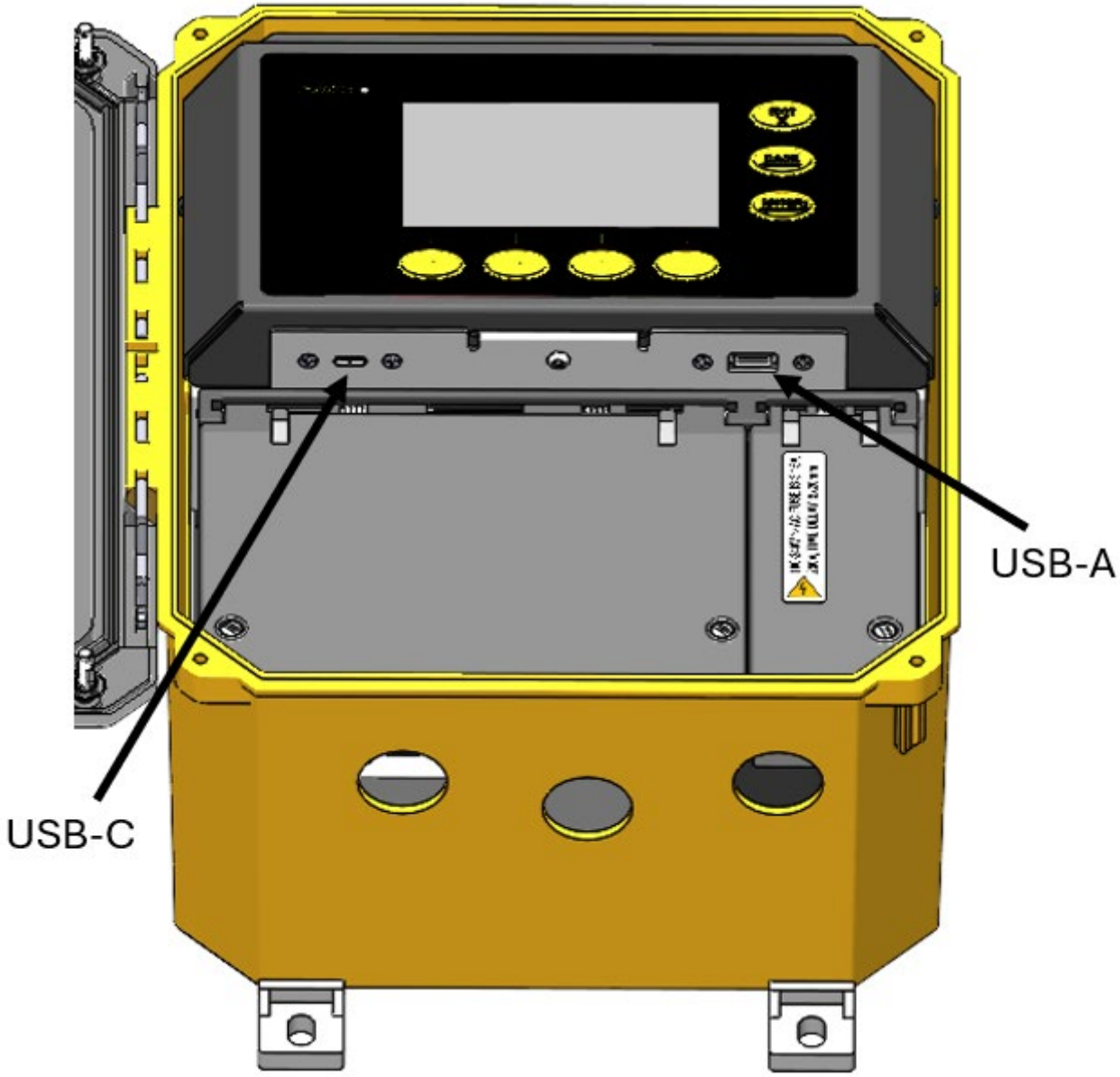


Figure 3-22: Location of USB connectors

Diag/USB is the sub-menu associated with the use of USB memory sticks.

THE USB MEMORY STICK THAT SHIPPED WITH THE TRANSMITTER WAS TESTED TO VERIFY COMPATIBILITY WITH THE TRANSMITTER. OTHER USB STICKS MAY BE USED, BUT NOT ALL USB STICKS ARE COMPATIBLE. THERE IS NO WAY TO CREATE A LIST OF USB STICK MODELS THAT ARE GUARANTEED TO BE COMPATIBLE. IF A USB STICK DIFFERENT FROM THE ONE SHIPPED WITH THE TRANSMITTER DOESN'T WORK, TRY A DIFFERENT MODEL USB STICK. NOTE THAT USB MEMORY STICKS FORMATTED TO

NTFS WILL NOT WORK. LIKEWISE, ENCRYPTED USB MEMORY STICKS WILL NOT WORK.

USB memory sticks are used to upload diagnostic files from the TRANSMITTER and to download certain other files provided by Customer Support (often provided via e-mail). A USB-A or USB-C memory stick can be inserted into the TRANSMITTER via connectors on the lower edge of the display panel. The USB memory stick is used to save or install Configuration files, or to collect raw data or data history info or other diagnostics in conjunction with receiving assistance from Customer Support. Some of the files are encrypted and intended for diagnostic use solely by Customer Support. When a USB stick is first inserted while the Operational Mode display is active, a pop-up message will appear. The message will typically ask if a "Snapshot" is desired, but if an "auto-run" script file is detected on the USB stick, the message will ask whether to run that script. A "Snapshot" is a collection of diagnostic files that Customer Support will request for diagnosing issues or optimizing configurations. Note that the "Snapshot" can be done in the background without disturbing the normal operation of the system, so there is no warning message asking a second time whether to proceed. If the "Snapshot" process needs to be aborted, just pull the USB stick out of its connector before it is finished. If the pop-up message action is declined, further options for USB stick functions are found in the *Diag/USB* sub-menu and are self-explanatory.

By default, the "Snapshot" creates a zip file holding 5 types of files: Configuration (Config), System Information (SysInfo), Data History (DataHist), Event Log (EventLog), and Raw Data (5 minutes). The USB menu allows creating these files individually (and not zipped) and altering the amount of data saved.

The Config file is encrypted but can be saved to the memory stick for use in subsequent restorations of that set of configuration settings in this or similarly deployed SYSTEMS. Alternatively, Customer Support may provide a Config file (typically via e-mail) with some settings optimizations based on an analysis of Snapshot files provided to them.

The SysInfo file is an unencrypted CSV file with a subset of the keypad-entered parameter settings plus information such as part number, and version information for the hardware and software, along with diagnostic data.

The encrypted Raw Data files have names with a date and time stamp followed by ".bin" – each holding 20 seconds of raw data - and are for use exclusively by Customer Support. The default time is 5 minutes (15 files).

The DataHist file is an unencrypted text file which includes a number of computed and time stamped results and may be copied onto the USB stick with selectable lengths of time and decimation factors – up to the limit of the circular buffer – but the default being results timestamped within the previous 24 hours, and with no decimation. The specific data stored in the DataHist file can be changed from the default settings, but not via the keypad. The default is 14 columns: Timestamp, Display VF, Velocity, VF Quality, SOS, SOS Quality, 4-20mA Ch 1, 4-20mA Ch 2, Display GVF, Sensor Band Temp, SPL Avg, VF Status (HEX), SOS Filtered, SOS Quality Filtered. The circular buffer that holds the Data History can be cleared by going to sub-menu *Basic/Reset*.

EventLog is an unencrypted text file that includes timestamped changes of the state of the TRANSMITTER.

The further options in the USB menu include uploading each of the types of files, above, individually and for changing the defaults of how much info gets saved. The remaining space on the USB stick can also be checked via this menu, but if files need to be deleted to make more room on the USB stick, that must be done on a separate computer.

The fifth page of sub-menu *Diag/Comms* has some diagnostic information about the USB interface.

To reset the counters in the USB diagnostics, go to sub-menu *Basic/Reset.*

See, also, the special use of the USB sticks in section 3.3.2 re: Self Tests.

Note that the USB-C only (not USB-A) interface also has the capability of being used with a USB-C cable as a short-range communication link to a laptop for diagnostic purposes. It will typically only be used for short times by Service personnel and typically only with special CiDRA software tools. In this mode it implements a proprietary protocol which is not described in this manual.

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4 Maintenance and Troubleshooting

4.1 General

The SYSTEM requires no regular preventative maintenance. However, when performing periodic inspections of the plant, take note of any damage to enclosures or seals associated with the TRANSMITTER, MODULE, or COVER, or to the insulation of the cables. Look for loose or damaged hardware, fittings, or cable glands. Look for improperly installed, protected, or strain-relieved cables. If the enclosure damage suggests that protection of the electronics from moisture intrusion is compromised or failure is imminent or if the cable damage suggests that cable shorts or opens are imminent, then take the appropriate corrective action depending on the situation – up to and including removal from service until repairs have been performed. Contact Customer Support for information regarding repairs and spare parts. If repairs are made, post-repair functional testing should include the self-tests in section 3.3.2. Depending on the type of repairs, raw data might need to be collected and sent to Customer Support for remote analysis.

4.1.1 RESET switch

In the TRANSMITTER under the larger hinged cover on the left in the upper-left corner of the Terminal board behind the J4 terminal block is a momentary push-button RESET switch. It should rarely (if ever) need to be used, but it exists for diagnostic purposes. Pressing and holding it for 1 second before releasing it will reset all processors in the TRANSMITTER and MODULE to their power-ON states. The normal processing and outputs will be interrupted for a few seconds, but none of the configuration parameters in non-volatile memory will be changed. It performs the equivalent of powering OFF and then ON the entire SYSTEM.

In the unlikely event that the SYSTEM needs to be restored to its factory default settings, keep the EXIT key depressed during and after using the RESET button and don't release the EXIT key until the Operational Mode display has fully come back and a pop-up window instructs you to release the EXIT key. Then another pop-up window will say which key to press to confirm that you want to do this restoration to defaults and which other key to press to exit without doing the restoration. If continuing with this restoration to defaults, all of the non-volatile configuration settings

will be changed to the factory defaults and the entire configuration process will need to be repeated.

4.2 Cleaning

If the TRANSMITTER or SENSOR HEAD needs cleaning of the exterior for cosmetic reasons, the use of water or a mild detergent is recommended. The use of high-pressure water jets is generally discouraged but should take into consideration the IP ratings of the enclosures involved and should avoid using such jets directly on seals and seams and cable glands.

4.3 Servicing

- Only trained personnel must carry out service on this equipment.
- Prior to servicing, lockout all electrical power sources.
- There are no user serviceable parts inside the MODULE. Modification or disassembly of the MODULE will void the warranty.
- Follow static sensitive device precautions when servicing.
- Do not wear rings or wristwatches when servicing this equipment.
- To preserve the safety of this product, use only manufacturer specified replacement parts, do not perform unauthorized substitutions or modifications, and do not use the SYSTEM in a manner not specified by manufacturer.

4.3.1 Notify Control Room

Note: In most cases, servicing will interrupt normal functioning of the SYSTEM and its outputs. If the SYSTEM is being used in a control loop, this can cause the loop to “open”. Inform Control Room personnel that the SYSTEM will be “off-line” so that the control loop can be placed into a manual mode of operation until adjustments are complete and the SYSTEM is ready to be brought back “on-line” in the control loop.

4.4 TRANSMITTER Servicing

4.4.1 Keep Clean and Dry

Keep the inside of the TRANSMITTER enclosure clean and dry during maintenance and troubleshooting when the TRANSMITTER door is briefly open.

4.4.2 Mains Power OFF

Wiring of the mains power terminal blocks shall only be performed with the mains power wiring in a de-powered and locked-out safe state.

4.4.3 Fuse Replacement

The two fuses on the power entry board are the only user serviceable fuses. They may only be replaced with the mains power wiring in a de-powered and locked-out safe state. Fuses are not intended to be Operator-replaceable and should be replaced only by skilled Service Personnel.

The factory-installed fuses are as follows:

Littelfuse 02153.15, 3.15A 250VAC 5x20mm time delay fuse.

Note that this particular fuse is a ceramic fuse with 1500A breaking capability. There must be an external overcurrent protection device on the lines powering the AC TRANSMITTER. If the specified fuse is not readily available as a replacement fuse, it is permissible to use alternative 250VAC 5x20mm time delay fuses with a current rating of 3A to 3.15A in either ceramic or glass – so long as the breaking capability of the fuse is higher than the rating of the external overcurrent protection device and that the fuse is UL-recognized.

4.4.4 Sensor Terminal Blocks

The Terminal blocks for the SENSOR HEAD CABLE that goes to the MODULE must be wired with the mains power OFF. This ensures that these signals are all de-powered.

4.4.5 Customer Input / Output and Modular Comms Terminal Blocks

To the extent possible, ensure that the equipment on the far end of these lines is de-powered before servicing the associated terminal block connections.

4.4.6 Electrical Circuitry and Electro-Static Discharge (ESD)

Take simple ESD precautions to protect the electronics such as touching a grounded metal object prior to reaching into the TRANSMITTER enclosure and avoiding touching circuit boards or connector pins with hands, gloves, or sleeves when servicing.

4.5 SENSOR HEAD Servicing

4.5.1 General

Ensure the inside of the COVER remains clean and dry during installation and inspection. Cleanliness of the COVER and BAND is a performance issue and not a safety issue.

There is no maintenance that can be done inside the MODULE and no reason to ever open the enclosure of the MODULE. If the MODULE is not functioning, the entire MODULE may be replaced by disconnecting it from the COVER mounting blocks at the hinge and installing a new MODULE in its place.

4.5.2 MODULE Electrical Connector

When mated, the SENSOR HEAD CABLE's connector and the mating connector on the MODULE are designed to be environmentally sealed. However, poor performance will result if those connectors aren't clean and dry around their electrical contacts before mating. Prevent contamination of the de-mated connectors. Prior to mating the SENSOR HEAD CABLE connector to the MODULE connector, inspect both to ensure they are clean and dry. Use the lanyard-attached covers when connectors are de-mated. To help keep those covers clean inside when not protecting a connector, mate the two covers together when the SENSOR HEAD CABLE is connected to the MODULE. See Customer Support for replacement connector covers, if needed.

4.5.3 MODULE Gasket

There is a gasket on the bottom of the MODULE which seals around the access opening in the COVER. That gasket must remain undamaged and both it and the mating surface on the COVER must be clean prior to securing the MODULE with the 4 mounting bolts to assure a good seal. If the gasket is lost or damaged or permanently dirty to the extent that its sealing function is likely to be compromised, then see Customer Support to arrange for repair.

4.5.4 Hinged Mounting Blocks for MODULE on COVER

Be certain to tighten all 4 retained bolts to secure MODULE to COVER after BAND umbilical is connected and before putting into service. If the bolts are lost or damaged, or the spring-loaded hinge pins are damaged or fouled such that they don't retain the MODULE, then they must be repaired before continuing to use the MODULE. Note that the hinge pin replacement can only be done in the factory. See Customer Support for replacement parts.

4.5.5 BAND Servicing

4.5.5.1 Use of Mounting Blocks for MODULE on COVER

The 4 retained bolts securing the DSE-1 MODULE must be loosened and the MODULE pivoted on its hinge to gain access to and disconnect the BAND umbilical connector from the MODULE (by pushing on the 2 far edges of the D-sub connector to release it from the Quicklock posts – see 2.3.6.5) before the COVER can be removed from the pipe. Failure to do this will damage the BAND.

4.5.5.2 Damaged BANDs

If the BAND is damaged to the extent that acceptable flow or GVF measurements are not possible, then it must be replaced. See Customer Support for advice and replacement BANDs.

4.6 Troubleshooting

The following is an abridged troubleshooting guide providing brief instructions for some of the more foreseeable issues. Within each of these categories, if the problem cannot be resolved, contact Customer Support who can provide access to a more detailed troubleshooting guide and/or provide additional assistance for otherwise unresolvable issues.

"POWER" LED to the upper left of the Display is not continuously ON

- Check for power ON, in-range, stable, and properly wired to the TRANSMITTER. See section 2.5.2 and 2.5.6.2.
- For DC TRANSMITTERs, is there excessive voltage drop in the wiring such that less than 18VDC is at the power terminals? See section 2.5.6.2.
- Are one or both fuses blown? See Section 4.4.3.

Other Display issues

- If hard to read, adjust brightness. See section 3.3.1.9.
- If symbol near upper left of display not "rotating", press RESET button. See section 3.3.1 and 4.1.1.
- If not displaying the info you want to see, re-configure the display. See section 3.3.1.9.
- If displaying the red "SENSOR FAILURE" screen, see Section 3.1.1.

Flow Rate, Velocity, or TLF not working

- **BAND issues**
    - Requires BAND to be sized correctly for the pipe and properly installed. See section 2.3.
    - Special BANDs are available for HDPE pipes to account for pipe diameter changes with temperature. They must be properly installed. See section 2.3.

- For horizontal pipes with slurries, special BANDs are available for addressing potential stratified slurries and must be installed in proper orientation. See section 2.3.
- For large diameter pipes with 2 BANDs, the BANDs must be properly connected to the Y-cable. See section 2.3.6.5.
- Requires the pipe surface to be properly prepared and weld seam issues properly addressed. See section 2.3.
- Requires a connected and functional BAND. Verify D-sub connection per section 2.3.6.5. Do “Band” test of section 3.3.2.
- Requires an undamaged BAND umbilical cable. Take care not to pinch it in clamshell halves of COVER when installing. Remember to disconnect it from MODULE before removing COVER.
- BAND is to be electrically isolated from the pipe. See section 2.3.5.2.
- Safety certified for process temp no higher than 100°C.

- **Process issues**
  - Requires the flow through the meter to be fully developed. Might require moving the meter farther from elbows, valves, reducers/expanders, pumps. See section 2.3.1.
  - Requires a full pipe. For vertical pipes, upward flow direction is preferred to ensure full pipe flow.
  - Flow rate possibly out-of-range. If not a custom configuration, flow rate must be in range of 3 to 30 ft/s. This is not settable through the keypad. Contact Customer Support to change this range.
- **Sensor Head Electronics issues**
  - Requires SENSOR HEAD CABLE connected to MODULE. See section 2.4.2.
  - Requires proper wiring of the SENSOR HEAD CABLE. See section 2.5.6.3.
  - Requires a functional Sensor Head electronics. Perform “Board” test of section 3.3.2. Check Sensor Head Diagnostic voltages using section 3.3.3.

- **Configuration Issues**
    - Requires the meter be configured for the proper flow direction. See section 3.3.1.3.
    - Possibly the Gain is set incorrectly. See section 3.3.1.4.
    - Possibly configured wrong. See section 3.3.1 – including Reynold's number calibrations in section 3.3.1.3.
    - For large-diameter pipes with 2 BANDs, the configuration requires a special file provided by Customer Support. Not configurable from keypad.

GVF, SOS, or TLF not working

- Not all TRANSMITTER models support these functions. See section 1.1.
- GVF requires a minimum acoustic noise level. Sensor Head might need to be relocated closer to a pump or valve – but not too close if also measuring Flow Rate or TLF. See section 2.3.1.
- Possibly GVF is too high or bubbles not adequately entrained. Meter assumes a homogeneous mix of entrained bubbles and GVF under 50%.
- Possibly GVF-related configuration parameters not set right. See section 3.3.1.
- See, also, the list of issues under "Flow Rate, Velocity, or TLF not working", above.

Noisy Flow or GVF readings

- Adjust various Filter settings. See section 3.3.1.7.

Totalizer not working right

- Possibly not configured right. See section 3.3.1.11.

Displayed value is right, but 4-20mA outputs are wrong

- Possibly confusing the two Analog Outputs. Analog Output #1 is the left-most set of 3 terminals and Analog Output #2 is the right-most set.
- Possibly wired wrong. See section 2.5.6.4.1.
- Possibly configured wrong. See section 3.3.1.5.

- Possibly needs to be trimmed. See section 3.3.1.5.
- Can show that problem is or isn't at the TRANSMITTER by using current meter in place of or in series with the DCS and running the self-tests in section 3.3.2.

HART not working

- The HART interface is possibly not enabled. See section 3.3.1.13.
- Only the Analog Output #1 (the left-most of the two sets of terminals) includes HART.
- Even if the HART interface is enabled, HART cannot be used with TRANSMITTERs with the Foundation Fieldbus or Profibus PA option.
- Possibly configured wrong. See section 3.3.1.13.
- See separate HART manual.

Modbus not working

- The Modbus interface is possibly not enabled. See section 3.3.1.12.
- Possibly configured wrong. See section 3.3.1.12.
- Possibly wired wrong. Try reversing the A- and B+ connections. See section 2.5.6.4.4.
- See separate Modbus manual.

USB Memory Stick not working

- The USB stick delivered with the TRANSMITTER was tested for compatibility. Other USB sticks may or may not be compatible. See section 3.3.4.

Pulse output not working right

- Possibly configured wrong. See section 3.3.1.6.
- Possibly wired wrong. Note that it requires an external power source with limited current. See section 2.5.6.4.3.
- Designed for IEC 61131-2 Type 1 interface. Simple pullup resistor interfaces will have slow rising edges which in noisy

environments and without hysteresis can cause problem with edge detection.

4-20mA Input not working right

- Possibly configured wrong. See section 3.3.1.5.
- Possibly wired wrong. Note that the interface supplies power to a 2-wire 4-20mA device powered by it. See section 2.5.6.4.2.
- To test it, put a current meter in series with one of the connecting wires and compare that reading to the current the TRANSMITTER reports. See section 3.3.1.5.

Foundation Fieldbus or Profibus PA interface not working right

- These are optional interfaces provided only on TRANSMITTERs with model number that include “-FF-“ or “-PA-“. See section 3.3.1.15.
- Possibly not wired right. The 2 primary bus connections are pins 2 and 3 on the 9-pin J4 terminal block. Polarity is arbitrary.
- See separate manual for the Foundation Fieldbus or Profibus PA interface

Profibus DP interface not working right

- This is an optional interface provided only on TRANSMITTERs with model number that include “-DP-“. See section 3.3.1.15.
- Possibly not wired right. The 2 primary bus connections are pins 2 and 3 on the 9-pin J4 terminal block. Polarity is NOT arbitrary. Try reversing the connections.
- See separate manual for the Profibus DP interface

Ethernet not working right

- Possibly configured wrong. See section 3.3.1.14.
- The device that the Ethernet is connected to needs a fixed IP address near to but different from the TRANSMITTER’s address.

Noise issues with Customer I/Os

- Use shielded Ethernet cable. The TRANSMITTER grounds its end of the shielded cable. EMC performance was verified with the shield at the other end also grounded. See section 1.3.
- Route cables separately from power cables or other cables that are noise sources. This applies also to the SENSOR HEAD CABLE.

Other

- If damaged, J4, J5, J6, J7, J8, and J9 are 2-piece pluggable terminals whose plugs are replaceable. Contact Customer Support.
- If condensation collects in COVER, a drain/vent should allow it to exit if the COVER is properly installed on horizontal pipe. If condensation is a problem on vertical pipes, contact Customer Support.
- Condensation in the TRANSMITTER enclosure is not expected to occur. If it does, contact Customer Support.

4.7 Recycling/Disposal at End of Life

At end of life, properly recycle or dispose of the equipment according to the local laws. In Europe, contact Customer Support for additional guidance concerning equipment marked with the “wheelie bin” WEEE (Waste Electrical and Electronic Equipment) symbol.

4.8 Customer Support

All references to “Customer Support” in this manual are references to the contact information provided in this section.

Contact Information:

CiDRA Corporate Services LLC
50 Barnes Park North
Wallingford, CT, USA 06492

Main Telephone: 1-203-265-0035 or 1-877-243-7277 (US and Canada)

Technical Support e-mail: SONARtracSupport@cidra.com

Customer Support e-mail: CustomerSupport@cidra.com

Customer Support web page: https://cidra.com/about-us/#contact-us

Sales Support e-mail: Sales@cidra.com

Manufactured by: CiDRA Corporate Services LLC (see above)

Note that in some instances Technical Support can remotely assist in diagnosing specific application issues and optimizing configuration settings. This can involve the collection of real-time raw signal data from the TRANSMITTER via USB memory stick and then transferring that data to Technical Support for remote re-processing and analysis. Technical Support will provide instructions on this process if this level of remote assistance is required.

Contact Technical Support for availability and scheduling of training courses.

4.8.1 Other Manuals

Other documents are available through Customer Support and/or on the CiDRA website covering topics including:

- Detailed information on the HART interface, and associated DDL (Device Description Language) files.
- Detailed information on the Modbus interface
- Detailed information on the optional modular communications interfaces (Profibus DP, Foundation Fieldbus, and Profibus PA) and associated DDL (Device Description Language) files.
- How to upload SYSTEM data for analysis by Customer Support as part of their remote troubleshooting assistance
- Detailed Troubleshooting procedures
- Data Sheets
- Envelope drawings for the SYSTEM (i.e. mechanical dimensions)
- Material Safety Data Sheets

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5 Technical Specifications

5.1 Power Requirements

AC Version: 100 to 240 Volts AC, 50/60 Hz, 25 watts

DC Version: 18-35 Volts DC, 25 watts

5.2 Environmental Ratings

5.2.1 Indoor/Outdoor Use

Rated for indoor or outdoor use.

5.2.2 Altitude

TRANSMITTER and SENSOR HEAD are rated for installations up to an altitude of 5000m (16,404ft).

5.2.3 Temperature

TRANSMITTER (Operating)	-40°F to +140°F (-40°C to +60°C)
TRANSMITTER (Storage)	-40°F to +176°F (-40°C to +80°C)
SENSOR HEAD Process Temperature	-40°F to +212°F (-40°C to +100°C)
SENSOR HEAD Ambient Temperature	-40°F to +140°F (-40°C to +60°C)
SENSOR HEAD (Storage)	-40°F to +185°F (-40°C to +85°C)

Table 5-1: Temperature Limitations

Note that the SENSOR HEAD CABLEs supplied that are marked Belden Y67688 or Y67689 are rated and marked for -40°C to +105°C.

5.2.4 Humidity

0 – 95%, non-condensing

5.2.5 Transient Overvoltage

The TRANSMITTER is rated for transient overvoltage Category II.

5.2.6 Wet Locations

The SYSTEM can be safely located in Dry and in Wet Locations. This topic concerns risk of electric shock. Wet Locations are defined here as environments with the possibility of water or other conductive liquids on surfaces or personnel such that the resistance from the equipment to earth through a person touching the equipment will be lowered due to the presence of that liquid at the contact points between the person and the equipment and/or between the person and earth. The MODULE is

powered from the TRANSMITTER by voltages that are not Hazardous Live and it generates no Hazardous Live voltages, so it is safe in both wet and dry locations. Similarly, the DC TRANSMITTER is powered by 18-35VDC which is not considered Hazardous Live even in wet locations and the TRANSMITTER generates no Hazardous Live voltages, so it is safe in both wet and dry locations. In contrast, the AC TRANSMITTER is powered by AC Mains which are Hazardous Live and those connections are key to the electric shock risk. A label that warns of the electric shock risk has been placed near the power entry terminals of the AC TRANSMITTER and those terminals are behind a cover that is retained with a screw to keep them from being accessible to operators.

5.2.7 Pollution Degree

When outdoors, the SYSTEM is intended to be installed in locations where Pollution Degree 3 or 4 (conductive wet or dry pollution) exists OUTSIDE of the enclosure, while the INSIDE of the enclosure is expected to remain at Pollution Degree 2 (no pollution, or non-conductive pollution, or a limited amount of dry pollution that is temporarily conductive only due to occasional condensation). The Ingress Protection rating of the enclosures helps assure this in conjunction with the care taken by the user whenever the enclosure is opened.

5.2.8 Ingress Protection

The Ingress Protection rating applies to enclosures with covers tightly closed and with cables, cable glands, and connectors properly installed. The TRANSMITTER enclosure is IP66 (and NEMA 4X) and is intended to be installed with the display perpendicular to the ground with the cable entry holes pointing down. The TRANSMITTER enclosure's IP66 rating is maintained only if the cable glands and fittings have equal or better IP ratings. The MODULE enclosure's IP rating is IP66. The IP rating of the COVER does not affect the safety of the SYSTEM, but it could affect the performance. It is a function of the design of the COVER's seals, but also the specifics of the pipe size and surface and the care taken by the installer. The fiberglass COVERs and stainless steel COVERs were designed for IP55. When mounted on horizontal or angled non-vertical pipes, the SENSOR HEAD should be oriented such that the MODULE is above the mid-line of the pipe. On vertical pipes, the SENSOR HEAD orientation should be such that the MODULE's right-angle connector for the SENSOR HEAD CABLE is pointing down.

5.3 Performance

5.3.1 Volumetric Flow

Calibrated Range	3-30 ft/s (~1-10 m/s) liquid
Accuracy	+/-1% of reading
Repeatability	+/- 0.3% of reading

Table 5-2: Volumetric Flow Performance

The calibration coefficients are from water loop tests at test facilities with NIST-traceable reference measurements. Contact Customer Support for accuracy of sizes larger than 36".

5.3.2 Gas Void Fraction

Range	0% to 20% by volume
Accuracy	+/-5% of reading, between 0.01% and 20% GVF
Repeatability	+/-1% of reading, between 0.01% and 20% GVF

Table 5-3: Gas Void Fraction Performance

GVF is a measurement of total entrained gas bubble volume at process conditions, not a measurement of dissolved gases. Accuracy is for digitally reported outputs and assumes real-time line pressure used as an input, and that the exact pipe dimensions and Young's modulus, and liquid and gas properties are properly configured. There is a default assumption in the algorithm that is bubble-size-dependent. Contact Customer Support if the accuracy needs to be trimmed nearer to some other known accurate measurement. The meter will make GVF measurements with lined pipe, but accuracy will be negatively affected by the liner (primarily a zero-offset error).

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