TFXL Clamp-On Ultrasonic Flow Meter for Liquids

Badger Meter

Installation & Operation Manual

06-TTM-UM-00158 (August 2012)

TABLE OF CONTENTS

FIGURES

TABLES

QUICK-START OPERATING INSTRUCTIONS

This manual contains detailed operating instructions for all aspects of the TFXL instrument. The following condensed instructions are provided to assist the operator in getting the instrument started up and running as quickly as possible. This pertains to basic operation only. If specific instrument features are to be used or if the installer is unfamiliar with this type of instrument, refer to the appropriate section in the manual for complete details.

***NOTE:** The following steps require information supplied by the TFXL meter itself so it will be necessary to supply power to the unit, at least temporarily, and connect to a computer using ULTRALINK to obtain setup information.*

Q1 - TRANSDUCER LOCATION

1) In general, select a mounting location on the piping system with a minimum of **10** pipe diameters (10 × the pipe inside diameter) of straight pipe upstream and **5** straight diameters downstream. See ***Table 2.1*** for additional configurations.
2) If the application requires DTTN or DTTH transducers select a mounting method for the transducers based on pipe size and liquid characteristics. See ***Table 2.2***. Transducer configurations are illustrated in ***Figure Q.1*** below.

***NOTE:** All DTTS and DTTC transducers use **V-**Mount configuration.*

3) Enter the following data into the TFXL transmitter via the ULTRALINK™ software utility:

    1. Transducer mounting method
    2. Pipe O.D. (Outside Diameter)
    3. Pipe wall thickness
    4. Pipe material
    5. Pipe sound speed*
    6. Pipe relative roughness*
    7. Pipe liner thickness
    8. Pipe liner material
    9. Fluid type
    10. Fluid sound speed*
    11. Fluid viscosity*
    12. Fluid specific gravity*

**** NOMINAL VALUES FOR THESE PARAMETERS ARE INCLUDED WITHIN THE TFXL OPERATING SYSTEM. THE NOMINAL VALUES MAY BE USED AS THEY APPEAR OR MAY BE MODIFIED IF THE EXACT SYSTEM VALUES ARE KNOWN.***

4) Record the value calculated and displayed as Transducer Spacing.

Q2 - PIPE PREPARATION AND TRANSDUCER MOUNTING

(INTEGRAL & REMOTE DTTS AND DTTC TRANSDUCERS)

1) Refer to the signal strength values available on the Data Display screen in the ULTRALINK software utility.
2) The pipe surface, where the transducers are to be mounted, must be clean and dry. Remove scale, rust or loose paint to ensure satisfactory acoustic conduction. Wire brushing the rough surfaces of pipes to smooth bare metal may also be useful. Plastic pipes do not require preparation other than cleaning.
   On horizontal pipe, choose a flow meter mounting location within approximately 45-degrees of the side of the pipe. See ***Figure Q.2***. Locate the flow meter so that the pipe will be completely full of liquid when flow is occurring in the pipe. Avoid mounting on vertical pipes where the flow is moving in a downward direction.
3) Apply a single ½” (12 mm) bead of acoustic couplant grease to the top half of the transducer and secure it to the pipe with bottom half or U-bolts.
4) Tighten the nuts so that the acoustic coupling grease begins to flow out from the edges of the transducer and from the gap between the transducer and the pipe. **Finger tighten only. Do not over tighten**.

(DTTN AND DTTH TRANSDUCERS)

1) Place the flow meter in signal strength measuring mode. This value is available in the data display of the software utility.
2) The pipe surface, where the transducers are to be mounted, must be clean and dry. Remove scale, rust or loose paint to ensure satisfactory acoustic conduction. Wire brushing the rough surfaces of pipes to smooth bare metal may also be useful. Plastic pipes do not require preparation other than cleaning. On horizontal

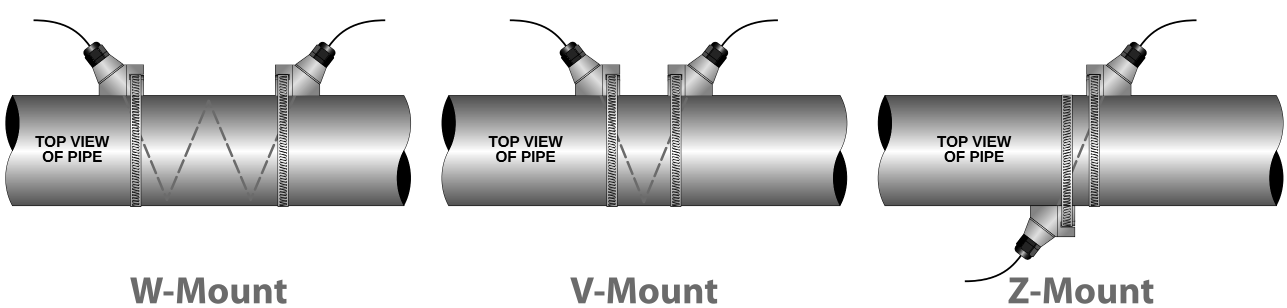
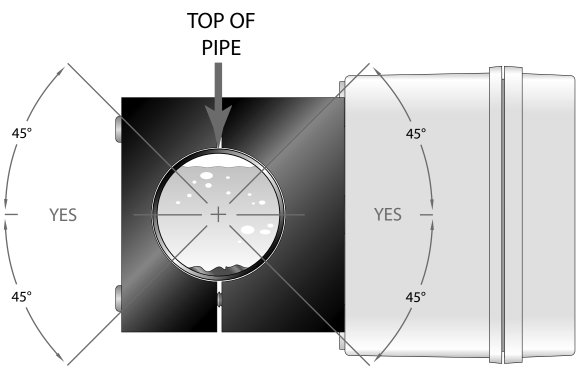


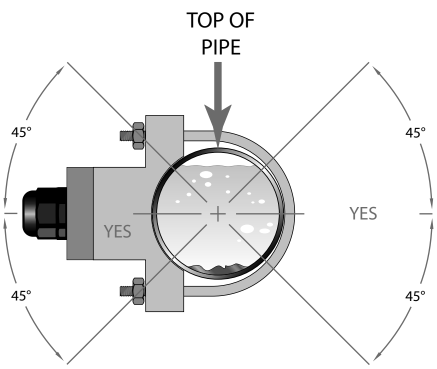
FIGURE Q.1 - TRANSDUCER MOUNTING CONFIGURATIONS

pipe, choose a flow meter mounting location within approximately 45-degrees of the side of the pipe. See ***Figure Q.2***. Locate the flow meter so that the pipe will be completely full of liquid when flow is occurring in the pipe. Avoid mounting on vertical pipes where the flow is moving in a downward direction.

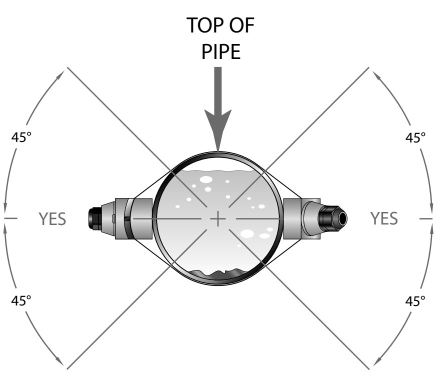
3) Apply a single ½" (12 mm) bead of acoustic couplant grease to the upstream transducer and secure it to the pipe with a mounting strap.
4) Apply acoustic couplant grease to the downstream transducer and press it onto the pipe using hand pressure at the lineal distance calculated by the ULTRALINK software utility.
5) Space the transducers according to the recommended values from the ULTRALINK software utility. Secure the transducers with the mounting straps at these locations.



FLOW METER
MOUNTING ORIENTATION
DTTS and DTTC TRANSDUCERS
(Integral mount shown)



FLOW METER
MOUNTING ORIENTATION
2" DTTS and DTTC TRANSDUCERS
(Remote mount shown)



FLOW METER
MOUNTING ORIENTATION
DTTN and DTTH TRANSDUCERS

FIGURE Q.2 - TRANSDUCER ORIENTATION

Q3 - ELECTRICAL CONNECTIONS

POWER CONNECTIONS

1) Power for the TFXL flow meter is obtained from a direct current (DC) power source. The power source should be capable of supplying between 11 and 28 VDC at a minimum of 250 milliamps. With the power from the DC power source disabled or disconnected, connect the positive supply wire and ground to the appropriate field wiring terminals in the flow meter. See ***Figure Q.3***. A wiring diagram decal is located on the inner cover of the flow meter enclosure for reference.

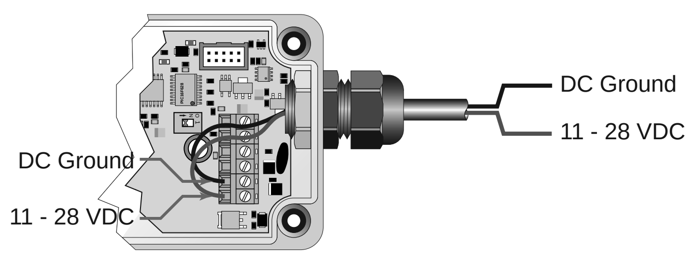


FIGURE Q.3 - POWER CONNECTIONS

TRANSDUCER CONNECTIONS

(Remote Mount Transducers)

1) Guide the transducer terminations through the transmitter conduit hole located in the bottom-left of the enclosure using a sealed cord grip or NEMA 4 conduit connection. Secure the transducer cable with the supplied conduit nut (if flexible conduit was ordered with the transducer).

2) The remote mount transducers use an add-in connection board on the left had side of the meter below the LCD (TFXL 2 version). The terminals within TFXL are of a screw-down barrier terminal type. Connect the appropriate wires at the corresponding screw terminals in the transmitter. Observe upstream and downstream orientation and wire polarity. See ***Figure Q.4***.

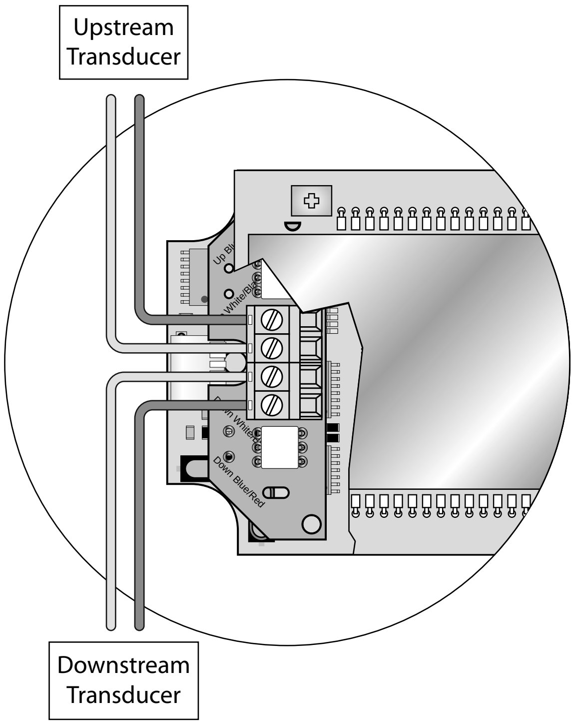


FIGURE Q.4 - REMOTE MOUNT CONNECTIONS

Q4 - STARTUP

INITIAL SETTINGS AND POWER UP

1) Apply power to the transmitter.
2) Verify that the signal strength is greater than 5.0.
3) Input proper units of measure and I/O data.

INTRODUCTION

GENERAL

The TFXL ultrasonic flow meter is designed to measure the fluid velocity of liquid within a closed conduit. The transducers are a non-contacting, clamp-on type or clamp-around, which will provide benefits of non-fouling operation and ease of installation.

The TFXL family of transit time flow meters utilize two transducers that function as both ultrasonic transmitters and receivers. The transducers are clamped on the outside of a closed pipe **at a specific distance from each other**. The transducers can be mounted in **V-Mount** where the sound transverses the pipe two times, **W-Mount** where the sound transverses the pipe four times, or in **Z-Mount** where the

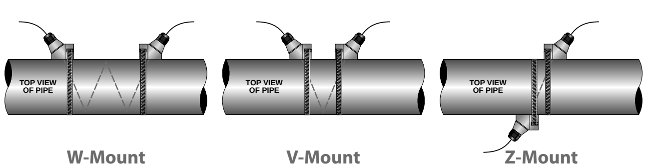


FIGURE 1.1 - ULTRASOUND TRANSMISSION

the sound crosses the pipe once. The selection of how transducers are mounted on opposite sides of the pipe and method is based on pipe and liquid characteristics which both have an effect on how much signal is generated. The flow meter operates by alternately transmitting and receiving a frequency modulated burst of sound energy between the two transducers and measuring the time interval that it takes for sound to travel between the two transducers. The difference in the time interval measured is directly related to the velocity of the liquid in the pipe.

APPLICATION VERSATILITY

The TFXL flow meter can be successfully applied on a wide range of metering applications. The simple-to-program transmitter allows the standard product to be used on pipe sizes ranging from ½ inch to 100 inches (12 mm to 2540 mm). A variety of liquid applications can be accommodated:

ultrapure liquids	**sewage**	**cooling water**
potable water	**reclaimed water**	**river water**
chemicals	**plant effluent**	**others**

Because the transducers are non-contacting and have no moving parts, the flow meter is not affected by system pressure, fouling or wear.

The DTTN transducer set is rated to a pipe surface temperature of 250° F (121° C). High temperature DTTH transducers can operate to a pipe surface temperature of 350° F (177° C). The DTTS series of small pipe transducers can be used to a pipe surface temperature of 185° F (85° C) and the DTTC high temperature small pipe transducers are rated for 250° F (121° C).

The TFXL uses a low voltage DC power source that provides electrical safety for the user. Removing the cover allows access to all the meter connections and the computer interface connection.

Non-volatile flash memory retains all user-entered configuration values in memory indefinitely, even if power is lost or turned off.

The enclosure should be mounted in an area that is convenient for servicing, calibration or for observation of the LCD readout.

Mount the TFXL transmitter in a location that is:
- ~ Where little vibration exists.
- ~ That is protected from corrosive fluids.
- ~ That is within the transmitters ambient temperature limits.
- ~ That is out of direct sunlight. Direct sunlight may increase transmitter temperature to above the maximum limit.

Locate the transmitter within the length of transducer cable that was supplied with the TFXL system. If this is not possible, it is recommended that the cable be exchanged for one that is of proper length. Both transducer cables must be of the same length.

> ***NOTE:*** *The transducer cable carries low level, high frequency signals. In general, it is not recommended to add additional cable to the cable supplied with the DTTN, DTTH, DTTS or DTTC transducers. If additional cable is required, contact the factory to arrange an exchange for a transducer with the appropriate length of cable. Cables to 990 feet (300 meters) are available. To add cable length to a transducer, the cable must be the same type as utilized on the transducer. Twinaxial cables can be lengthened with like cable to a maximum overall length of 100 feet (30 meters). Coaxial cables can be lengthened with RG59 75 Ohm cable and BNC connectors to 990 feet (300 meters).*

If the transmitter will be subjected to a wet environment, it is recommended that the cover remain closed after configuration is completed. The faceplate of the TFXL is watertight, but avoid letting water collect on it. A sealed cord grip or NEMA 4 conduit connection should be used where cables enter the enclosure. Holes not used for cable entry should be sealed with plugs.

To access terminal strips for electronic connectors, loosen the four screws in the display lid and remove the cover. The terminals where the transducers connect are located underneath the display. To connect transducers, remove the four screws that secure the display and carefully move it out of the way. Do not over stress the ribbon cable located between the display and the microprocessor circuit boards.

PRODUCT IDENTIFICATION

The serial number and complete model number of each TFXL are located on the side of the instrument enclosure. Should technical assistance be required, please provide the Customer Service Department with this information.

PART 1 - TRANSMITTER INSTALLATION

After unpacking, it is recommended to save the shipping carton and packing materials in case the instrument is stored or re-shipped. Inspect the equipment and carton for damage. If there is evidence of shipping damage, notify the carrier immediately.

The enclosure should be mounted in an area that is convenient for servicing, calibration or for observation of the LCD readout (if equipped).

1) Locate the transmitter within the length of transducer cables supplied. If this is not possible, it is recommended that the cable be exchanged for one that is of proper length. To add cable length to a transducer, the cable must be the same type as utilized on the transducer. Twinaxial cables can be lengthened with like cable to a maximum overall length of 100 feet (30 meters). Coaxial cables can be lengthened with RG59 75 Ohm cable and BNC connectors to 990 feet (300 meters).
2) Mount the TFXL transmitter in a location:
   ~ Where little vibration exists.
   ~ That is protected from corrosive fluids.
   ~ That is within the transmitters ambient temperature limits -40 to +185° F (-40 to +85° C).
   ~ That is out of direct sunlight. Direct sunlight may increase transmitter temperature to above the maximum limit.
3) Mounting - Refer to ***Figure 1.2*** for enclosure and mounting dimension details. Ensure that enough room is available to allow for door swing, maintenance and conduit entrances. Secure the enclosure to a flat surface with two appropriate fasteners.
4) Conduit Holes - Conduit holes should be used where cables enter the enclosure. Holes not used for cable entry should be sealed with plugs.

NOTE: *Use NEMA 4 [IP-65] rated fittings/plugs to maintain the watertight integrity of the enclosure. Generally, the right side conduit hole (viewed from front) is used for power, the bottom conduit hole(s) for transducer connections.*

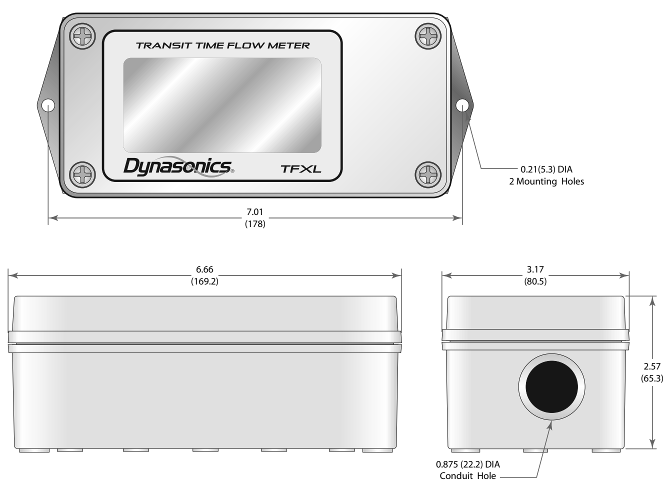


FIGURE 1.2 - ENCLOSURE DIMENSIONS

GENERAL

The remote mount TFXL is equipped with three conduit holes located in the flow meter enclosure that should be suitable for most installations. A sealed cord grip or NEMA 4 conduit connection should be utilized to retain the NEMA 3 integrity of the flow meter enclosure. Failure to do so will void the manufacturer's warranty and can lead to product failure.

The TFXL is housed in an insulating plastic enclosure that does not provide continuity of bonding between field wiring conduit and the TFXL chassis or other conduits connected to the enclosure.

Wiring methods and practices are to be made in accordance with the **NEC - National Electrical Code®** - and/or other local ordinances that may be in effect. Consult the local electrical inspector for information regarding wiring regulations.

When making connections to the field wiring terminals inside the flow meter, strip back the wire insulation approximately 0.25 inch (6 mm). Stripping back too little may cause the terminals to clamp on the insulation and not make good contact. Stripping back too much insulation may lead to a situation where the wires could short together between adjacent terminals. Wires should be secured in the field wiring terminals using a screw torque of between 0.5 and 0.6 Nm.

If the DC ground terminal is to be utilized as a protective conductor terminal, the protective conductor shall be applied first and secured independently of other connections. The protective conductor shall be connected in such a way that it is unlikely to be removed by servicing not involving the protective conductor or there shall be a warning marking requiring the replacement of the protective conductor after removal.

Power the TFXL flow meter with a Class 2 direct current (DC) power source. The power source should be capable of supplying between 11 and 28 VDC at a minimum of 250 milliamps. With the power from the DC power source disabled or disconnected, connect the positive supply wire and ground to the appropriate field wiring terminals in the flow meter. See ***Figure 1.5***. A wiring diagram decal is located on the inner cover of the flow meter enclosure for reference.

IMPORTANT NOTE:
Not following instructions properly may impair safety of equipment and/or personnel.

IMPORTANT NOTE:
Must be operated by a power supply suitable for the location.

IMPORTANT NOTE:
Do not connect or disconnect either power or outputs unless the area is known to be nonhazardous

IMPORTANT NOTE:
Do not connect the interface cable between a TFXL flow meter and a personal computer unless the area is known to be non-hazardous.

TRANSDUCER CONNECTIONS

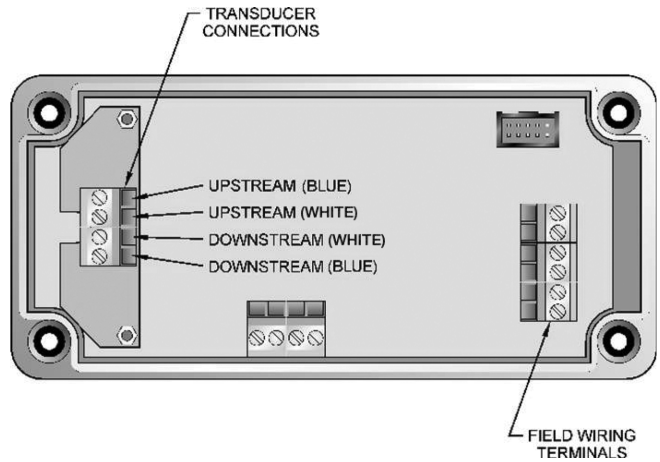


FIGURE 1.3 - TRANSDUCER CONNECTIONS

To access terminal strips for wiring, first loosen the four screws holding the top of the case to the bottom.

NOTE: *The four screws are "captive" screws and cannot be removed from the top of the case.*

If the unit has a display remove the four Phillips head screws that hold the display to the main circuit board and carefully move it out of the way. Do not over stress the ribbon cable located between the display and the microprocessor circuit boards.

Guide the transducer terminations through the transmitter conduit hole located in the bottom-left of the enclosure. Secure the transducer cable with the supplied conduit nut (if flexible conduit was ordered with the transducer).

NOTE: *TFXL models with integral transducers have the transducers connected at the factory and the transducer connections section can be skipped.*

The terminals within TFXL are of a screw-down barrier terminal type. Depending on the type of transducers being used there are two terminal strip arrangements possible.

Remote mount small pipe transducers are connected to the terminals found on the main circuit board.

Remote mount transducers are connected to a "daughter" board found on the left hand side of the meter.

Connect the appropriate wires at the corresponding screw terminals in the transmitter. Observe upstream and downstream orientation and wire polarity. See ***Figure 1.3***.

NOTE: *High temperature transducer cables come with red and black wire colors. For the red and black combination, the red wire is positive (+) and the black wire is negative (-).*

NOTE: *The transducer cable carries low level, high frequency signals. In general, it is not recommended to add additional length to the cable supplied with the transducers. If additional cable is required, contact the factory to arrange an exchange for a transducer with the appropriate length of cable. Cables 100 to 990 feet (30 to 300 meters) are available with RG59 75 Ohm coaxial cable. If additional cable is added, ensure that it is the same type as utilized on the transducer. Twinaxial (blue and white conductor) cables can be lengthened with like cable to a* ***maximum overall length of 100 feet (30 meters)****. Coaxial cables can be lengthened with RG59 75 Ohm cable and BNC connectors to 990 feet (300 meters).*

DC POWER CONNECTIONS

The TFXL should be operated from an 11 to 28 VDC Class 2 power source capable of supplying a minimum of 250 mA of current.

Connect power to the screw terminal block in the TFXL transmitter. See ***Figure 1.4***. Utilize the conduit hole on the right side of the enclosure for this purpose. Use wiring practices that conform to local and national codes (e.g., The National Electrical Code® Handbook in the U.S.)

Connect the DC power to 11 to 28 VDC In, and DC Gnd., as in ***Figure 1.4***.

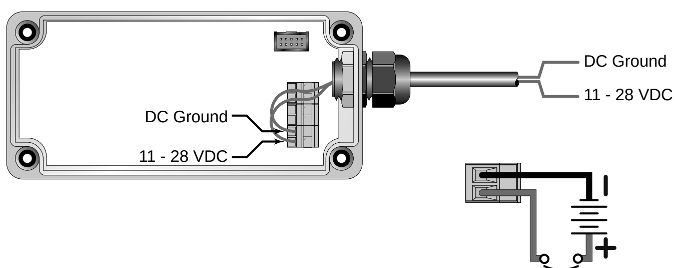


FIGURE 1.4 - DC POWER CONNECTIONS

1) Connect an 11-28 VDC Class 2 power source as illustrated in the schematic in ***Figure 1.4.*** Wire up to 14 AWG can be accommodated in the TFXL terminal blocks
   a) A switch or circuit breaker is required in the installation.
   b) The switch or circuit breaker must be in close proximity of the TFXL and within easy reach of the operator.
   c) The switch or circuit breaker must be marked as the disconnect device for the TFXL.

PART 2 – TRANSDUCER INSTALLATION

GENERAL

The transducers that are utilized by the TFXL contain piezoelectric crystals for transmitting and receiving ultrasonic signals through walls of liquid piping systems. DTTN and DTTH transducers are relatively simple and straightforward to install, but spacing and alignment of the transducers is critical to the system's accuracy and performance. Extra care should be taken to ensure that these instructions are carefully executed. DTTS and DTTC, small pipe transducers, have integrated transmitter and receiver elements that eliminate the requirement for spacing measurement and alignment.

Mounting of the DTTN and DTTH clamp-on ultrasonic transit time transducers is comprised of three steps:

1) Selection of the optimum location on a piping system.
2) Entering the pipe and liquid parameters into the software utility. The software utility will calculate proper transducer spacing based on these entries.
3) Pipe preparation and transducer mounting.

STEP 1 - MOUNTING LOCATION

The first step in the installation process is the selection of an optimum location for the flow measurement to be made. For this to be done effectively, a basic knowledge of the piping system and its plumbing are required.

An optimum location is defined as:

~ A piping system that is completely full of liquid when measurements are being taken. The pipe may become completely empty during a process cycle – which will result in the error code 0010 (Low Signal Strength) being displayed on the flow meter while the pipe is empty. This error code will clear automatically once the pipe refills with liquid. It is not recommended to mount the transducers in an area where the pipe may become partially filled. Partially filled pipes will cause erroneous and unpredictable operation of the meter.

~ A piping system that contains lengths of straight pipe such as those described in ***Table 2.1***. The optimum straight pipe diameter recommendations apply to pipes in both horizontal and vertical orientation. The straight runs in ***Table 2.1*** apply to liquid velocities that are nominally 7 FPS (2.2 MPS). As liquid velocity increases above this nominal rate, the requirement for straight pipe increases proportionally.

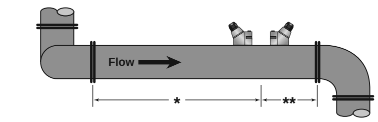
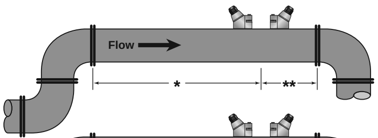
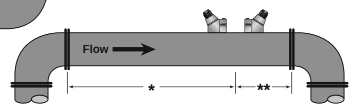
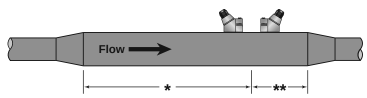
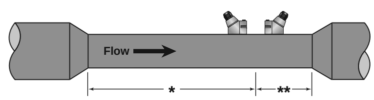
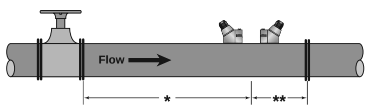
Piping Configuration and Transducer Positioning	Upstream Pipe Diameters	Downstream Pipe Diameters
	*	**
	24	5
	14	5
	10	5
	10	5
	10	5
	24	5

TABLE 2.1 - PIPING CONFIGURATION AND TRANSDUCER POSITIONING

- Mount the transducers in an area where they will not be inadvertently bumped or disturbed during normal operation.
- Avoid installations on downward flowing pipes unless adequate downstream head pressure is present to overcome partial filling of or cavitation in the pipe.

The flow meter system will provide repeatable measurements on piping systems that do not meet these requirements, but accuracy of these readings may be influenced to various degrees.

STEP 2 - TRANSDUCER SPACING

TFXL remote mount transit time flow meters can be used with four different transducer types: DTTN, DTTH, DTTS and DTTC. Meters that utilize the DTTN or DTTH transducer sets consist of two separate sensors that function as both ultrasonic transmitters and receivers. DTTS and DTTC transducers integrate both the transmitter and receiver into one assembly that fixes the separation of the piezoelectric crystals. DTTN and DTTH transducers are clamped on the outside of a closed pipe at a specific distance from each other.

Transducer Mount Mode	Pipe Material	Pipe Size	Liquid Composition
W-Mount	Plastic (all types)	2-4 in. (50-100 mm)	Low TSS; non-aerated
	Carbon Steel		
	Stainless Steel		
	Copper		
	Ductile Iron	Not recommended	
	Cast Iron		
V-Mount	Plastic (all types)	4-12 in. (100-300 mm)	
	Carbon Steel		
	Stainless Steel		
	Copper	4-30 in. (100-750 mm)	
	Ductile Iron	2-12 in. (50-300 mm)	
	Cast Iron		
Z-Mount	Plastic (all types)	> 30 in. (> 750 mm)	
	Carbon Steel	> 12 in. (> 300 mm)	
	Stainless Steel		
	Copper	> 30 in. (> 750 mm)	
	Ductile Iron	> 12 in. (> 300 mm)	
	Cast Iron		
TSS = Total Suspended Solids			

TABLE 2.2 - TRANSDUCER MOUNTING MODES — DTTN AND DTTH

The DTTN and DTTH transducers can be mounted in:

> **W**-Mount where the sound traverses the pipe four times. This mounting method produces the best relative travel time values but the weakest signal strength.
> **V**-Mount where the sound traverses the pipe twice. V-Mount is a compromise between travel time and signal strength.
> **Z**-Mount where the transducers are mounted on opposite sides of the pipe and the sound crosses the pipe once. Z-Mount will yield the best signal strength but the smallest relative travel time.

For further details, reference ***Figure 2.1***. The appropriate mounting configuration is based on pipe and liquid characteristics. Selection of the proper transducer mounting method is not entirely predictable and many times is an

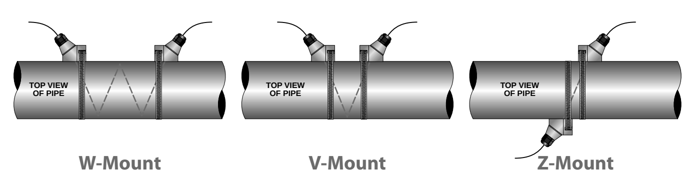


FIGURE 2.1- TRANSDUCER MOUNTING MODES — DTTN AND DTTH

iterative process. ***Table 2.2*** contains recommended mounting configurations for common applications. These recommended configurations may need to be modified for specific applications if such things as aeration, suspended solids, out of round piping or poor piping conditions are present. Use of the TFXL diagnostics in determining the optimum transducer mounting is covered later in this section.

<table>
<tr><th>Size</th><th>Frequency Setting</th><th>Transducer</th><th>Mounting Mode</th></tr>
<tr><td rowspan="3">½</td><td rowspan="3">2 MHz</td><td>DTTSnP</td><td rowspan="17">V</td></tr>
<tr><td>DTTSnC</td></tr>
<tr><td>DTTSnT</td></tr>
<tr><td rowspan="3">¾</td><td rowspan="3">2 MHz</td><td>DTTSnP</td></tr>
<tr><td>DTTSnC</td></tr>
<tr><td>DTTSnT</td></tr>
<tr><td rowspan="3">1</td><td rowspan="3">2 MHz</td><td>DTTSnP</td></tr>
<tr><td>DTTSnC</td></tr>
<tr><td>DTTSnT</td></tr>
<tr><td rowspan="3">1¼</td><td rowspan="3">2 MHz</td><td>DTTSnP</td></tr>
<tr><td>DTTSnC</td></tr>
<tr><td>DTTSnT</td></tr>
<tr><td rowspan="3">1½</td><td rowspan="3">2 MHz</td><td>DTTSnP</td></tr>
<tr><td>DTTSnC</td></tr>
<tr><td>DTTSnT</td></tr>
<tr><td rowspan="3">2</td><td rowspan="2">1 MHz</td><td>DTTSnP</td></tr>
<tr><td>DTTSnC</td></tr>
<tr><td>2 MHz</td><td>DTTSnT</td></tr>
<tr><td colspan="4">NOTE: DTTS transducer designation refers to both DTTS and DTTC transducer types.</td></tr>
</table>

TABLE 2.3 - TRANSDUCER MOUNTING MODES — DTTS / DTTC

STEP 3 - ENTERING PIPE AND LIQUID DATA

The TFXL system calculates proper transducer spacing by utilizing piping and liquid information entered by the user. This information can be entered on a TFXL via the software utility.

The best accuracy is achieved when transducer spacing is exactly what the TFXL calculates, so the calculated spacing should be used if signal strength is satisfactory. If the pipe is not round, the wall thickness not correct or the actual liquid being measured has a different sound speed than the liquid programmed into the transmitter, the spacing can vary from the calculated value. If that is the case, the transducers should be placed at the highest signal level observed by moving the transducers slowly around the mount area.

NOTE: *Transducer spacing is calculated on "ideal" pipe. Ideal pipe is almost never found so the transducer spacing distances may need to be altered. An effective way to maximize signal strength is to configure the display to show signal strength, fix one transducer on the pipe and then starting at the calculated spacing, move the remaining transducer small distances forward and back to find the maximum signal strength point.*

Important! Enter all of the data on this list, save the data and reset the TFXL before mounting transducers.

The following information is required before programming the instrument:

Transducer mounting configuration	Pipe O.D. (outside diameter)
Pipe wall thickness	Pipe material
Pipe sound speed[1]	Pipe relative roughness[1]
Pipe liner thickness (if present)	Pipe liner material (if present)
Fluid type	Fluid sound speed[1]
Fluid viscosity[1]	Fluid specific gravity[1]

NOTE: *Much of the data relating to material sound speed, viscosity and specific gravity is pre-programmed into the TFXL flow meter. This data only needs to be modified if it is known that a particular application's data varies from the reference values. Refer to* ***Part 4*** *of this manual for instructions on entering configuration data into the TFXL flow meter via the software.*

[1]NOMINAL VALUES FOR THESE PARAMETERS ARE INCLUDED WITHIN THE TFXL OPERATING SYSTEM. THE NOMINAL VALUES MAY BE USED AS THEY APPEAR OR MAY BE MODIFIED IF EXACT SYSTEM VALUES ARE KNOWN.

After entering the data listed above, the TFXL will calculate proper transducer spacing for the particular data set. This distance will be in inches if the TFXL is configured in English units, or millimeters if configured in metric units.

STEP 4 - TRANSDUCER MOUNTING

PIPE PREPARATION

After selecting an optimal mounting location (**Step 1**) and successfully determining the proper transducer spacing (**Step 2 & 3**), the transducers may now be mounted onto the pipe (**Step 4**).

Before the transducers are mounted onto the pipe surface, an area slightly larger than the flat surface of each transducer must be cleaned of all rust, scale and moisture. For pipes with rough surfaces, such as ductile iron pipe, it is recommended that the pipe surface be wire brushed to a shiny finish. Paint and other coatings, if not flaked or bubbled, need not be removed. Plastic pipes typically do not require surface preparation other than soap and water cleaning.
The DTTN and DTTH transducers must be properly oriented and spaced on the pipe to provide optimum reliability and performance. On horizontal pipes, when **Z**-Mount is required,

the transducers should be mounted 180 radial degrees from one another and at least 45 degrees from the top-dead-center and bottom-dead-center of the pipe. See ***Figure 2.2***. Also see **Z**-Mount Transducer Installation. On vertical pipes the orientation is not critical.

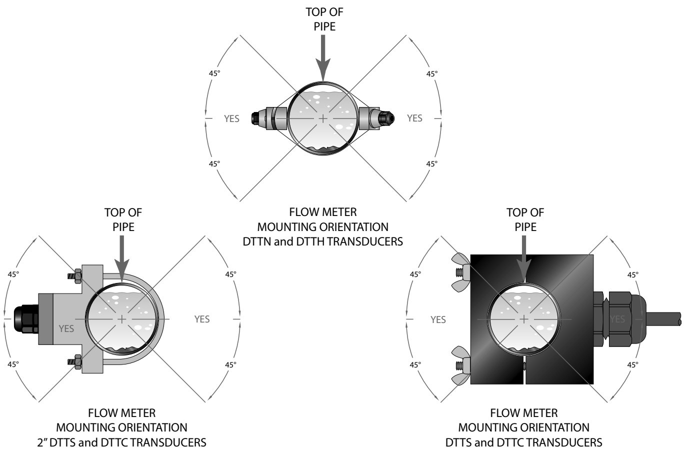


FIGURE 2.2 - TRANSDUCER ORIENTATION — HORIZONTAL PIPES

The spacing between the transducers is measured between the two spacing marks on the sides of the transducers. These marks are approximately 0.75" (19 mm) back from the nose of the DTTN and DTTH transducers. See ***Figure 2.3***.

DTTS and DTTC transducers should be mounted with the cable exiting within ±45 degrees of the side of a horizontal pipe. See ***Figure 2.2***. On vertical pipes the orientation does not apply.

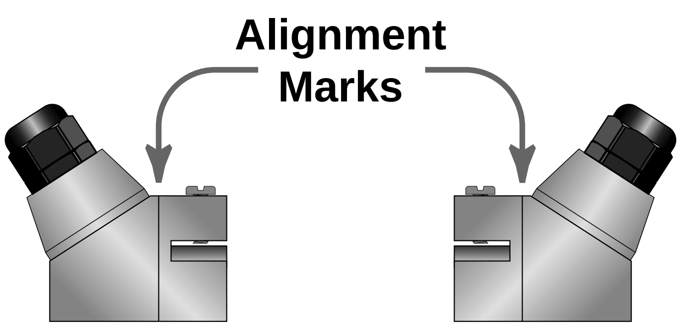


FIGURE 2.3 - TRANSDUCER ALIGNMENT MARKS

V-MOUNT AND W-MOUNT INSTALLATION

APPLICATION OF COUPLANT

For DTTN and DTTH transducers, place a single bead of couplant, approximately ½ inch (12 mm) thick, on the flat face of the transducer. See ***Figure 2.4***. Generally, a silicone-based grease is used as an acoustic couplant, but any grease-like substance that is rated not to "flow" at the temperature that the pipe may operate at will be acceptable. For pipe surface temperature over 150° F (65° C), acoustic couplant (P.N. D002-2011-011) is recommended.

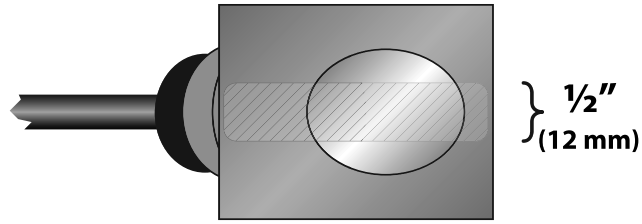


FIGURE 2.4 - APPLICATION OF COUPLANT

TRANSDUCER POSITIONING

1) Place the upstream transducer in position and secure with a mounting strap. Straps should be placed in the arched groove on the end of the transducer. A screw is provided to help hold the transducer onto the strap. Verify that the transducer is true to the pipe and adjust as necessary. Tighten the transducer strap securely.
2) Place the downstream transducer on the pipe at the calculated transducer spacing. See ***Figure 2.5***. Apply firm hand pressure. If signal strength is greater than 5, secure the transducer at this location. If the signal strength is not 5 or greater, using firm hand pressure slowly move the transducer both towards and away from the upstream transducer while observing signal strength.

NOTE: *Signal strength readings update only every few seconds, so it is advisable to move the transducer ⅛", wait, see if signal is increasing or decreasing and then repeat until the highest level is achieved.*

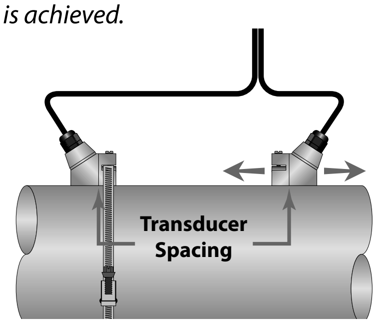


FIGURE 2.5 - TRANSDUCER POSITIONING

Signal strength is displayed on the main data screen in the software utility. See ***Part 4*** of this manual for details regarding the software utility. Clamp the transducer at the position where the highest signal strength is observed. The factory default signal strength cutoff setting is 5, however there are many application specific conditions that may prevent the signal strength from attaining this level. For the TFXL, signal levels much less than 5 will probably not be acceptable for reliable readings.

3) If after adjustment of the transducers the signal strength does not rise to above 5, then an alternate transducer mounting method should be selected. If the mounting method was **W**-Mount, then re-configure the transmitter for **V**-Mount, move the downstream transducer to the new spacing distance and repeat ***Step 4***.

***NOTE:** Mounting of high temperature transducers is similar to mounting the DTTN transducers. High temperature installations require acoustic couplant that is rated not to "flow" at the temperature that will be present on the pipe surface.*

DTTS/DTTC SMALL PIPE TRANSDUCER AND INTEGRAL MOUNT INSTALLATION

The small pipe transducers are designed for specific pipe outside diameters. Do not attempt to mount a DTTS/DTTC or integral mount transducer onto a pipe that is either too large or too small for the transducer. Contact the manufacturer to arrange for a replacement transducer that is the correct size.

DTTS/DTTC and integral installation consists of the following steps:

1) Apply a thin coating of acoustic coupling grease to both halves of the transducer housing where the housing will contact the pipe. See ***Figure 2.6***.
2) On horizontal pipes, mount the transducer in an orientation such that the cable exits at ±45 degrees from the side of the pipe. Do not mount with the cable exiting on either the top or bottom of the pipe. On vertical pipes the orientation does not matter. See ***Figure 2.2***.
3) Tighten the wing nuts or "U" bolts so that the acoustic coupling grease begins to flow out from the edges of the transducer or from the gap between the transducer halves. **Do not over tighten**.
4) If signal strength is less than 5, remount the transducer at another location on the piping system.

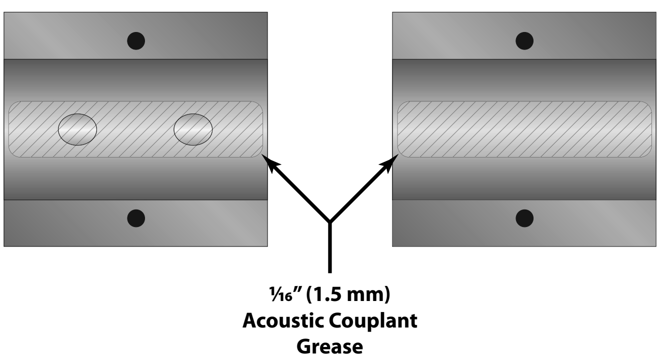


FIGURE 2.6 - APPLICATION OF ACOUSTIC COUPLANT — DTTS/DTTC AND INTEGRAL TRANSDUCERS

***NOTE:** If a DTTS/DTTC small pipe transducer was purchased separately from the TFXL meter, the following configuration procedure is required.*

DTTS/DTTC Small Pipe Transducer Configuration Procedure

1) Establish communications with the transit time meter. See ***Part 4 - Software Utility***.
2) From the Tool Bar select Calibration. See ***Figure 2.7***.
3) On the pop-up screen, click **Next** button twice to get to Page 3 of 3. See ***Figure 2.8***.
4) Click **Edit**.
5) If calibration point is displayed in Calibration Points Editor screen, record the information, highlight and click **Remove**. See ***Figure 2.9***.
6) Click **ADD...**
7) Enter Delta T, Un-calibrated Flow, and Calibrated Flow values from the DTTS/DTTC calibration label, the click **OK**. See ***Figure 2.10***.
8) Click **OK** in the Edit Calibration Points screen.
9) Process will return to Page 3 of 3. Click **Finish**. See ***Figure 2.8***.
10) After "Writing Configuration File" is complete, turn power off. Turn on again to activate new settings.

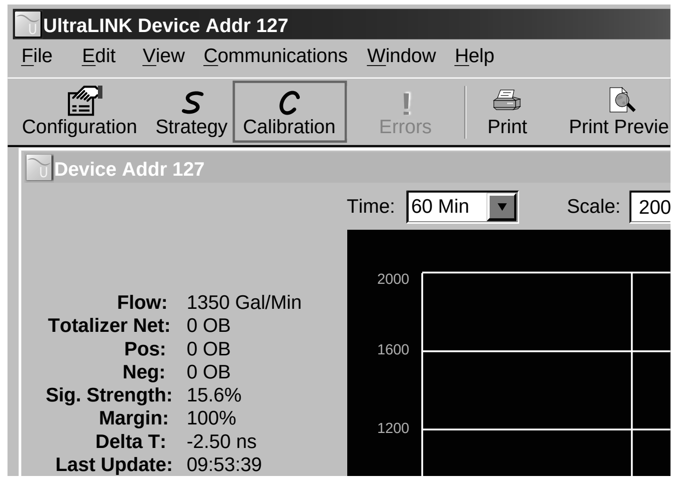


FIGURE 2.7 - DATA DISPLAY SCREEN

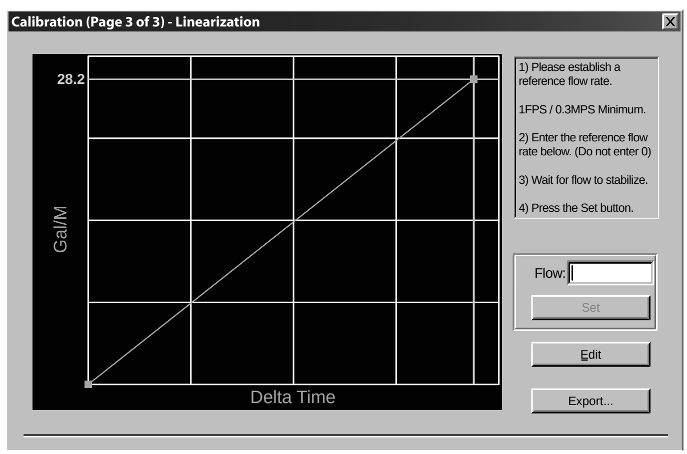


FIGURE 2.8 - CALIBRATION PAGE 3 OF 3

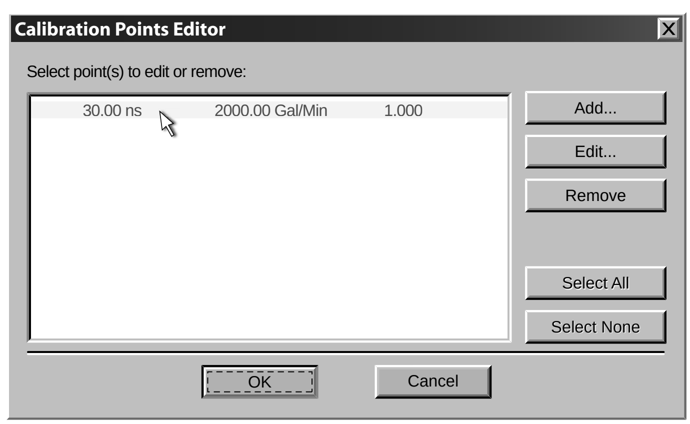


FIGURE 2.9 - CALIBRATION POINTS EDITOR

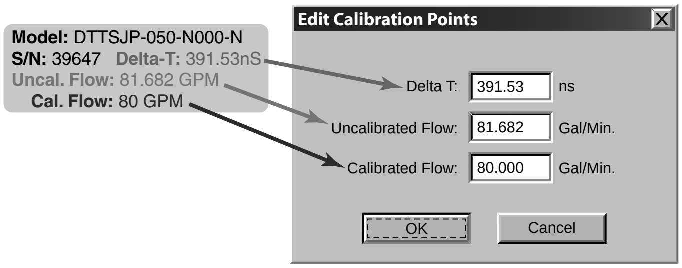


FIGURE 2.10 - EDIT CALIBRATION POINTS

MOUNTING TRANSDUCERS IN Z-MOUNT CONFIGURATION

Installation on larger pipes requires careful measurements of the linear and radial placement of the DTTN and DTTH transducers. Failure to properly orient and place the transducers on the pipe may lead to weak signal strength and/or inaccurate readings. This section details a method for properly locating the transducers on larger pipes. This method requires a roll of paper such as freezer paper or wrapping paper, masking tape and a marking device.

1) Wrap the paper around the pipe in the manner shown in ***Figure 2.11***. Align the paper ends to within ¼ inch (6 mm).
2) Mark the intersection of the two ends of the paper to indicate the circumference. Remove the template and spread it out on a flat surface. Fold the template in half, bisecting the circumference. See ***Figure 2.12***.

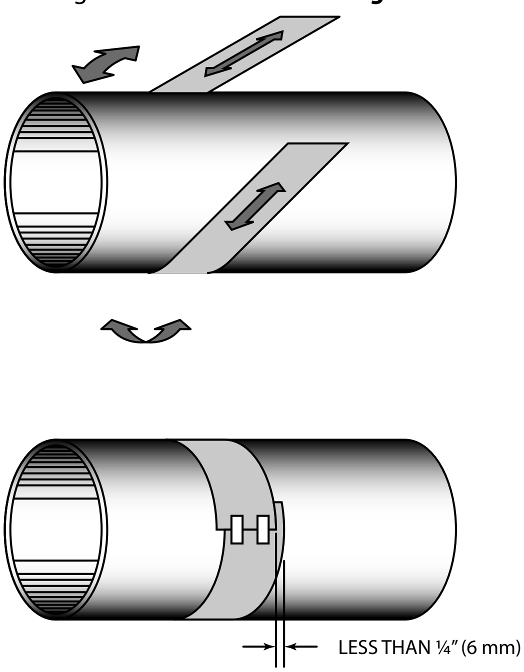


FIGURE 2.11 - PAPER TEMPLATE ALIGNMENT

3) Crease the paper at the fold line. Mark the crease. Place a mark on the pipe where one of the transducers will be located. See ***Figure 2.2*** for acceptable radial orientations. Wrap the template back around the pipe, placing the beginning of the paper and one corner in the location of the mark. Move to the other side of the pipe and mark the pipe at the ends of the crease. Measure from the end of the crease (directly across the pipe from the first transducer location) the dimension derived in ***Step 2***, Transducer Spacing. Mark this location on the pipe.

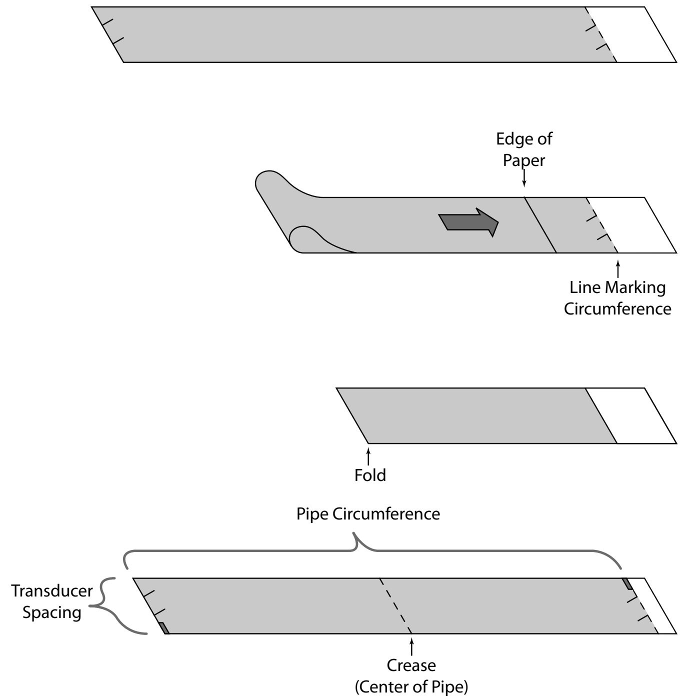


FIGURE 2.12 - BISECTING THE PIPE CIRCUMFERENCE

4) The two marks on the pipe are now properly aligned and measured. If access to the bottom of the pipe prohibits the wrapping of the paper around the circumference, cut a piece of paper ½ the circumference of the pipe and lay it over the top of the pipe. The length of ½ the circumference can be found by:

   ½ Circumference = Pipe O.D. × 1.57

   The transducer spacing is the same as found in the Transducer Positioning section. Mark opposite corners of the paper on the pipe. Apply transducers to these two marks.
5) For DTTN and DTTH transducers, place a single bead of couplant, approximately ½ inch (12 mm) thick, on the flat face of the transducer. See ***Figure 2.4***. Generally, a silicone-based grease is used as an acoustic couplant, but any good quality grease-like substance that is rated to not “flow” at the temperature that the pipe may operate at will be acceptable.
6) Place the upstream transducer in position and secure with a stainless steel strap or other fastening device. Straps should be placed in the arched groove on the end of the transducer. A screw is provided to help hold the transducer onto the strap. Verify that the transducer is true to the pipe, adjust as necessary. Tighten transducer strap securely. Larger pipes may require more than one strap to reach the circumference of the pipe.
7) Place the downstream transducer on the pipe at the

calculated transducer spacing. See ***Figure 2.13***. Using firm hand pressure, slowly move the transducer both towards and away from the upstream transducer while observing signal strength. Clamp the transducer at the position where the highest signal strength is observed. Signal strength of between 5 and 98 is acceptable. The factory default signal strength setting is 5, however there are many application specific conditions that may prevent the signal strength from attaining this level. A minimum signal strength of 5 is acceptable as long as this signal level is maintained under all flow conditions. On certain pipes, a slight twist to the transducer may cause signal strength to rise to acceptable levels.

8) Certain pipe and liquid characteristics may cause signal strength to rise to greater than 98. The problem with operating a TFXL with very high signal strength is that the signals may saturate the input amplifiers and cause erratic readings. Strategies for lowering signal strength would be changing the transducer mounting method to the next longest transmission path. For example, if there is excessive signal strength and the transducers are mounted in a **Z**-Mount, try changing to **V**-Mount or **W**-Mount. Finally you can also move one transducer slightly off line with the other transducer to lower signal strength.
9) Secure the transducer with a stainless steel strap or other fastener.

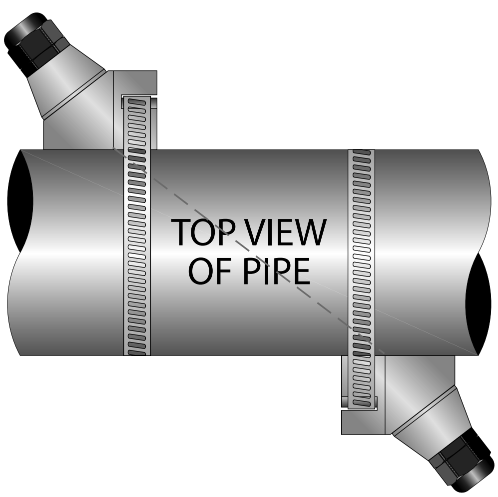


FIGURE 2.13 - Z-MOUNT TRANSDUCER PLACEMENT

MOUNTING TRACK INSTALLATION

1) A convenient transducer mounting track can be used for pipes that have outside diameters between 2 and 10 inches (50 and 250 mm). If the pipe is outside of that range, select a **V**-Mount or **Z**-Mount mounting method.
2) Install the single mounting rail on the side of the pipe with the stainless steel bands provided. Do not mount it on the top or bottom of the pipe. Orientation on vertical pipe is not critical. Ensure that the track is parallel to the pipe and that all four mounting feet are touching the pipe.
3) Slide the two transducer clamp brackets towards the center mark on the mounting rail.
4) Place a single bead of couplant, approximately ½ inch (12 mm) thick, on the flat face of the transducer. See ***Figure 2.4***.
5) Place the first transducer in between the mounting rails near the zero point on the scale. Slide the clamp over the transducer. Adjust the clamp/transducer such that the notch in the clamp aligns with zero on the scale. See ***Figure 2.14***.

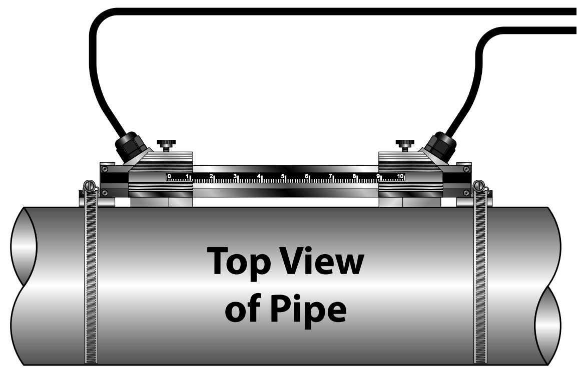


FIGURE 2.14 - MOUNTING TRACK INSTALLATION

6) Secure with the thumb screw. Ensure that the screw rests in the counter bore on the top of the transducer. (Excessive pressure is not required. Apply just enough pressure so that the couplant fills the gap between the pipe and transducer.)
7) Place the second transducer in between the mounting rails near the dimension derived in the transducer spacing section. Read the dimension on the mounting rail scale. Slide the transducer clamp over the transducer and secure with the thumb screw.

PART 3 - INPUTS/OUTPUTS

GENERAL

The TFXL is available in two general configurations. There is the standard TFXL flow model that is equipped with a 4-20 mA output and a rate frequency output.

The TFXL is also available with a totalizing pulse output.

4-20 mA OUTPUT

The 4-20 mA output interfaces with most recording and logging systems by transmitting an analog current signal that is proportional to system flow rate. The 4-20 mA output is internally powered (current sourcing) and can span negative to positive flow/energy rates.

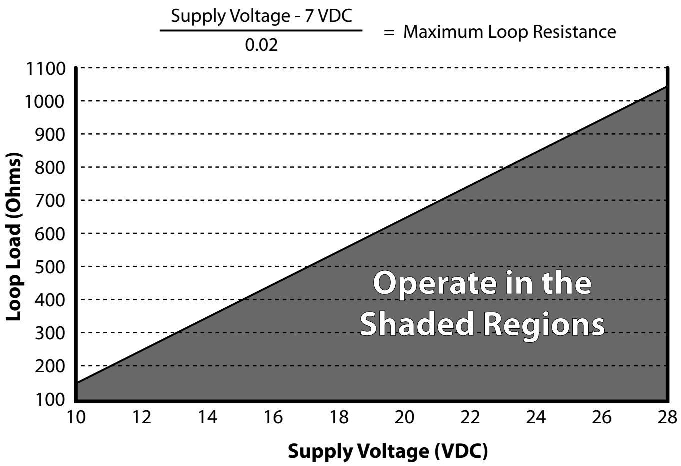


FIGURE 3.1 - ALLOWABLE LOOP RESISTANCE

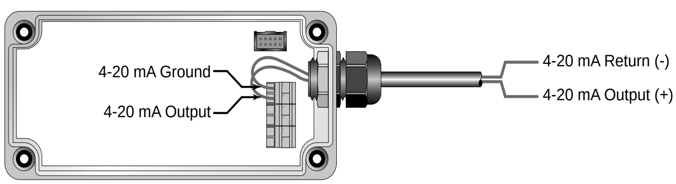


FIGURE 3.2 - 4-20 MA OUTPUT

The 4-20 mA output signal is available between the 4-20 mA Out and Signal Gnd terminals as shown in ***Figure 3.2***.

BATCH/TOTALIZER OUTPUT FOR TFXL

Totalizer mode configures the output to send a 33 mSec pulse each time the display totalizer increments divided by the **TOT MULT.** The **TOT MULT** value must be a whole, positive, numerical value.

For example, if the totalizer exponent (**TOTL E**) is set to **E0** (×1) and the totalizer multiplier (**TOT MULT**) is set to 1, then the output will pulse each time the totalizer increments one count, or each single, whole measurement unit totalized.

If the totalizer exponent (**TOTL E**) is set to **E2** (×100) and the totalizer multiplier (**TOT MULT**) is set to 1, then the control output will pulse each time the display totalizer increments or once per 100 measurement units totalized.

If the totalizer exponent (**TOTL E**) is set to **E0** (×1) and the totalizer multiplier (**TOT MULT**) is set to 2, the control output will pulse once for every two counts that the totalizer increments.

TOTALIZER OUTPUT OPTION FOR TFXL

TFXL units can be ordered with a totalizer pulse output option. This option is installed in the position where the rate pulse would normally be installed.

OPTIONAL TOTALIZING PULSE SPECIFICATIONS	
OPTIONAL TFXL TOTALIZING PULSE OUTPUT	
Signal	1 pulse for each increment of the totalizers least significant digit.
Operation	Normal state - high; pulses low with display total increments
Pulse Duration	30mSec minute
Source/ sink	2 mA maximum
Logic	5 VDC

Wiring and configuration of this option is similar to the totalizing pulse output for the TFXL variation. This option **must use** an external current limiting resistor.

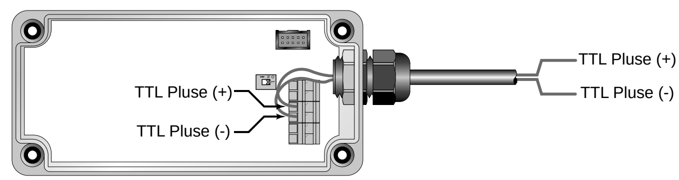


FIGURE 3.3 - TFXL TOTALIZER OUTPUT OPTION

FREQUENCY OUTPUT

The frequency output is a TTL circuit that outputs a pulse waveform that varies proportionally with flow rate. This type of frequency output is also know as a "Rate Pulse" output. The output spans from 0 Hz, normally at zero flow rate to 1,000 Hz at full flow rate (configuration of the **MAX RATE** parameter is described in detail in the flow meter configuration section of this manual).

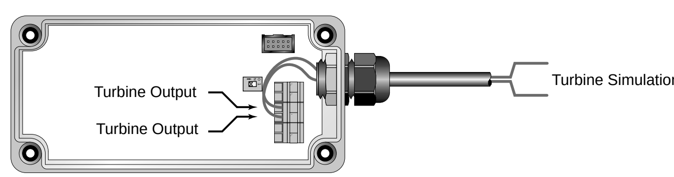


FIGURE 3.4 - FREQUENCY OUTPUT SWITCH SETTINGS

The frequency output is proportional to the maximum flow rate entered into the meter. The maximum output frequency is 1,000 Hz.

If, for example, the **MAX RATE** parameter was set to 400 GPM then an output frequency of 500 Hz (half of the full scale frequency of 1,000 Hz) would represent 200 GPM.

In addition to the control outputs, the frequency output can be used to provide total information by use of a "K-factor". A K-factor simply relates the number of pulses from the frequency output to the number of accumulated pulses that equates to a specific volume.

For the TFXL this relationship is described by the following equation. The 60,000 relates to measurement units in volume/min. Measurement units in seconds, hours or days would require a different numerator.

$$K - factor = \frac{60,000}{Full\ Scale\ Units}$$

EQUATION 3.1 - K-FACTOR CALCULATION

A practical example would be if the **MAX RATE** for the application were 400 GPM, the K-factor (representing the number of pulses accumulated needed to equal 1 Gallon) would be:

$$K - factor = \frac{60,000}{400\ GPM} = 150\ Pulses\ Per\ Gallon$$

If the frequency output is to be used as a totalizing output, the TFXL and the receiving instrument must have identical K-factor values programmed into them to ensure that accurate readings are being recorded by the receiving instrument. Unlike standard mechanical flow meters such as turbines, gear or nutating disk meters, the K-factor can be changed by modifying the **MAX RATE** flow rate value.

NOTE: *For a full treatment of K-factors please see the* ***Appendix*** *of this manual.*

There are two frequency output types available:

Turbine meter simulation - This option is utilized when a receiving instrument is capable of interfacing directly with a turbine flow meter's magnetic pickup. The output is a relatively low voltage AC signal whose amplitude swings above and below the signal ground reference. The minimum AC amplitude is approximately 500 mV peak-to-peak. To activate the turbine output circuit, turn SW1 **OFF**.

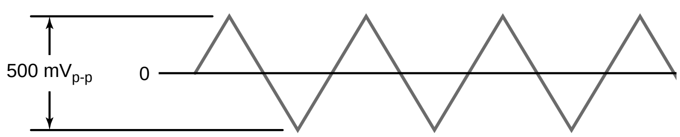


FIGURE 3.5 - FREQUENCY OUTPUT WAVEFORM (SIMULATED TURBINE)

Square-wave frequency - This option is utilized when a receiving instrument requires that the pulse voltage level be either of a higher potential and/or referenced to DC ground. The output is a TTL square-wave (5V).

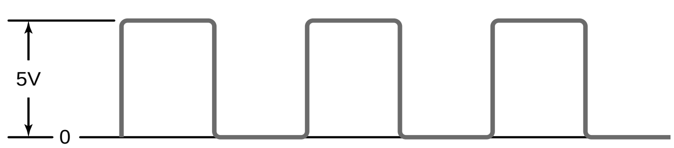


FIGURE 3.6 - FREQUENCY OUTPUT WAVEFORM (SQUARE WAVE)

PART 4 - ULTRALINK UTILITY

INTRODUCTION

The ULTRALINK utility is used for configuring, calibrating and communicating with the TFXL family of flow meters. Additionally, it has numerous troubleshooting tools to make diagnosing and correcting installation problems easier.

This software has been designed to provide the TFXL user with a powerful and convenient way to configure calibrate and troubleshoot all TFXL family flow meters.

SYSTEM REQUIREMENTS

ULTRALINK requires a PC-type computer, running Windows 98, Windows ME, Windows 2000, Windows NT, Windows XP, Windows Vista® or Windows® 7 operating systems and an RS-232 9-pin communications port. (Part # D010-0204-001)

INSTALLATION

1) From the Windows "Start" button, choose the Run command. From the "Run" dialog box, use the Browse button to navigate to the ULTRALINK_Setup.exe file and double-click.
2) The ULTRALINK Setup will automatically extract and install on the hard disk. The ULTRALINK icon can then be copied to the desktop, if desired.

NOTE: *If a previous version of this software is installed, it must be un-installed before a new version of the software can be installed. Newer versions will "ask" to remove the old version and perform the task automatically. Older versions must be removed using the Microsoft Windows® Add/Remove Programs applet.*

NOTE: *Most PCs will require a restart after a successful installation.*

INITIALIZATION

1) Connect the 9-pin serial end to an available port on the PC. Connect the other end to the TFXL.

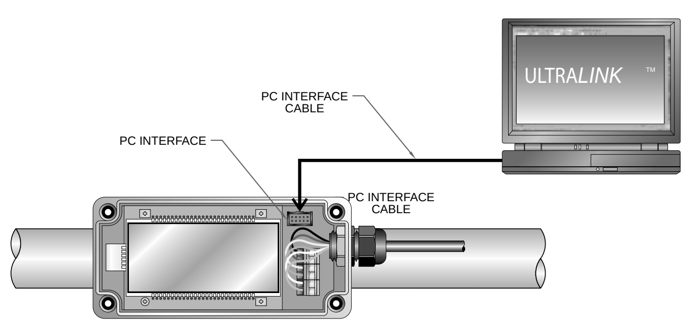


FIGURE 4.1 - PC CONNECTIONS

NOTE: *It is advisable to have the TFXL meter powered up prior to running this software.*

2) Double-click on the ULTRALINK icon. The first screen is the "RUN" mode screen (see ***Figure 4.2***), which contains real-time information regarding flow rate, totals, signal strength, communications status, and the flow meter's serial number. The **COMM** indicator in the lower right-hand corner indicates that the serial connection is active. If the **COMM** box contains a red **ERROR,** click on the **Communications** button on the **Menu** bar and select Initialize. Choose the appropriate COM port and the RS232 / USB **Com Port Type**. Proper communication is verified when a green **OK** is indicated in the lower right-hand corner of the PC display and the "**Last Update**" indicator in the text area on the left side of the screen changes from red to an active clock indication.

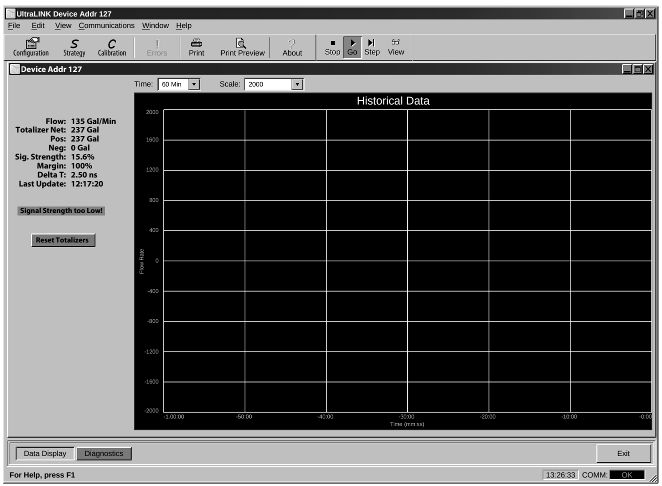
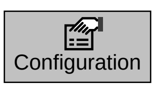


FIGURE 4.2 - DATA DISPLAY SCREEN



The Configuration drop-down houses six screens used to control how the TFXL is set up and responds to varying flow conditions. The first screen that appears after clicking the **Configuration** button is the **Basic** screen. See ***Figure 4.3***.

BASIC TAB

GENERAL

The general heading allows users to select the measurement system for meter setup, either **English** or **Metric** and choose from a number of pre-programmed small pipe configurations in the **Standard Configurations** drop-down. If pipe measurements are to be entered in inches, select **English**. If pipe measurements are to be entered in millimeters, select **Metric**. If the **General** entries are altered from those at instrument start-up, then click on the **Download** button in the lower right-hand portion of the screen and cycle power to the TFXL.

When using the **Standard Configurations** drop-down menu alternate, menu choices can be made by using the following guidelines:

1) Select the transducer type and pipe size for the transducer to be used. The firmware will automatically enter the appropriate values for that pipe size and type. Every entry parameter except for **Units, Standard Configurations,** and **Specific Heat Capacity** will be unavailable behind a "grayed out" entry box.
2) Go back to the **Standard Configurations** drop-down menu and select **Custom**. As soon as **Custom** is chosen, the previously grayed out selections will become available for editing.
3) Make any changes to the **Basic** configuration deemed necessary and press **Download**.
4) To ensure that the configuration changes take effect, turn the power off and then back on again to the transmitter.

TRANSDUCER

***Transducer* Type** selects the transducer that will be connected to the TFXL flow meter. Select the appropriate transducer type from the drop-down list. This selection influences transducer spacing and flow meter performance, so it must be correct. If you are unsure about the type of transducer to which the TFXL will be connected, consult the shipment packing list or call the manufacturer for assistance.

NOTE: *A change of* ***Transducer Type*** *will cause a System Configuration Error (1002: Sys Config Changed) to occur. This error will clear when the microprocessor is reset or power is cycled on the flow meter.*

Transducer* Mount** selects the orientation of the transducers on the piping system. See ***Part 2 of this manual and ***Table 2.2*** for detailed information regarding transducer mounting modes for particular pipe and liquid characteristics. Whenever ***Transducer* Mount** is changed, a download command and subsequent microprocessor reset or flow meter power cycle must be conducted.

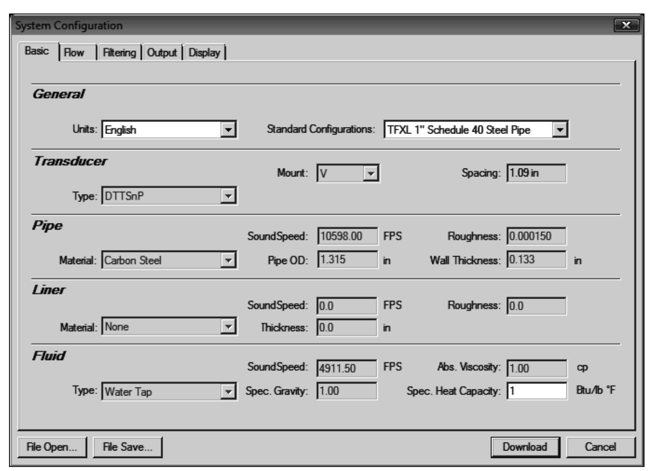


FIGURE 4.3 - BASIC TAB

Frequency	Transducers	Transmission Modes	Pipe Size and Type
2 MHz	All ½″ thru 1½″ Small Pipe and Tube 2″ Tubing	Selected by Firmware	Specific to Transducer
1 MHz	2″ ANSI Pipe and Copper Tube	Selected by Firmware	Specific to Transducer
	Standard and High Temp	W, V, and Z	2″ and Greater

TABLE 4.1 - TRANSDUCER FREQUENCIES

***Transducer* Spacing** is a value calculated by the TFXL firmware that takes into account pipe, liquid, transducer and mounting information. This spacing will adapt as these parameters are modified. The spacing is given in inches for **English** units selection and millimeters for **Metric**. This value is the lineal distance that must be between the transducer alignment marks. Selection of the proper transducer mounting method is not entirely predictable and many times is an iterative process.

> ***NOTE:*** *This setting only applies to DTTN, and DTTH transducers.*

***Transducer* Flow Direction** allows the change of the direction the meter assumes is forward. When mounting TFXL meters with integral transducers, this feature allows upstream and downstream transducers to be "electronically" reversed, making upside down mounting of the display unnecessary.

***Pipe* Material** is selected from the pull-down list. If the pipe material utilized is not found in the list, select **Other** and enter the actual pipe material **Sound Speed** and **Roughness** (much of this information is available at web sites such as www.ondacorp.com/tecref_acoustictable.shtml for pipe relative roughness calculations.

***Pipe* O.D.** and **Wall Thickness** are based on the physical dimensions of the pipe on which the transducers will be mounted. Enter this value in inches for **English** units or millimeters for **Metric** units.

> ***NOTE:*** *Charts listing popular pipe sizes have been included in the* ***Appendix*** *of this manual. Correct entries for pipe O.D. and pipe wall thickness are critical to obtaining accurate flow measurement readings.*

Liner* Material** is selected from the pull-down list. If the pipe liner material utilized is not included in the list, select **Other** and enter liner material **Sound Speed** and **Roughness** (much of this information is available at web sites such as www.ondacorp.com/tecref_acoustictable.shtml. See ***Page 40 for pipe liner relative roughness calculations.

***Fluid* Type** is selected from a pull-down list. If the liquid is not found in the list, select **Other** and enter the liquid **Sound Speed** and **Absolute Viscosity** into the appropriate boxes. The liquid's **Specific Gravity** is required if mass measurements are to be made.

FLOW TAB

Flow Rate Units are selected from the drop-down lists. Select an appropriate rate unit and time from the two lists. This entry also includes the selection of **Flow Rate Interval** after the **/** sign.

Totalizer Units are selected from drop-down lists. Select an appropriate totalizer unit and totalizer exponent. The totalizer exponents are in scientific notation and permit the eight digit totalizer to accumulate very large values before the totalizer "rolls over" and starts again at zero. ***Table 4.2*** illustrates the scientific notation values and their respective decimal equivalents.

Exponent	Display Multiplier
E-1	× 0.1 (÷10)
E0	× 1 (no multiplier)
E1	× 10
E2	× 100
E3	× 1,000
E4	× 10,000
E5	× 100,000
E6	× 1,000,000

TABLE 4.2 - EXPONENT VALUES

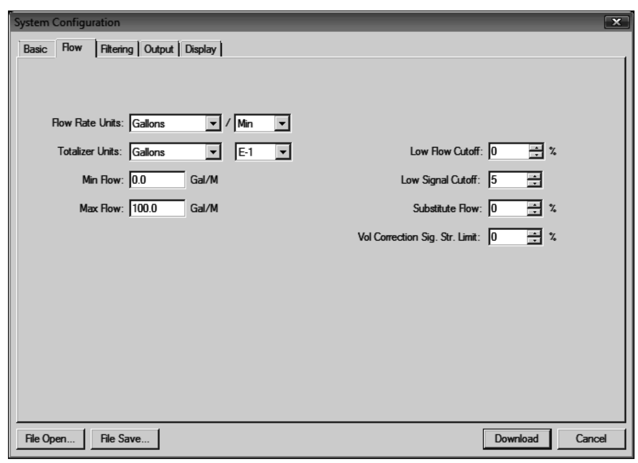


FIGURE 4.4 - FLOW TAB

Min Flow is the minimum volumetric flow rate setting entered to establish filtering parameters. Volumetric entries will be in the **Flow Rate Units**. For unidirectional measurements, set **Min Flow** to zero. For bidirectional measurements, set **Min Flow** to the highest negative (reverse) flow rate expected in the piping system.

Max Flow is the maximum volumetric flow rate setting entered to establish filtering parameters. Volumetric entries will be in the **Flow Rate Units**. For unidirectional measurements, set **Max Flow** to the highest (positive) flow rate expected in the piping system. For bidirectional measurements, set **Max Flow** to the highest (positive) flow rate expected in the piping system.

Low Flow Cutoff is provided to allow very low flow rates (that can be present when pumps are off and valves are closed) to be displayed as zero flow. Typical values that should be entered are between 1.0% and 5.0% of the flow range between **Min Flow** and **Max Flow**.

Low Signal Cutoff is used to drive the flow meter and its outputs to the value specified in the **Substitute Flow** field when conditions occur that cause low signal strength. A signal strength indication below 5 is generally inadequate for measuring flow reliably, so generally the minimum setting for **Low Signal Cutoff** is 5. A good practice is to set the **Low Signal Cutoff** at approximately 60-70% of actual measured maximum signal strength.

NOTE: *The factory default "Low Signal Cutoff" is 5.*

If the measured signal strength is lower than the **Low Signal Cutoff** setting, a "Signal Strength too Low" highlighted in red will become visible in the text area to the left in the **Data Display** screen until the measured signal strength becomes greater than the cutoff value.

Signal strength indication below 2 is considered to be no signal at all. Verify that the pipe is full of liquid, the pipe size and liquid parameters are entered correctly, and that the transducers have been mounted accurately. Highly aerated liquids will also cause low signal strength conditions.

Substitute Flow is a value that the analog outputs and the flow rate display will indicate when an error condition in the flow meter occurs. The typical setting for this entry is a value that will make the instrument display zero flow during an error condition.

Substitute Flow is set as a percentage between **Min Flow** and **Max Flow**. In a unidirectional system, this value is typically set to zero to indicate zero flow while in an error condition. In a bidirectional system, the percentage can be set such that zero is displayed in an error condition. To calculate where to set the Substitute Flow value in a bidirectional system, perform the following operation:

$$\text{Substitute Flow} = 100 - \frac{100 \times \text{Maximum Flow}}{\text{Maximum Flow} - \text{Minimum Flow}}$$

Entry of data in the **Basic** and **Flow** tabs is all that is required to provide flow measurement functions to the flow meter. If the user is not going to utilize input/output functions, click on the **Download** button to transfer the configuration to the TFXL instrument. When the configuration has been completely downloaded, turn the power to the meter off and then on again to guarantee the changes take effect.

FILTERING TAB

The Filtering tab contains several filter settings for the TFXL flow meter. These filters can be adjusted to match response times and data "smoothing" performance to a particular application.

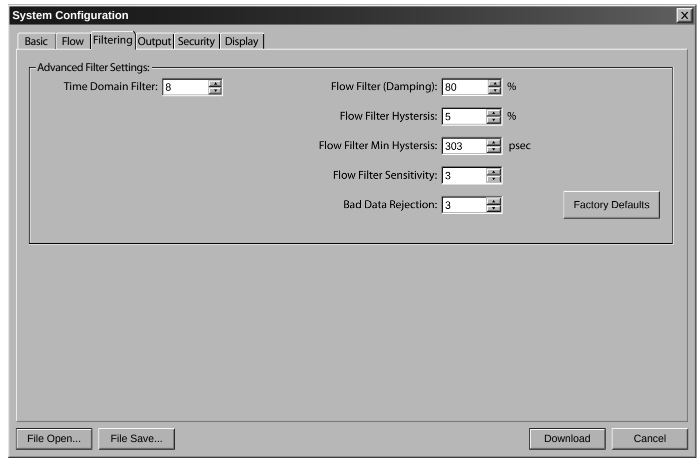


FIGURE 4.5 - FILTERING TAB

Time Domain Filter (range 1-256) adjusts the number of raw data sets (the wave forms viewed on the software Diagnostics Screen) that are averaged together. Increasing this value will provide greater damping of the data and slow the response time of the flow meter. Conversely, lowering this value will decrease the response time of the meter to changes in flow/energy rate. This filter is not adaptive, it is operational to the value set at all times.

NOTE: *The TFXL completes a measurement in approximately 350-400 mS. The exact time is pipe size dependent.*

Flow Filter (Damping) establishes a maximum adaptive filter value. Under stable flow conditions (flow that varies less than the **Flow Filter Hysteresis** entry), this adaptive filter will increase the number of successive flow readings that are averaged together up to this maximum value. If flow changes outside of the **Flow Filter Hysteresis** window, the filter adapts by decreasing the number of averaged readings and allows the meter to react faster.

The damping value is increased to increase stability of the flow rate readings. Damping values are decreased to allow the flow meter to react faster to changing flow rates. The factory settings are suitable for most installations. Increasing this value tends to provide smoother steady-state flow readings and outputs.

Flow Filter Hysteresis creates a window around the average flow measurement reading allowing small variations in flow without changing the damping value. If the flow varies within that hysteresis window, greater display damping will occur up to the maximum values set by the **Flow Filter (Damping)** entry. The filter also establishes a flow rate window where measurements outside of the window are examined by the **Bad Data Rejection** filter. The value is entered as a percentage of actual flow rate.

For example, if the average flow rate is 100 GPM and the **Flow Filter Hysteresis** is set to 5%, a filter window of 95-105 GPM is established. Successive flow measurements that are measured within that window are recorded and averaged in accordance with the **Flow Filter Damping** setting. Flow readings outside of the window are held up in accordance with the **Bad Data Rejection** filter.

Flow Filter MinHysteresis sets a minimum hysteresis window that is invoked at sub 0.25 FPS (0.08 MPS) flow rates, where the "of rate" **Flow Filter Hysteresis** is very small and ineffective. This value is entered in pico-seconds (ρ sec) and is differential time. If very small fluid velocities are to be measured, increasing the **Flow Filter MinHysteresis** value can increase reading stability.

Flow Filter Sensitivity allows configuration of how fast the **Flow Filter Damping** will adapt in the positive direction. Increasing this value allows greater damping to occur faster than lower values. Adaptation in the negative direction is not user adjustable.

Bad Data Rejection is a value related to the number of successive readings that must be measured outside of the **Flow Filter Hysteresis** or **Flow Filter MinHysteresis** windows before the flow meter will use that flow value. Larger values are entered into **Bad Data Rejection** when measuring liquids that contain gas bubbles, as the gas bubbles tend to disturb the ultrasonic signals and cause more extraneous flow readings to occur. Larger **Bad Data Rejection** values tend to make the flow meter more sluggish to rapid changes in actual flow rate.

OUTPUT TAB

The entries made in the Output tab establish input and output parameters for the flow meter. Select the appropriate function from the pull-down menu and press the Download button. When a function is changed from the factory setting, a Configuration error (1002) will result. This error will be cleared by resetting the TFXL microprocessor from the Communications/Commands/Reset Target button or by cycling power on the TFXL flow meter. Once the proper output is selected and the microprocessor is reset, calibration and configuration of the modules can be completed.

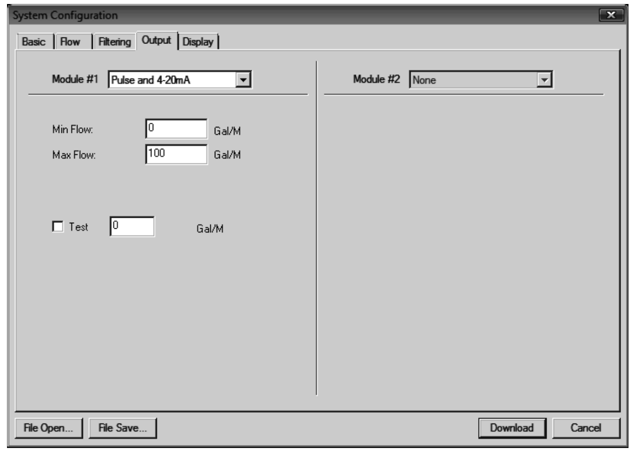


FIGURE 4.6 - OUTPUT TAB

CHANNEL 1 - 4-20 mA FREQUENCY CONFIGURATION

> ***NOTE:*** *The 4-20 mA Output Frequency Menu applies to all TFXL versions and is the only output choice for Channel 1.*

The **Channel 1** menu controls how the 4-20 mA output is spanned for all TFXL models.

The Flow at 4 mA / 0 Hz and Flow at 20 mA / 1,000 Hz settings are used to set the span for both the 4-20 mA output and the 0-1,000 Hz frequency output on the TFXL meter versions.

The 4-20 mA output is internally powered (current sourcing) and can span negative to positive flow rates. This output interfaces with virtually all recording and logging systems by transmitting an analog current that is proportional to system flow rate. Independent 4 mA and 20 mA span settings are established in firmware using the flow measuring range entries. These entries can be set anywhere in the - 40 to + 40 FPS (-12 to +12 MPS) range of the instrument. Resolution of the output is 12-bits (4096 discrete points) and can drive up to a 900 Ohm load. When powered by a DC supply, the load is limited by the input voltage supplied to the instrument. See ***Figure 3.1*** for allowable loop loads.

Flow at 4 mA / 0 Hz
Flow at 20 mA / 1,000 Hz

The Flow at 4 mA / 0 Hz and Flow at 20 mA / 1,000 Hz entries are used to set the span of the 4-20 mA analog output and the frequency output on TFXL versions. These entries are volumetric rate units that are equal to the volumetric units configured as rate units and rate interval discussed on ***Page 23*****.**

For example, to span the 4-20 mA output from -100 GPM to +100 GPM with 12 mA being 0 GPM, set the Flow at 4 mA / 0 Hz and Flow at 20 mA / 1,000 Hz inputs as follows:

Flow at 4 mA / 0 Hz = -100.0
Flow at 20 mA / 1,000 Hz = 100.0

If the meter were a TFXL, this setting would also set the span for the frequency output. At -100 GPM, the output frequency would be 0 Hz. At the maximum flow of 100 GPM, the output frequency would be 1,000 Hz, and in this instance a flow of zero would be represented by an output frequency of 500 Hz.

Example 2 - To span the 4-20 mA output from 0 GPM to +100 GPM with 12 mA being 50 GPM, set the Flow at 4 mA / 0 Hz and Flow at 20 mA / 1,000 Hz inputs as follows:

Flow at 4 mA / 0 Hz = 0.0
Flow at 20 mA / 1,000 Hz = 100.0

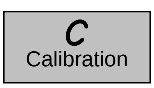
For the TFXL meter, in this instance, zero flow would be represented by 0 Hz and 4 mA. The full scale flow or 100 GPM would be 1,000 Hz and 20 mA and a midrange flow of 50 GPM would be expressed as 500 Hz and 12 mA.

4-20 Test -- 4-20 mA Output Test (Value)

Allows a simulated flow value to be sent from the 4-20 mA output. By incrementing this value, the 4-20 mA output will transmit the indicated current value.

Errors
Alarm outputs on any error condition. See ***Error Table*** in the ***Appendix*** of this manual.

SETTING ZERO AND CALIBRATION



The software utility contains a powerful multi-point calibration routine that can be used to calibrate the TFXL flow meter to a primary measuring standard in a particular installation. To initialize the three-step calibration routine, click on the ***Calibration*** button located on the top of the Data Screen. The display shown in ***Figure 4.7*** will appear.

The first screen (Page 1 of 3) , establishes a baseline zero flow rate measurement for the instrument. Because every flow meter installation is slightly different and sound waves can travel in slightly different ways through these various installations, it is important to remove the zero offset at zero flow to maintain the meters accuracy. A provision is made using this entry to establish "Zero" flow and eliminate the offset.

To zero the flow meter:

1) Establish zero flow in the pipe (ensure that the pipe is full of fluid, turn off all pumps, and close a dead-heading valve). Wait until the delta-time interval shown in "**Current Delta T**" is stable (and typically very close to zero).
2) Click the **Set** button.
3) Click the **Next** button when prompted, then click the **Finish** button on the calibration screen.

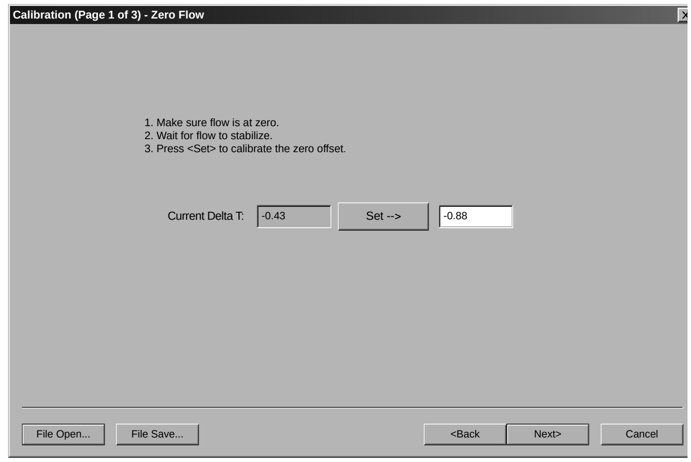


FIGURE 4.7 - CALIBRATION PAGE 1 OF 3

The zeroing process is essential in systems using the DTTS and DTTC transducer sets to ensure the best accuracy.

The second step (Page 2 of 3) in the calibration process is the selection of the engineering units with which the calibration will be performed. Select the **Flow Rate Units** and click the **Next** button at the bottom of the window.

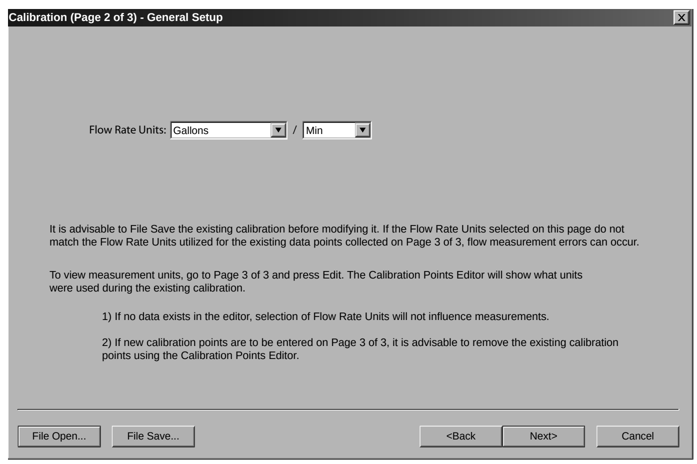


FIGURE 4.8 - CALIBRATION PAGE 2 OF 3

Page 3 of 3 as shown in ***Figure 4.9*** allows multiple actual flow rates to be recorded by the TFXL. To calibrate a point, establish a stable, known flow rate (verified by a real-time primary flow instrument), enter the actual flow rate in the ***Figure 4.9*** window and click the **Set** button. Repeat for as many points as desired.

NOTE: *If only two points are to be used (zero and span), it is preferable to use the highest flow rate anticipated in normal operation as the calibration point. If an erroneous data point is collected, the point can be removed by pressing the Edit button, selecting the bad point and then selecting Remove.*

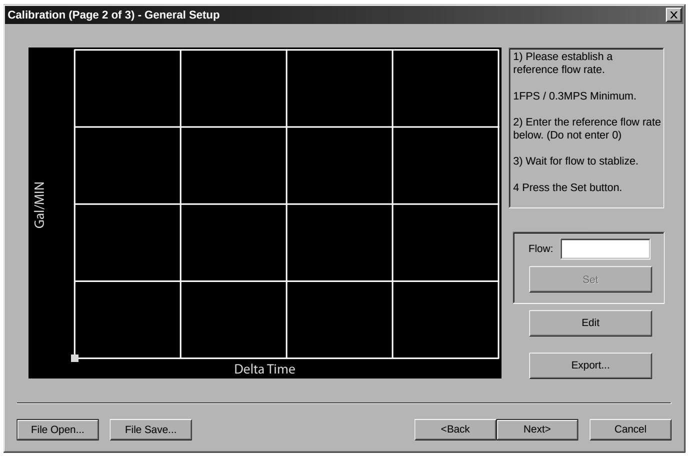
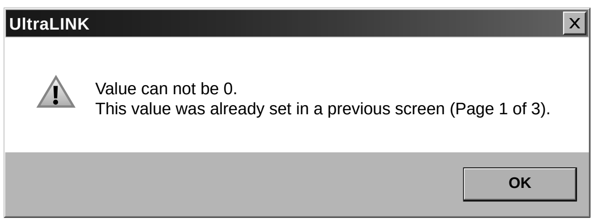


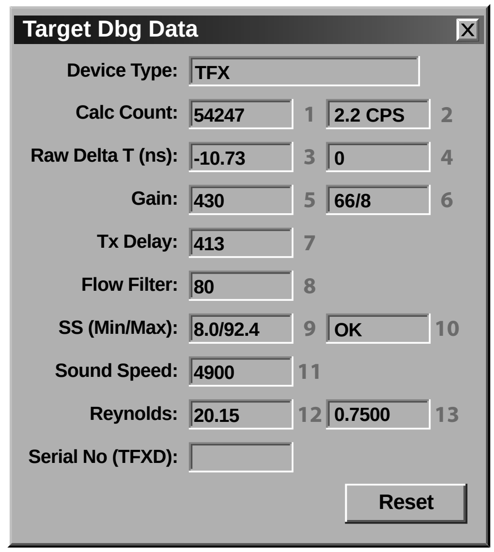
FIGURE 4.9 - CALIBRATION PAGE 3 OF 3

Zero values are not valid for linearization entries. Flow meter zero is entered on Page 1 of 3. If a zero calibration point is attempted, the following error message will be shown:



Press the **Finish** button when all points have been entered.

TARGET DBG DATA SCREEN - DEFINITIONS



1) Calc Count - The number of flow calculations performed by the meter beginning at the time the power to the meter was last turned off and then on again.

2) Sample Count - The number of samples currently being taken in one second.

3) Raw Delta T (ηs) - The actual amount of time it takes for an ultrasonic pulse to cross the pipe.

4) Course Delta T - The TFX series uses two wave forms. The coarse to find the best delay and other timing measurements and a fine to do the flow measurement.

5) Gain - The amount of signal amplification applied to the reflected ultrasound pulse to make it readable by the digital signal processor.

6) Gain Setting/Waveform Power - The first number is the gain setting on the digital pot (automatically controlled by the AGC circuit). Valid numbers are from 1 to 100. The second number is the power factor of the current waveform being used. For example, "8" indicates that a ⅛ power wave form is being used.

7) Tx Delay - The amount of time the transmitting transducer waits for the receiving transducer to recognize an ultrasound signal before the transmitter initiates another measurement cycle.

8) Flow Filter - The current value of the adaptive filter.

9) SS (Min/Max) - The minimum and maximum signal strength levels encountered by the meter beginning at the time the power to the meter was last turned off and then on again.

10) Signal Strength State - Indicates if the present signal strength minimum and maximum are within a pre-programed signal strength window.

11) Sound Speed **- The actual sound speed being measured by the transducers at that moment.**

12) Reynolds - A number indicating how turbulent a fluid is. Reynolds numbers between 0 and 2000 are considered laminar flow. Numbers between 2000 and 4000 are in transition between laminar and turbulent flows and numbers greater than 4000 indicate turbulent flow.

13) Reynolds Factor - The value applied to the flow calculation to correct for variations in Reynolds numbers.

SAVING METER CONFIGURATION ON A PC

The complete configuration of the flow meter can be saved from the Configuration screen. Select File Save button located in the lower left-hand corner of the screen and name the file. Files are saved as a *.dcf extension. This file may be transferred to other flow meters or may be recalled should the same pipe be surveyed again or multiple meters programmed with the same information.

PRINTING A FLOW METER CONFIGURATION REPORT

Select **File** from the upper task bar and **Print** to print a calibration/configuration information sheet for the installation.

APPENDIX

SPECIFICATIONS

Liquid Types	Most clean liquids or liquids containing small amounts of suspended solids
Power Requirements	11-28VDC @ 0.25A
Protection	Reverse polarity, surge suppression
Velocity	0.1…40 fps (0.03…12 mps)
Inputs/Outputs	**4-20mA Output (Standard Output)** Resolution: 12-bit for all outputs Power: Source Insertion loss: 5V Max. Loop impedance: 900 Ohms Max. Isolation: Can share ground common with power supply isolated from piping system **Totalizer Pulse** Operation: Normal state high; pulses low with display total increments Pulse duration: 30mSec min. Source/sink: 2 mA max. Logic: 5 VDC **Turbine Frequency Output/TTL—Pulse Output (Switch selectable)** Type: Non-grounded referenced AC/ground referenced square wave Amplitude: 500mVpp min. /5 VDC Frequency range: 0…1,000Hz Duty cycle: 50% ± 10%
Display	Type: 2 line x 8 character LCD Rate: 8 maximum digits with lead zero blanking Total: 8 maximum digits with exponential multipliers from –1…6
Units	Engineering units: Feet, gallons, ft^3, million-gal, barrels (liquid & oil), acre-feet. lbs, meters, m^3, liters, million-liters, kg Rate: second, minute, hour, day
Enclosure – Rating: **Dimensions:**	NEMA 3 (Type 3) ABS, PVC and Ultem® (integral system), brass or SS hardware 3"W x 2.5" H x 6" D (75 mm x 63 mm x 150 mm)
Transducer Type:	Clamp-on, uses time of flight ultrasonics
Ambient Temperature:	General purpose: –40° F…185° F (–40° C…85° C); Hazardous locations integral mount: 0° F…105° F (–20° C…40° C); Hazardous locations DTTN: –40° F…185° F (–40° C…85° C)
Transducer Ratings:	DTTN/DTTC: NEMA 6* (IP 67), CPVC, Ultem®, Nylon cord grip, PVC cable jacket; -40…250° F (-40…121° C) Construction DTTN: NEMA 6P* (IP 68) option, CPVC, Ultem®, Nylon cord grip, Polyethylene cable jacket; -40…250° F (-40…121° C) DTTH: NEMA 6* (IP 67), PTFE, Vespel®, Nickel-plated brass cord grip, PFA cable jacket; -40…350° F (-40…176° C) DTTS: NEMA 6* (IP 67), PVC, Ultem®, Nylon cord grip, PVC cable jacket; -40…185° F (-40…85° C) *NEMA 6 units: to a depth of 3 ft. (1 m) for 30 days max. NEMA 6P units: to a depth of 100 ft. (30 m) seawater equivalent density indefinitely.
Pipe/Tubing Sizes:	1/2" (12 mm) and larger
Pipe/Tubing Materials:	Carbon steel, stainless steel, copper and plastic
Accuracy:	DTTN/DTTH ±1% of reading at rates >1 FPS (0.3 MPS), ±0.01 FPS (±0.003 MPS) at rates lower than 1 FPS; DTTS/DTTC 1" and larger units ±1% of reading from 10-100% of measuring range, ±0.01 FPS (±0.003 MPS) at rates lower than 10% of measuring range; ¾" and smaller units ±1% FS. Refer to the Dimensional Specifications page for applicable measuring ranges for each DTTS/DTTN transducer models.
Repeatability:	±0.5% of reading
Response Time:	0.3…30 seconds, adjustable
Certifications:	**All TFXL Models** General Requirements: UL 61010-1 and CSA C22.2 No. 61010-1 Hazardous Locations: Class I Div. 2 Groups C&D T4 to UL 1604 and CSA 22.2 No. 213 **DTTN Transducer and IS Barrier (-F option)** Hazardous Location Designation: Class I Div 1, Groups C & D; T5 Intrinsically Safe Exia Process Control Equipment: CSA C22.2 No. 142 Intrinsically Safe Equipment: CSA C22.2 No. 157 Intrinsically Safe & Associated Apparatus: UL913 Energy Management Equipment: UL916
ULTRALINK™ Utility:	Software utility, requires serial communication cable Windows 2000, Windows XP, Windows Vista®, and Windows® 7 compatible

Part Number Construction

Integral System 1/2"…2" (12…50 mm)

Part Number: DTFXL [ ] - [ ] [ ] [ ] - **N** [ ]

Display Options
1) No display
2) Rate & Toatalizer display

Output
1) 4-20 mA & TTL Pulse
3) Totalizer Pulse

Connector Options
N) 1/2" Conduit Hole (2)
A) Water-tight Cable Clamp(2)
C) 4-Pin (male) Brad Harrison® Micro-Change® Connector
D) 1/2" Flexible Conduit Connectors (2)

Options
N) None
C) CPVC Transducer Material

Pipe Size
A) 1/2" ANSI Pipe (DN 15)
B) 3/4" ANSI Pipe (DN 20)
C) 1" ANSI Pipe (DN 25)
D) 1-1/4" ANSI Pipe (DN 32)
E) 1-1/2" ANSI Pipe (DN 40)
F) 2" ANSI Pipe (DN 50)
G) 1/2" Copper
H) 3/4" Copper
I) 1" Copper
J) 1-1/4" Copper
K) 1-1/2" Copper
L) 2" Copper
M) 1/2" Tubing
N) 3/4" Tubing
P) 1" Tubing
Q) 1-1/4" Tubing
R) 1-1/2" Tubing
S) 2" Tubing

Remote System 1/2" and larger (12 mm and larger)

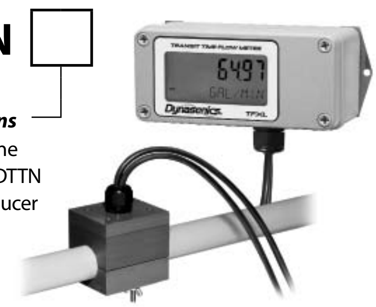
A system consists of one DTFXL part number and a choice of one large or small pipe transducer part number.

DTFXL [ ] - [ ] [ ] [ ] - **N** [ ]

System Size
X) Large Pipe
Y) Small Pipe

Select Options from Integral System Table

Options
N) None
F) I.S. DTTN Transducer



Standard Pipe Transducer
Pipes larger than 2" (DN 50 mm)

DTT [ ]-[ ][ ][ ]-[ ] [ ][ ][ ]-[ ]

Piping Environment
N) Standard: 250° F (121° C) Max. Temp.
L) Large Pipe: 250° F (121° C) Max. Temp.
H) High Temp: 350° F (176° C) Max. Temp.

Cable Length
020) 20 feet (6 m)
050) 50 feet (15 m)
100) 100 feet (30 m)

Transducer Options
N) None
S) Submersible (IP68)
A) Flexible armored
P) BNC Connectors

Conduit Length
000) 0 feet (0 m)
020) 20 feet (6 m)
050) 50 feet (15 m)
100) 100 feet (30 m)

Area Options
N) None
F) Class I, Div. 1, Groups C & D w/I.S. barrrier
P) Portable w/ I.S. barrier

Small Pipe Transducer
Pipes 1/2…2" (12…50 mm)

DTT [ ]-[ ][ ]-[ ][ ][ ]-[ ][ ][ ][ ]

Piping Environment
S) Standard: 185° F 185° F (85° C) (PVC, Ultem®)
C) High Temp: 250° F (121° C) (CPVC, Ultem®)

Nominal Pipe Size
D) 1/2"
F) 3/4"
G) 1"
H) 1-1/4"
J) 1-1/2"
L) 2"

Pipe Type
P) ANSI Pipe
C) Copper Pipe
T) Tubing

Cable Length
020) 20 ft. (6.1 m)
050) 50 ft. (15 m)
100) 100 ft. (30 m)

Conduit Type
N) None
A) Flexible Armored
P) BNC Connectors

Conduit Length
000) 0 ft. (0 m)
020) 20 ft. (6.1 m)
050) 50 ft. (15 m)
100) 100 ft. (30 m)

TFXL ERROR CODES		
Revised 5-25-2009		
Code Number	Description	Correction
Warnings		
0010	Signal Strength is below Signal Strength Cutoff entry	Low signal strength is typically caused by one of the following: » Empty pipe » Improper programming/incorrect values » Improper transducer spacing » Non-homogeneous pipe wall
0011	Measured Speed of Sound in the liquid is greater than ±10% different than the value entered during meter setup	Verify that the correct liquid was selected in the BASIC menu. Verify that pipe size parameters are correct.
Class C Errors		
1001	System tables have changed	Initiate a meter RESET by cycling power or by selecting SYSTEM RESET in the SEC MENU.
1002	System configuration has changed	Initiate a meter RESET by cycling power or by selecting SYSTEM RESET in the SEC MENU.
Class B Errors		
3001	Invalid hardware configuration	Upload corrected file.
3002	Invalid system configuration	Upload corrected file.
3003	Invalid strategy file	Upload corrected file.
3004	Invalid calibration data	Re-calibrate the system.
3005	Invalid speed of sound calibration data	Upload new data.
3006	Bad system tables	Upload new table data.
Class A Errors		
4001	Flash memory full	Return unit to factory for evaluation

TABLE A-5.1 - TFXL ERROR CODES

1. REFER TO TRANSMITTER'S INSTALLATION MANUAL FOR TRANSDUCER LOCATION AND MOUNTING INSTRUCTIONS.
2. WARNING - TO PREVENT IGNITION OF FLAMMABLE ATMOSPHERES, DISCONNECT POWER BEFORE SERVICING.
3. WARNING: SUBSTITUTION OF COMPONENTS MAY IMPAIR INTRINSIC SAFETY.
4. NO REVISION TO DRAWING WITHOUT PRIOR CSA-INTERNATIONAL APPROVAL.
5. ASSOCIATED APPARATUS MANUFACTURER'S INSTALLATION DRAWING MUST BE FOLLOWED WHEN INSTALLING THIS EQUIPMENT.
6. INSTALLATION IN CANADA SHOULD BE IN ACCORDANCE WITH THE CANADIAN ELECTRICAL CODE, CSA C22.1, PART 1, APPENDIX F.
7. INSTALLATION SHALL BE IN ACCORDANCE WITH THE NATIONAL ELECTRICAL CODE (ANSI / NFPA 70) SECTIONS 504 AND 505 AND THE ANSI / ISA RP12.6 INSTALLATION OF INTRINSICALLY SAFE SYSTEMS FOR HAZARDOUS (CLASSIFIED) LOCATIONS.
8. THE MAXIMUM NON-HAZARDOUS LOCATION VOLTAGE IS 250V AC/DC.

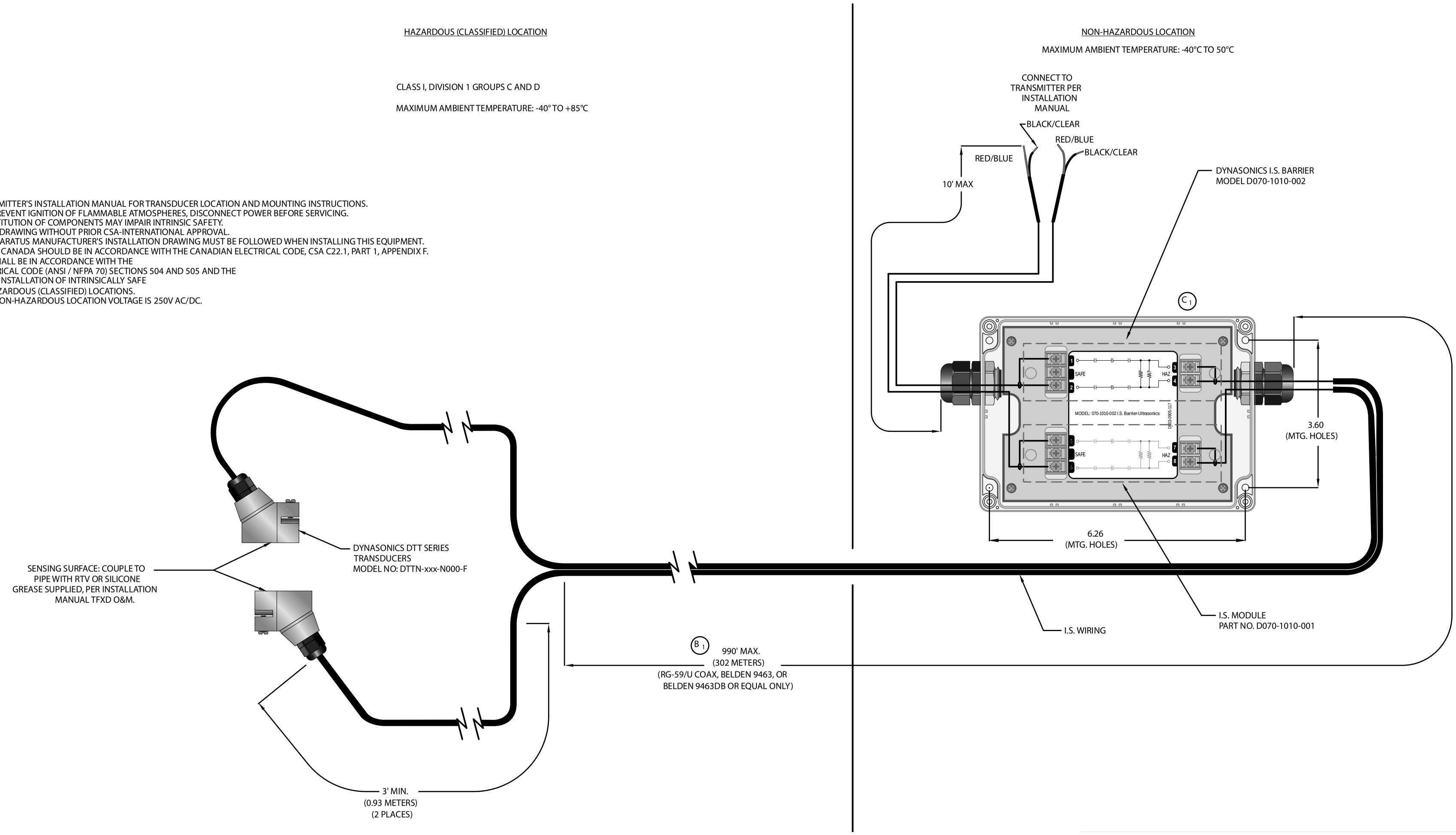


FIGURE A-6.1 - CONTROL DRAWING I.S. BARRIER DTT TRANSDUCERS

HAZARDOUS (CLASSIFIED) LOCATION

CLASS I, DIVISION 1 GROUPS C AND D

MAXIMUM AMBIENT TEMPERATURE: -40° TO +85°C

1. REFER TO TRANSMITTER'S INSTALLATION MANUAL FOR TRANSDUCER LOCATION AND MOUNTING INSTRUCTIONS.
2. WARNING - TO PREVENT IGNITION OF FLAMMABLE ATMOSPHERES, DISCONNECT POWER BEFORE SERVICING.
3. WARNING: SUBSTITUTION OF COMPONENTS MAY IMPAIR INTRINSIC SAFETY.
4. NO REVISION TO DRAWING WITHOUT PRIOR CSA-INTERNATIONAL APPROVAL.
5. ASSOCIATED APPARATUS MANUFACTURER'S INSTALLATION DRAWING MUST BE FOLLOWED WHEN INSTALLING THIS EQUIPMENT.
6. INSTALLATION IN CANADA SHOULD BE IN ACCORDANCE WITH THE CANADIAN ELECTRICAL CODE, CSA C22.1, PART 1, APPENDIX F.
7. INSTALLATION SHALL BE IN ACCORDANCE WITH THE NATIONAL ELECTRICAL CODE (ANSI / NFPA 70) SECTIONS 504 AND 505 AND THE ANSI / ISA RP12.6 INSTALLATION OF INTRINSICALLY SAFE SYSTEMS FOR HAZARDOUS (CLASSIFIED) LOCATIONS.
8. THE MAXIMUM NON-HAZARDOUS LOCATION VOLTAGE IS 250V AC/DC.

NON-HAZARDOUS LOCATION

MAXIMUM AMBIENT TEMPERATURE: -40°C TO 50°C

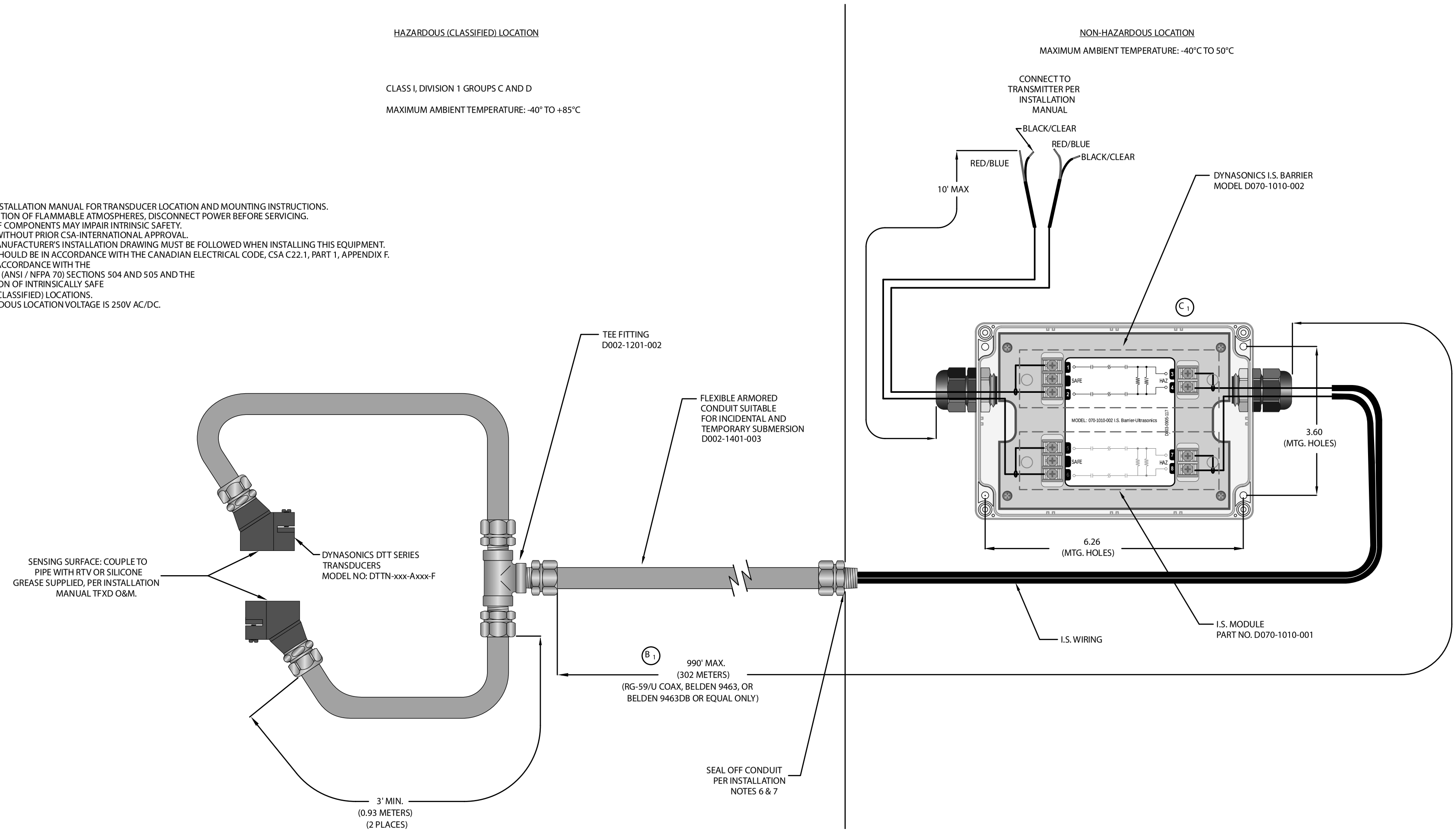
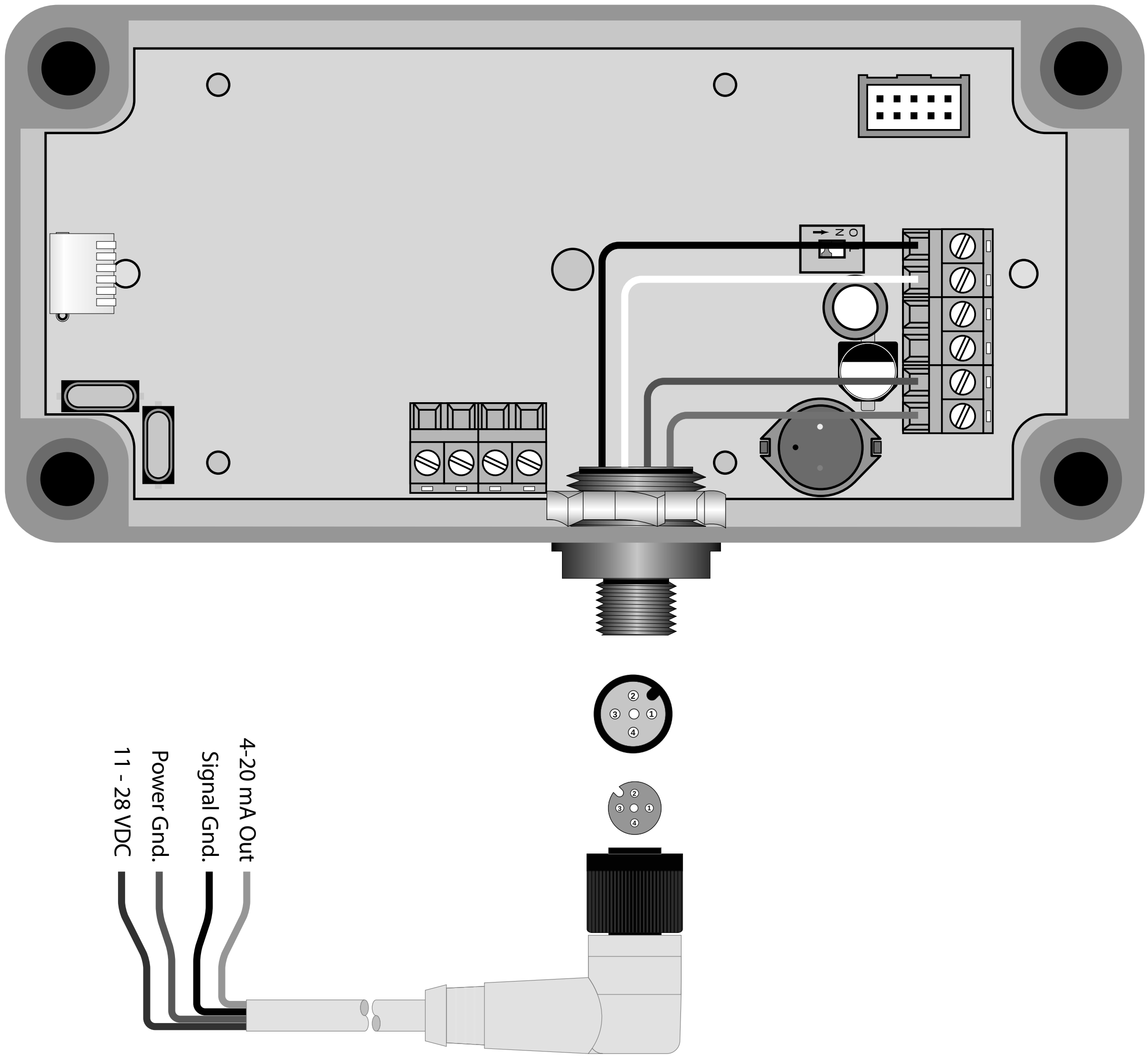


FIGURE A-6.2 - CONTROL DRAWING I.S. BARRIER DTT TRANSDUCERS FLEXIBLE CONDUIT

BRAD HARRISON® CONNECTOR OPTION



Cable
D005-0956-001 (Straight Connector)
D005-0956-002 (90° Connector)

Bulkhead Connector
D005-0954-001

FIGURE A-7.1 - BRAD HARRISON® CONNECTIONS

K-FACTORS EXPLAINED

The K-factor (with regards to flow) is the number of pulses that must be accumulated to equal a particular volume of fluid. You can think of each pulse as representing a small fraction of the totalizing unit.

An example might be a K-factor of 1000 (pulses per gallon). This means that if you were counting pulses, when the count total reached 1000, you would have accumulated 1 Gallon of liquid. Using the same reasoning each individual pulse represents an accumulation of 1/1000 of a gallon. This relationship is independent of the time it takes to accumulate the counts.

The frequency aspect of K-factors is a little more confusing because it also involves the flow rate. The same K-factor number, with a time frame added, can be converted into a flow rate. If you accumulated 1000 counts (one gallon) in one minute, then your flow rate would be 1 GPM. The output frequency, in Hz, is found simply by dividing the number of counts (1000) by the number of seconds (60) to get the output frequency.

1000 ÷ 60 = 16.6666... Hz. If you were looking at the pulse output on a frequency counter, an output frequency of 16.666...Hz would be equal to 1 GPM. If the frequency counter registered 33.333...Hz (2 × 16.666...Hz), then the flow rate would be 2 GPM.

Finally, if the flow rate is 2 GPM, then the accumulation of 1000 counts would take place in 30 seconds because the flow rate, and hence the speed that the 1000 counts is achieved, is twice as great.

Calculating K-factors for Ultrasonic meters

Many styles of ultrasonic flow meters are capable of measuring flow in a wide range of pipe sizes. Because the pipe size and volumetric units the meter will be used on vary, it is not possible to provide a discrete K-factor. Instead the velocity range of the meter is usually provided along with a maximum frequency output.

The most basic K-factor calculation requires that an accurate flow rate and the output frequency associated with that flow rate be known.

Example 1:

Known values are:

Frequency	=	700 Hz
Flow Rate	=	48 GPM

1) 700 Hz × 60 sec = 42,000 pulses per min

2) $$K - factor = \frac{42{,}000 \; pulses \; per \; min}{48 \; GPM} = 875 \; pulses \; per \; gallon$$

Example 2:

Known values are:

Full Scale Flow Rate	=	85 GPM
Full Scale Output Frequency	=	650 Hz

1) 650 Hz x 60 sec = 39,000 pulses per min

2)

$$K - factor = \frac{39{,}000 \; pulses \; per \; min}{85 \; GPM} = 458.82 \; pulses \; per \; gallon$$

The calculation is a little more complex if velocity is used because you first must convert the velocity into a volumetric flow rate to be able to compute a K-factor.

To convert a velocity into a volumetric flow, the velocity measurement and an accurate measurement of the inside diameter of the pipe must be known. Also needed is the fact that 1 US gallon of liquid is equal to 231 cubic inches.

Example 3:

Known values are:

Velocity	=	4.3 ft/sec
Inside Diameter of Pipe	=	3.068 in

1) Find the area of the pipe cross section.

$$Area = \pi r^2$$

$$Area = \pi \left(\frac{3.068}{2}\right)^2 = \pi \ x \ 2.353 = 7.39 \ in^2$$

2) Find the volume in 1 ft of travel.

$$7.39 \, in^2 \ x \ 12 \, in \ (1ft) = \frac{88.71 \, in^2}{ft}$$

3) What portion of a gallon does 1 ft of travel represent?

$$\frac{88.71 \, in^3}{231 \, in^3} = 0.384 \ gallons$$

So for every foot of fluid travel 0.384 gallons will pass.

What is the flow rate in GPM at 4.3 ft/sec?

0.384 gallons × 4.3 FPS × 60 sec (1 min) = 99.1 GPM

Now that the volumetric flow rate is known, all that is needed is an output frequency to determine the K-factor.

Known values are:

Frequency	=	700 Hz (By measurement)
Flow Rate	=	99.1 GPM (By calculation)

1) 700 Hz × 60 sec = 42,000 pulses per gallon

2)

$$K - factor = \frac{42{,}000 \ pulses \ per \ min}{99.1} = 423.9 \ pulses \ per \ gallon$$

FLUID PROPERTIES						
Fluid	Specific Gravity 20 °C	Sound Speed		delta-v/°C m/s/°C	Kinematic Viscosity (cSt)	Absolute Viscosity (Cp)
		ft/s	m/s			
Acetate, Butyl		4163.9	1270			
Acetate, Ethyl	0.901	3559.7	1085	4.4	0.489	0.441
Acetate, Methyl	0.934	3973.1	1211		0.407	0.380
Acetate, Propyl		4196.7	1280			
Acetone	0.79	3851.7	1174	4.5	0.399	0.316
Alcohol	0.79	3960.0	1207	4.0	1.396	1.101
Alcohol, Butyl	0.83	4163.9	1270	3.3	3.239	2.688
Alcohol, Ethyl	0.83	3868.9	1180	4	1.396	1.159
Alcohol, Methyl	0.791	3672.1	1120	2.92	0.695	0.550
Alcohol, Propyl		3836.1	1170			
Alcohol, Propyl	0.78	4009.2	1222		2.549	1.988
Ammonia	0.77	5672.6	1729	6.7	0.292	0.225
Aniline	1.02	5377.3	1639	4.0	3.630	3.710
Benzene	0.88	4284.8	1306	4.7	0.7 11	0.625
Benzol, Ethyl	0.867	4389.8	1338		0.797	0.691
Bromine	2.93	2916.7	889	3.0	0.323	0.946
n-Butane	0.60	3559.7	1085	5.8		
Butyrate, Ethyl		3836.1	1170			
Carbon dioxide	1.10	2752.6	839	7.7	0.137	0.151
Carbon tetrachloride	1.60	3038.1	926	2.5	0.607	0.968
Chloro-benezene	1.11	4176.5	1273	3.6	0.722	0.799
Chloroform	1.49	3211.9	979	3.4	0.550	0.819
Diethyl ether	0.71	3231.6	985	4.9	0.3 11	0.222
Diethyl Ketone		4295.1	1310			
Diethylene glycol	1.12	5203.4	1586	2.4		
Ethanol	0.79	3960.0	1207	4.0	1.390	1.097
Ethyl alcohol	0.79	3960.0	1207	4.0	1.396	1.101
Ether	0.71	3231.6	985	4.9	0.3 11	0.222
Ethyl ether	0.71	3231.6	985	4.9	0.3 11	0.222
Ethylene glycol	1.11	5439.6	1658	2.1	17.208	19.153
Freon R12		2540	774.2			
Gasoline	0.7	4098.4	1250			
Glycerin	1.26	6246.7	1904	2.2	757.100	953.946
Glycol	1.11	5439.6	1658	2.1		
Isobutanol	0.81	3976.4	1212			
Iso-Butane		4002	1219.8			
Isopentane	0.62	3215.2	980	4.8	0.340	0.211
Isopropanol	0.79	3838.6	1170		2.718	2.134
Isopropyl Alcohol	0.79	3838.6	1170		2.718	2.134
Kerosene	0.81	4343.8	1324	3.6		

FLUID PROPERTIES (continued)						
Fluid	Specific Gravity 20 °C	Sound Speed		delta-v/°C m/s/°C	Kinematic Viscosity (cSt)	Absolute Viscosity (Cp)
		ft/s	m/s			
Linalool		4590.2	1400			
Linseed Oil	.925-.939	5803.3	1770			
Methanol	0.79	3530.2	1076	2.92	0.695	0.550
Methyl Alcohol	0.79	3530.2	1076	2.92	0.695	0.550
Methylene Chloride	1.33	3510.5	1070	3.94	0.310	0.411
Methylethyl Ketone		3967.2	1210			
Motor Oil (SAE 20/30)	.88-.935	4875.4	1487			
Octane	0.70	3845.1	1172	4.14	0.730	0.513
Oil, Castor	0.97	4845.8	1477	3.6	0.670	0.649
Oil, Diesel	0.80	4101	1250			
Oil (Lubricating X200)		5019.9	1530			
Oil (Olive)	0.91	4694.9	1431	2.75	100.000	91 .200
Oil (Peanut)	0.94	4783.5	1458			
Paraffin Oil		4655.7	1420			
Pentane	0.626	3346.5	1020		0.363	0.227
Petroleum	0.876	4229.5	1290			
1-Propanol	0.78	4009.2	1222			
Refrigerant 11	1.49	2717.5	828.3	3.56		
Refrigerant 12	1.52	2539.7	774.1	4.24		
Refrigerant 14	1.75	2871.5	875.24	6.61		
Refrigerant 21	1.43	2923.2	891	3.97		
Refrigerant 22	1.49	2932.7	893.9	4.79		
Refrigerant 113	1.56	2571.2	783.7	3.44		
Refrigerant 114	1.46	2182.7	665.3	3.73		
Refrigerant 115		2153.5	656.4	4.42		
Refrigerant C318	1.62	1883.2	574	3.88		
Silicone (30 cp)	0.99	3248	990		30.000	29.790
Toluene	0.87	4357	1328	4.27	0.644	0.558
Transformer Oil		4557.4	1390			
Trichlorethylene		3442.6	1050			
1,1,1 -Trichloroethane	1.33	3231.6	985		0.902	1.200
Turpentine	0.88	4117.5	1255		1.400	1.232
Water, distilled	0.996	4914.7	1498	-2.4	1.000	0.996
Water, heavy	1	4593	1400			
Water, sea	1.025	5023	1531	-2.4	1.000	1.025
Wood Alcohol	0.791	3530.2	1076	2.92	0.695	0.550
m-Xylene	0.868	4406.2	1343		0.749	0.650
o-Xylene	0.897	4368.4	1331.5	4.1	0.903	0.810
p-Xylene		4376.8	1334		0.662	

TABLE A-8.1 - FLUID PROPERTIES

SYMBOL EXPLANATIONS

Caution—Refer to accompanying documents.

FLOW METER INSTALLATION

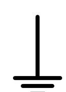
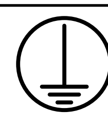
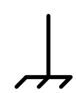
WARNING:
EXPLOSION HAZARD - SUBSTITUTION OF COMPONENTS MAY IMPAIR SUITABILITY FOR CLASS I, DIVISION 2.

WARNING:
DO NOT CONNECT OR DISCONNECT EITHER POWER OR OUTPUTS UNLESS THE AREA IS KNOWN TO BE NON-HAZARDOUS.

IMPORTANT NOTE:
Not following instructions properly may impair safety of equipment and/or personnel.

IMPORTANT NOTE:
Must be operated by a Class 2 supply suitable for the location.

IMPORTANT NOTE:
Do not connect the interface cable between a TFXL flow meter and a personal computer unless the area is known to be non-hazardous.

ELECTRICAL SYMBOLS					
Function	Direct Current	Alternating Current	Earth (Ground)	Protective Ground	Chassis Ground
Symbol					

"STEEL, STAINLESS STEEL, P.V.C. PIPE" STANDARD CLASSES

Nominal Pipe Size Inches	Outside Diameter	SCH 5		SCH 10 (Lt Wall)		SCH 20		SCH 30		STD		SCH 40	
		ID	Wall	ID	Wall	ID	Wall	ID	Wall	ID	Wall	ID	Wall
1	1.315	1.185	0.065	1.097	0.109					1.049		1.049	0.133
1.25	1.660	1.53	0.065	1.442	0.109					1.380		1.380	0.140
1.5	1.900	1.77	0.065	1.682	0.109					1.610		1.610	0.145
2	2.375	2.245	0.065	2.157	0.109					2.067		2.067	0.154
2.5	2.875	2.709	0.083	2.635	0.120					2.469		2.469	0.203
3	3.500	3.334	0.083	3.260	0.120					3.068		3.068	0.216
3.5	4.000	3.834	0.083	3.760	0.120					3.548		3.548	0.226
4	4.500	4.334	0.083	4.260	0.120					4.026	0.237	4.026	0.237
5	5.563	5.345	0.109	5.295	0.134					5.047	0.258	5.047	0.258
6	6.625	6.407	0.109	6.357	0.134					6.065	0.280	6.065	0.280
8	8.625	8.407	0.109	8.329	0.148	8.125	0.250	8.071	0.277	7.981	0.322	7.981	0.322
10	10.75	10.482	0.134	10.42	0.165	10.25	0.250	10.13	0.310	10.02	0.365	10.02	0.365
12	12.75	12.42	0.165	12.39	0.180	12.25	0.250	12.09	0.330	12.00	0.375	11.938	0.406
14	14.00			13.50	0.250	13.37	0.315	13.25	0.375	13.25	0.375	13.124	0.438
16	16.00			15.50	0.250	15.37	0.315	15.25	0.375	15.25	0.375	15.000	0.500
18	18.00			17.50	0.250	17.37	0.315	17.12	0.440	17.25	0.375	16.876	0.562
20	20.00			19.50	0.250	19.25	0.375	19.25	0.375	19.25	0.375	18.814	0.593
24	24.00			23.50	0.250	23.25	0.375	23.25	0.375	23.25	0.375	22.626	0.687
30	30.00			29.37	0.315	29.00	0.500	29.00	0.500	29.25	0.375	29.25	0.375
36	36.00			35.37	0.315	35.00	0.500	35.00	0.500	35.25	0.375	35.25	0.375
42	42.00									41.25	0.375	41.25	0.375
48	48.00									47.25	0.375	47.25	0.375

TABLE A-10.1 - ANSI PIPE DATA

"STEEL, STAINLESS STEEL, P.V.C. PIPE" STANDARD CLASSES

Nominal Pipe Size Inches	Outside Diameter	SCH 60		X STG.		SCH 80		SCH 100		SCH 120/140		SCH 180	
		ID	Wall	ID	Wall	ID	Wall	ID	Wall	ID	Wall	ID	Wall
1	1.315			0.957	0.179	0.957	0.179					0.815	0.250
1.25	1.660			1.278	0.191	1.278	0.191					1.160	0.250
1.5	1.900			1.500	0.200	1.500	0.200					1.338	0.281
2	2.375			1.939	0.218	1.939	0.218					1.687	0.344
2.5	2.875			2.323	0.276	2.323	0.276					2.125	0.375
3	3.500			2.900	0.300	2.900	0.300					2.624	0.438
3.5	4.000			3.364	0.318	3.364	0.318						
4	4.500			3.826	0.337	3.826	0.337			3.624	0.438	3.438	0.531
5	5.563			4.813	0.375	4.813	0.375			4.563	0.500	4.313	0.625
6	6.625			5.761	0.432	5.761	0.432			5.501	0.562	5.187	0.719
8	8.625	7.813	0.406	7.625	0.500	7.625	0.500	7.437	0.594	7.178	0.719	6.183	1.221
10	10.75	9.750	0.500	9.75	0.500	9.562	0.594	9.312	0.719	9.062	0.844	8.500	1.125
12	12.75	11.626	0.562	11.75	0.500	11.37	0.690	11.06	0.845	10.75	1.000	10.12	1.315
14	14.00	12.814	0.593	13.00	0.500	12.50	0.750	12.31	0.845	11.81	1.095	11.18	1.410
16	16.00	14.688	0.656	15.00	0.500	14.31	0.845	13.93	1.035	13.56	1.220	12.81	1.595
18	18.00	16.564	0.718	17.00	0.500	16.12	0.940	15.68	1.160	15.25	1.375	14.43	1.785
20	20.00	18.376	0.812	19.00	0.500	17.93	1.035	17.43	1.285	17.00	1.500	16.06	1.970
24	24.00	22.126	0.937	23.00	0.500	21.56	1.220	20.93	1.535	20.93	1.535	19.31	2.345
30	30.00			29.00	0.500								
36	36.00			35.00	0.500								
42	42.00			41.00	0.500								
48	48.00			47.00	0.500								

TABLE A-10.2 - ANSI PIPE DATA

Nominal Diameter		Copper Tubing Type K	Copper Tubing Type L	Copper Tubing Type M	Copper & Brass Pipe	ALUMINUM
½″	O. D.	0.625	0.625	0.625	0.840	
	Wall	0.049	0.040	0.028	0.108	
	I.D.	0.527	0.545	0.569	0.625	
⅝″	O. D.	0.750	0.750	0.750		
	Wall	0.049	0.042	0.030		
	I.D.	0.652	0.666	0.690		
¾″	O. D.	0.875	0.875	0.875	1.050	
	Wall	0.065	0.045	0.032	0.114	
	I.D.	0.745	0.785	0.811	0.822	
1″	O. D.	1.125	1.125	1.125	1.315	
	Wall	0.065	0.050	0.035	0.127	
	I.D.	0.995	1.025	1.055	1.062	
1¼″	O. D.	1.375	1.375	1.375	1.660	
	Wall	0.065	0.055	0.042	0.146	
	I.D.	1.245	1.265	1.291	1.368	
1½″	O. D.	1.625	1.625	1.625	1.900	
	Wall	0.072	0.060	0.049	0.150	
	I.D.	1.481	1.505	1.527	1.600	
2″	O. D.	2.125	2.125	2.125	2.375	
	Wall	0.083	0.070	0.058	0.157	
	I.D.	1.959	1.985	2.009	2.062	
2½″	O. D.	2.625	2.625	2.625	2.875	2.500
	Wall	0.095	0.080	0.065	0.188	0.050
	I.D.	2.435	2.465	2.495	2.500	2.400
3″	O. D.	3.125	3.125	3.125	3.500	3.000
	Wall	0.109	0.090	0.072	0.219	0.050
	I.D.	2.907	2.945	2.981	3.062	2.900

Nominal Diameter		Copper Tubing Type K	Copper Tubing Type L	Copper Tubing Type M	Copper & Brass Pipe	ALUMINUM
3½″	O. D.	3.625	3.625	3.625	4.000	
	Wall	0.120	0.100	0.083	0.250	
	I.D.	3.385	3.425	3.459	3.500	
4″	O. D.	4.125	4.125	4.125	4.500	4.000
	Wall	0.134	0.110	0.095	0.095	0.250
	I. D.	3 857	3.905	3.935	3.935	4.000
4½″	O D.					5.000
	Wall					0.250
	I. D.					4.500
5″	0. D.	5.125	5.125	5.125	5.563	5.000
	Wall	0.160	0.125	0.109	0.250	0.063
	I. D.	4.805	4.875	4.907	5.063	4.874
6″	0. D.	6.125	6.125	6.125	6.625	6.000
	Wall	0.192	0.140	0.122	0.250	0.063
	ID.	5.741	5.845	5.881	6.125	5.874
7″	O. D				7.625	7.000
	Wall				0.282	0.078
	I. D.				7.062	6.844
8″	O D	8.125	8.125	8.125	8.625	8 000
	Wall	0,271	0.200	0.170	0.313	0.094
	I. D.	7.583	7.725	7.785	8.000	7.812
10″	0. D.	10.125	10.125	10.125	10 000	
	Wall	0.338	0.250	0.212	0.094	
	I. D.	9.449	9.625	9.701	9.812	
12″	0. D.	12.125	12.125	12.125		
	Wall	0.405	0.280	0.254		
	I. D.	11.315	11.565	11.617		

TABLE A-10.3 - COPPER TUBE DATA

Ductile Iron Pipe (Standard Classes)

Size (Inches)		Class 50	Class 51	Class 52	Class 53	Class 54	Class 55	Class 56	Mortar Lining
3"	O.D.		3.96	3.96	3.96	3.96	3.96	3.96	Std. 0.123 Dbl. 0.250
3"	Wall		0.25	0.28	0.31	0.34	0.37	0.41	Std. 0.123 Dbl. 0.250
3"	I.D.		3.46	3.40	3.34	3.28	3.22	3.14	Std. 0.123 Dbl. 0.250
4"	O.D.		4.80	4.80	4.80	4.80	4.80	4.80	Std. 0.123 Dbl. 0.250
4"	Wall		0.26	0.29	0.32	0.35	0.38	0.42	Std. 0.123 Dbl. 0.250
4"	I.D.		4.28	4.22	4.16	4.10	4.04	3.93	Std. 0.123 Dbl. 0.250
6"	O.D.	6.90	6.90	6.90	6.90	6.90	6.90	6.90	Std. 0.123 Dbl. 0.250
6"	Wall	0.25	0.28	0.31	0.34	0.37	0.40	0.43	Std. 0.123 Dbl. 0.250
6"	I.D.	6.40	6.34	6.28	6.22	6.16	6.10	6.04	Std. 0.123 Dbl. 0.250
8"	O.D.	9.05	9.05	9.05	9.05	9.05	9.05	9.05	Std. 0.123 Dbl. 0.250
8"	Wall	0.27	0.30	0.33	0.36	0.39	0.42	0.45	Std. 0.123 Dbl. 0.250
8"	I.D.	8.51	8.45	8.39	8.33	8.27	8.21	8.15	Std. 0.123 Dbl. 0.250
10"	O.D.	11.10	11.10	11.10	11.10	11.10	11.10	11.10	Std. 0.123 Dbl. 0.250
10"	Wall	0.39	0.32	0.35	0.38	0.41	0.44	0.47	Std. 0.123 Dbl. 0.250
10"	I.D.	10.32	10.46	10.40	10.34	10.28	10.22	10.16	Std. 0.123 Dbl. 0.250
12"	O.D.	13.20	13.20	13.20	13.20	13.20	13.20	13.20	Std. 0.123 Dbl. 0.250
12"	Wall	0.31	0.34	0.37	0.40	0.43	0.46	0.49	Std. 0.123 Dbl. 0.250
12"	I.D.	12.58	12.52	12.46	12.40	12.34	12.28	12.22	Std. 0.123 Dbl. 0.250
14"	O.D.	15.30	15.30	15.30	15.30	15.30	15.30	15.30	Std . 0.1875 Dbl. 0.375
14"	Wall	0.33	0.36	0.39	0.42	0.45	0.48	0.51	Std . 0.1875 Dbl. 0.375
14"	I.D.	14.64	14.58	14.52	14.46	14.40	14.34	14.28	Std . 0.1875 Dbl. 0.375
16"	O.D.	17.40	17.40	17.40	17.40	17.40	17.40	17.40	Std . 0.1875 Dbl. 0.375
16"	Wall	0.34	0.37	0.40	0.43	0.46	0.49	0.52	Std . 0.1875 Dbl. 0.375
16"	I.D.	16.72	16.66	16.60	16.54	16.48	16.42	16.36	Std . 0.1875 Dbl. 0.375

Size (Inches)		Class 50	Class 51	Class 52	Class 53	Class 54	Class 55	Class 56	Mortar Lining
18"	O.D.	19.50	19.50	19.50	19.50	19.50	19.50	19.50	Std . 0.1875 Dbl. 0.375
18"	Wall	0.35	0.38	0.41	0.44	0.47	0.50	0.53	Std . 0.1875 Dbl. 0.375
18"	I.D.	18.80	18.74	18.68	18.62	18.56	18.50	18.44	Std . 0.1875 Dbl. 0.375
20"	O.D.	21.60	21.60	21.60	21.60	21.60	21.60	21.60	Std . 0.1875 Dbl. 0.375
20"	Wall	0.36	0.39	0.42	0.45	0.48	0.51	0.54	Std . 0.1875 Dbl. 0.375
20"	I.D.	20.88	20.82	20.76	20.70	20.64	20.58	20.52	Std . 0.1875 Dbl. 0.375
24"	O.D.	25.80	25.80	25.80	25.80	25.80	25.80	25.80	Std . 0.1875 Dbl. 0.375
24"	Wall	0.38	0.41	0.44	0.47	0.50	0.53	0.56	Std . 0.1875 Dbl. 0.375
24"	I.D.	25.04	24.98	24.92	24.86	24.80	24.74	24.68	Std . 0.1875 Dbl. 0.375
30"	O. D.	32.00	32.00	32.00	32.00	32.00	32.00	32.00	Std. 0.250 Dbl. 0.500
30"	Wall	0.39	0.43	0.47	0.51	0.55	0.59	0.63	Std. 0.250 Dbl. 0.500
30"	I.D.	31.22	31.14	31.06	30.98	30.90	30.82	30.74	Std. 0.250 Dbl. 0.500
36"	O.D.	38.30	38.30	38.30	38.30	38.30	38.30	38.30	Std. 0.250 Dbl. 0.500
36"	Wall	0.43	0.48	0.62	0.58	0.45	0.68	0.73	Std. 0.250 Dbl. 0.500
36"	I.D.	37.44	37.34	37.06	37.14	37.40	36.94	36.48	Std. 0.250 Dbl. 0.500
42"	O.D.	44.50	44.50	44.50	44.50	44.50	44.50	44.50	Std. 0.250 Dbl. 0.500
42"	Wall	0.47	0.53	0.59	0.65	0.71	0.77	0.83	Std. 0.250 Dbl. 0.500
42"	I.D.	43.56	43.44	43.32	43.20	43.08	42.96	42.84	Std. 0.250 Dbl. 0.500
48"	O.D.	50.80	50.80	50.80	50.80	50.80	50.80	50.80	Std. 0.250 Dbl. 0.500
48"	Wall	0.51	0.58	0.65	0.72	0.79	0.86	0.93	Std. 0.250 Dbl. 0.500
48"	I.D.	49.78	49.64	49.50	49.36	49.22	49.08	48.94	Std. 0.250 Dbl. 0.500
54"	O.D.	57.10	57.10	57.10	57.10	57.10	57.10	57.10	Std. 0.250 Dbl. 0.500
54"	Wall	0.57	0.65	0.73	0.81	0.89	0.97	1.05	Std. 0.250 Dbl. 0.500
54"	I.D.	55.96	55.80	55.64	55.48	55.32	55.16	55.00	Std. 0.250 Dbl. 0.500

TABLE A-10.4 - DUCTILE IRON PIPE DATA

Cast Iron Pipe (Standard Classes)

Size (Inches)		A	B	C	D	E	F	G	H
3″	O.D.	3.80	3.96	3.96	3.96				
	Wall	0.39	0.42	0.45	0.48				
	I.D.	3.02	3.12	3.06	3.00				
4″	O.D.	4.80	5.00	5.00	5.00				
	Wall	0.42	0.45	0.48	0.52				
	I.D.	3.96	4.10	4.04	3.96				
6″	O.D.	6.90	7.10	7.10	7.10	7.22	7.22	7.38	7.38
	Wall	0.44	0.48	0.51	0.55	0.58	0.61	0.65	0.69
	I.D.	6.02	6.14	6.08	6.00	6.06	6.00	6.08	6.00
8″	O.D.	9.05	9.05	9.30	9.30	9.42	9.42	9.60	9.60
	Wall	0.46	0.51	0.56	0.60	0.66	0.66	0.75	0.80
	I.D.	8.13	8.03	8.18	8.10	8.10	8.10	8.10	8.00
10″	O.D.	11.10	11.10	11.40	11.40	11.60	11.60	11.84	11.84
	Wail	0.50	0.57	0.62	0.68	0.74	0.80	0.86	0.92
	I.D.	10.10	9.96	10.16	10.04	10.12	10.00	10.12	10.00
12″	O.D.	13.20	13.20	13.50	13.50	13.78	13.78	14.08	14.08
	Wall	0.54	0.62	0.68	0.75	0.82	0.89	0.97	1.04
	I.D.	12.12	11.96	12.14	12.00	12.14	12.00	12.14	12.00
14″	O.D.	15.30	15.30	15.65	15.65	15.98	15.98	16.32	16.32
	Wall	0.57	0.66	0.74	0.82	0.90	0.99	1.07	1.16
	I.D.	14.16	13.98	14.17	14.01	14.18	14.00	14.18	14.00
16″	O.D.	17.40	17.40	17.80	17.80	18.16	18.16	18.54	18.54
	Wall	0.60	0.70	0.80	0.89	0.98	1.08	1.18	1.27
	I.D.	16.20	16.00	16.20	16.02	16.20	16.00	16.18	16.00
18″	O.D.	19.50	19.50	19.92	19.92	20.34	20.34	20.78	20.78
	Wall	0.64	0.75	0.87	0.96	1.07	1.17	1.28	1.39
	I.D.	18.22	18.00	18.18	18.00	18.20	18.00	18.22	18.00
20″	O.D.	21.60	21.60	22.06	22.06	22.54	22.54	23.02	23.02
	Wall	0.67	0.80	0.92	1.03	1.15	1.27	1.39	1.51
	I.D.	20.26	20.00	20.22	20.00	20.24	20.00	20.24	20.00

Size (Inches)		A	B	C	D	E	F	G	H
24″	O.D.	25.80	25.80	26.32	26.32	26.90	26.90	27.76	27.76
	Wall	0.76	0.98	1.05	1.16	1.31	1.45	1.75	1.88
	I.D.	24.28	24.02	24.22	24.00	24.28	24.00	24.26	24.00
30″	O. D.	31.74	32.00	32.40	32.74	33.10	33.46		
	Wall	0.88	1.03	1.20	1.37	1.55	1.73		
	I.D.	29.98	29.94	30.00	30.00	30.00	30.00		
36″	O.D.	37.96	38.30	38.70	39.16	39.60	40.04		
	Wall	0.99	1.15	1.36	1.58	1.80	2.02		
	I.D.	35.98	36.00	35.98	36.00	36.00	36.00		
42″	O.D.	44.20	44.50	45.10	45.58				
	Wall	1.10	1.28	1.54	1.78				
	I.D.	42.00	41.94	42.02	42.02				
48″	O.D.	50.55	50.80	51.40	51.98				
	Wall	1.26	1.42	1.71	1.99				
	I.D.	47.98	47.96	47.98	48.00				
54″	O.D.	56.66	57.10	57.80	58.40				
	Wall	1.35	1.55	1.90	2.23				
	I.D.	53.96	54.00	54.00	53.94				
60″	O.D.	62.80	63.40	64.20	64.28				
	Wall	1.39	1.67	2.00	2.38				
	I.D.	60.02	60.06	60.20	60.06				
72″	O.D.	75.34	76.00	76.88					
	Wall	1.62	1.95	2.39					
	I.D.	72.10	72.10	72.10					
84″	O.D.	87.54	88.54						
	Wall	1.72	2.22						
	I.D.	84.10	84.10						

TABLE A-10.5 - CAST IRON PIPE DATA

PRODUCTS COVERED

The Badger Meter warranty shall apply to the Dynasonics TFXL clamp-on Ultrasonic flow meter for liquids ("Product").

MATERIALS AND WORKMANSHIP

Badger Meter warrants the Product to be free from defects in materials and workmanship for a period of 12 months from the original purchase date.

PRODUCT RETURNS

Product failures must be proven and verified to the satisfaction of Badger Meter. The Badger Meter obligation hereunder shall be limited to such repair and replacement and shall be conditioned upon Badger Meter receiving written notice of any asserted defect within 10 (ten) days after its discovery. If the defect arises and a valid claim is received within the Warranty Period, at its option, Badger Meter will either (1) exchange the Product with a new, used or refurbished Product that is at least functionally equivalent to the original Product, or (2) refund the purchase price of the Product. DO NOT RETURN ANY PRODUCT UNTIL YOU HAVE CALLED THE BADGER METER CUSTOMER SERVICE DEPARTMENT AND OBTAINED A RETURN AUTHORIZATION.

Product returns must be shipped by the Customer prepaid F.O.B. to the nearest Badger Meter factory or distribution center. The Customer shall be responsible for all direct and indirect costs associated with removing the original Product and reinstalling the repaired or replacement Product. A replacement Product assumes the remaining warranty of the original Product or ninety (90) days from the date of replacement, whichever provides longer coverage.

LIMITS OF LIABILITY

This warranty shall not apply to any Product repaired or altered by any Product other than Badger Meter. The foregoing warranty applies only to the extent that the Product is installed, serviced and operated strictly in accordance with Badger Meter instructions. The warranty shall not apply and shall be void with respect to a Product exposed to conditions other than those detailed in applicable technical literature and Installation and Operation Manuals (IOMs) or which have been subject to vandalism, negligence, accident, acts of God, improper installation, operation or repair, alteration, or other circumstances which are beyond the reasonable control of Badger Meter.

With respect to products not manufactured by Badger Meter, the warranty obligations of Badger Meter shall in all respects conform and be limited to the warranty extended to Badger Meter by the supplier.

THE FOREGOING WARRANTIES ARE EXCLUSIVE AND IN LIEU OF ALL OTHER EXPRESS AND IMPLIED WARRANTIES WHATSOEVER, INCLUDING BUT NOT LIMITED TO IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE (except warranties of title).

Any description of a Product, whether in writing or made orally by Badger Meter or its agents, specifications, samples, models, bulletins, drawings, diagrams, engineering sheets or similar materials used in connection with any Customer's order are for the sole purpose of identifying the Product and shall not be construed as an express warranty. Any suggestions by Badger Meter or its agents regarding use, application or suitability of the Product shall not be construed as an express warranty unless confirmed to be such, in writing, by Badger Meter.

EXCLUSION OF CONSEQUENTIAL DAMAGES AND DISCLAIMER OF OTHER LIABILITY

Badger Meter liability with respect to breaches of the foregoing warranty shall be limited as stated herein. Badger Meter liability shall in no event exceed the contract price. BADGER METER SHALL NOT BE SUBJECT TO AND DISCLAIMS: (1) ANY OTHER OBLIGATIONS OR LIABILITIES ARISING OUT OF BREACH OF CONTRACT OR OF WARRANTY, (2) ANY OBLIGATIONS WHATSOEVER ARISING FROM TORT CLAIMS (INCLUDING NEGLIGENCE AND STRICT LIABILITY) OR ARISING UNDER OTHER THEORIES OF LAW WITH RESPECT TO PRODUCTS SOLD OR SERVICES RENDERED BY BADGER METER, OR ANY UNDERTAKINGS, ACTS OR OMISSIONS RELATING THERETO, AND (3) ALL CONSEQUENTIAL, INCIDENTAL AND CONTINGENT DAMAGES WHATSOEVER.

info@dynasonics.com | www.dynasonics.com | www.badgermeter.com
Phone: 262-639-6770 | Fax: 262-639-2267

The Americas | Badger Meter | 4545 West Brown Deer Rd | PO Box 245036 | Milwaukee, WI 53224-9536 | 800-876-3837 | 414-355-0400
México | Badger Meter de las Americas, S.A. de C.V. | Pedro Luis Ogazón N°32 | Esq. Angelina N°24 | Colonia Guadalupe Inn | CP 01050 | México, DF | México | +52-55-5662-0882
Europe, Middle East and Africa | Badger Meter Europa GmbH | Nurtinger Str 76 | 72639 Neuffen | Germany | +49-7025-9208-0
Czech Republic | Badger Meter Czech Republic s.r.o. | Mařikova 2082/26 | 621 00 Brno, Czech Republic | +420-5-41420411
Slovakia | Badger Meter Slovakia s.r.o. | Racianska 109/B | 831 02 Bratislava, Slovakia | +421-2-44 63 83 01
Asia Pacific | Badger Meter | 80 Marine Parade Rd | 21-04 Parkway Parade | Singapore 449269 | +65-63464836
China | Badger Meter | Rm 501, N° 11 Longyue Apartment | N° 180 Longjin Rd, Jiuting Songjiang District | Shanghai, China | 201615 | +86-21-5763 5412