DYNASONICS™

Series TFXD

Transit Time Ultrasonic Flow Meter

Operations & Maintenance
Manual

REV 5/07

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This manual contains detailed operating instructions for all aspects of the TFX 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.

Transducer Location

1. TRANSDUCER LOCATION

A. In general, select a mounting location on the piping system with a minimum of 10 pipe diameters (10 x the pipe inside diameter) of straight pipe upstream and 5 straight diameters downsteam. See **Table 2.1** on page 2.4 for additional configurations.

B. Select a mounting method for the transducers, based on pipe size and liquid characteristics. See **Table 2.2** on page 2.5. Transducer configurations are illustrated in **Figure 1.1**.

C. Enter the following data into the TFX transmitter via the integral keypad or *UltraLink*™ software utility.

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

[1] Nominal values for these parameters are included within the TFX operating system.
The nominal values may be used as they appear or may be modified if exact system values are known.

D. Record the value calculated and displayed as Transducer Spacing/XDCR SPC.

Figure 1.1
Transducer Mounting Configurations

Connections

2. TRANSDUCER/POWER CONNECTIONS

A. Route the transducer cables from the transducer mount location back to the TFX enclosure. If additional cable and connections are required, ensure that they are RG59 75 Ohm compatible. Connect the transducer wires to the terminal block J4 in the TFX enclosure. A wiring diagram is located on the inner door label.

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 or DTTS transducers. If additional cable is required, contact the Dynasonics factory to arrange an exchange for a transducer with the appropriate length of cable. Cables to 990 feet [300 meters] are available. If additional cable and connections are added, ensure that they are RG59 75 Ohm compatible.

B. Verify that power supply jumpers are properly configured. Reference the wiring diagram located on the TFX inner door. Connect power to the TFX flow meter.

3. PIPE PREPARATION AND TRANSDUCER MOUNTING

DTTN and DTTH Transducers

A. Place the flow meter in signal strength measuring mode. This value is available on the TFXD2 display (Service Menu) or in the Data display of the *UltraLink*™ software utility.

B. The piping surface, where the transducers are to be mounted, must be clean and dry. Remove loose scale, rust and paint to ensure satisfactory acoustical bonds. Grind rough surfaces of pipes to smooth bare metal. Plastic pipes do not require preparation other than cleaning.

C. Apply a single 1/2" [12 mm] bead of couplant grease to the upstream transducer and secure it to the pipe with a mounting strap.

D. Apply acoustic couplant grease to the downstream transducer and press it onto the pipe using hand pressure at the lineal distance calculated in Step 1.

E. Move the transducer slowly around the mount area until the highest signal strength is observed. Secure with a mounting strap at this location.

DTTS Transducers

A. Place the flow meter in signal strength measuring mode. This value is available on the TFXD2 display (Service Menu) or in the Data display of the *UltraLink*™ software utility.

B. The pipe surface, where the transducers are to be mounted, must be clean and dry. Remove loose scale, rust and paint to ensure satisfactory acoustical bonds. Grind rough surfaces of pipes to smooth bare metal. Plastic pipes do not require preparation other than cleaning.

C. Apply a single 1/2" [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.

D. Tighten the wing nuts so that the grease begins to flow out from the edges of the transducer and from the gap between the transducer halves. Do not over tighten.

Startup

4. INITIAL SETTINGS AND POWER UP

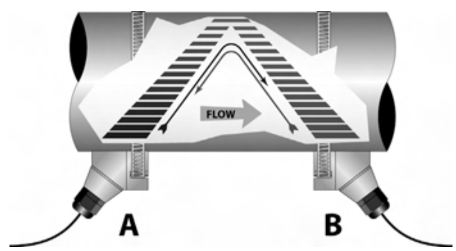
A. Verify that SIG STR is greater than 2.0%.

B. Verify that measured liquid SSPD is within 3% of the configuration value.

C. Input proper units of measure and I/O data.

General

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



The TFX family of transit time flow meters utilize transducers that function as both ultrasonic transmitters and receivers. DTTN and DTTH 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 transducers are mounted on opposite sides of the pipe and the sound crosses the pipe once. This selection is based on pipe and liquid characteristics.

DTTS (Small Pipe Transducers) have both transmit and receive crystals imbedded in a single clamp-around transducer so no measurement between transducers is required.

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 TFXD 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 1/2 inch [12 mm] and larger. (Transducers sets from 1/2 to 1-1/2 inch require 2 MHz transmitters and dedicated pipe transducers.) 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 300 °F [150 °C]. High temperature DTTH transducers can operate to a pipe surface temperature of 380 °F [193 °C]. The DTTS series of small pipe transducers can be used to a pipe surface temperature of 185 °F [85 °C].

User Safety

The TFX employs modular construction and provides electrical safety for the operator. The display face contains voltages no greater than 10 Vdc. The display face swings open to allow access to user connections. Disconnect electrical power before opening the instrument enclosure.

Data Integrity

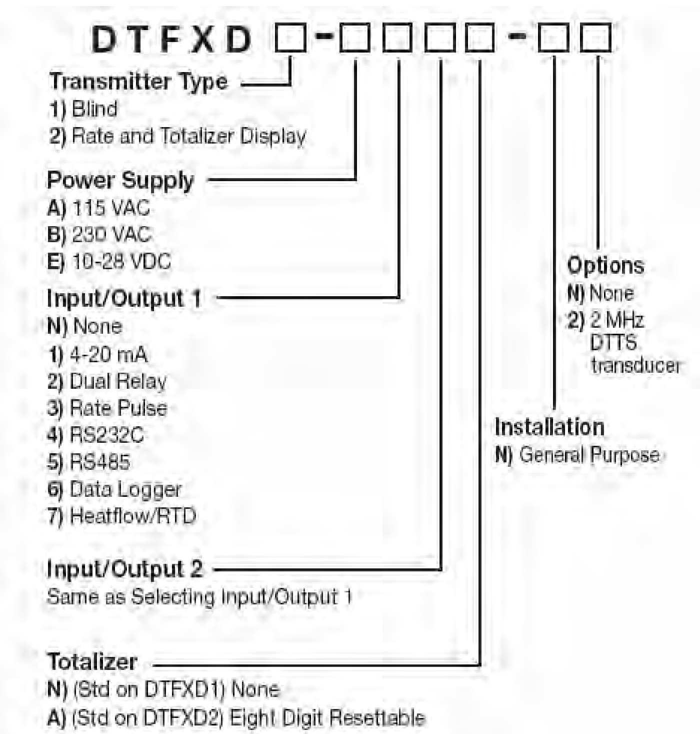
Non-volatile FLASH memory retains all user-entered configuration values in memory for several years (at 25 °C), even if power is lost or turned off. Password protection is provided as part of the Security menu and prevents inadvertent configuration changes or totalizer resets.

Product Identification

The serial number and complete model number of the TFX is located on the inside of the transmitter's front cover. Should technical assistance be required, please provide the Dynasonics Customer Service Department with this information.

Transmitter

Product Matrix



PART 1 - PRODUCT SPECIFICATIONS

TRANSMITTER	
Power Requirements	115/230 VAC 50/60 Hz ±15% at 5 VA max or 10-28 VDC at 3.0 W
Velocity Range	-40 to +40 FPS [-12 to +12 MPS]
Input/Output Bays	2
Options	All modules optically isolated from earth and system ground
4-20 mA	800 Ohm max; 12-bit resolution, internal or external power
Dual Relay	2 separate Form C relays, 200 VAC max at 0.5 A [resistive]
Rate Pulse	Open collector, 0 to 2,500 Hz max; 1.0 A max
RS232C	Data rate to 57.6k
RS485	Supports up to 126 drops on a two-wire network
Data Logger	200k events in 30k pages, 16-bit, integral DB-9 RS232C connection
Heat Flow (RTD)	Supports two 1000 Ohm RTDs, multiplexed, 12-bit resolution
Display (DTFXD2 only)	2 line x 8 character backlit LCD; 8 digit rate, 8 digit re-settable totalizer Top row: 7 segment, 0.7" [18 mm] high, numeric Bottom row: 14 segment, 0.35" [9mm] high alpha-numeric
Units	User configured
Rate	Gal, liters, million gal, ft³, m³, acre-ft, oil barrels [42 gal], liquid barrels [31.5 gal], ft, m, lb, kg, BTU, MBTU, MMBTU, kJ, kCal, ton
Time	Seconds, minutes, hours, days
Totalizer	Gal, liters, million gal, ft³, m³, acre-ft, oil barrels [42 gal], liquid barrels [31.5 gal], lb, kg, BTU, MBTU, MMBTU, kJ, kCal, ton
Mode	Forward, reverse, net, batch
Ambient Conditions	-40 °F to +185 °F [-40 °C to +85 °C], 0 to 95% relative humidity [non-condensing]
Enclosure	NEMA 4X [IP-66], polycarbonate, SS, brass, plated steel
Size	7.00" H × 5.75" W × 3.88" D [178 mm H × 146 mm W × 99 mm D]
Flow Rate Accuracy	±1% of reading for velocities ≥ 1 FPS [0.3 MPS]; ±0.5% of reading for field calibrated units ±0.1 FPS [0.03 MPS] for velocities < 1 FPS [0.3 MPS]
Flow Sensitivity	0.001 FPS [0.0003 MPS]
Repeatability	±0.01% of reading
Response Time (Flow)	0.3 to 30 seconds, user configured, for 10% to 90% step change in flow
Security	Keypad lockout, user selected 4 digit access code
Approvals	Ordinary areas
Software	*UltraLink*™, compatible with Window® 95/98/2000/XP

TRANSDUCERS	
Liquid Types	Most non-aerated, clean liquids
Cable Length	Up to 990 ft [300 meters]; standard lengths 20, 50, 100 ft [6, 15, 30 meters]
Pipe Sizes	DTTN / DTTH: 2 inch and larger DTTS [small pipe]: 1/2", 3/4", 1", 1-1/4", 1-1/2" [ANSI pipe, copper tube, tube]
Environment	NEMA 6
Pipe Surface Temperature	DTTN: -40 °F to +300 °F [-40 °C to +150 °C] DTTS: -40 °F to +185 °F [-40 °C to +85 °C] DTTH: -40 °F to +380 °F [-40 °C to +193 °C]
Ambient Conditions	-40 °F to +185 °F [-40 °C to +85 °C]
Housing Material	DTTN: CPVC, Ultem®, and nylon DTTS: PVC, Ultem®, and nylon DTTH: PTFE, Vespel®, and nickel-plated brass
Approvals	Standard: None Optional - DTTN only: CSA Class I, Div 1, Groups C & D; requires intrinsically safe transducer kit with barrier

Transmitter Installation

After unpacking, it is recommended to save the shipping carton and packing materials in case the instrument is stored or reshipped. 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 so equipped).

1. Locate the transmitter within the length of transducer cable that was supplied with the TFXD system. If this is not possible, it is recommended that the cable be exchanged for one that is of proper 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 or DTTS transducers. If additional cable is required, contact the Dynasonics factory to arrange an exchange for a transducer with the appropriate length of cable. Cables to 990 feet [300 meters] are available. If additional cable and connections are added, ensure that they are RG59 75 Ohm compatible.

2. Mount the TFX transmitter in a location that is:
   - Where little vibration exists.
   - Protected from corrosive fluids.
   - Within ambient temperature limits -40 to 185 °F [-40 to 85 °C].
   - Out of direct sunlight. Direct sunlight may increase transmitter temperature to above the maximum limit.

3. Mounting: Refer to **Figure 1.2** on page 1.10 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 four appropriate fasteners.

4. Conduit holes: Conduit hubs should be used where cables enter the enclosure. Holes not used for cable entry should be sealed with plugs.

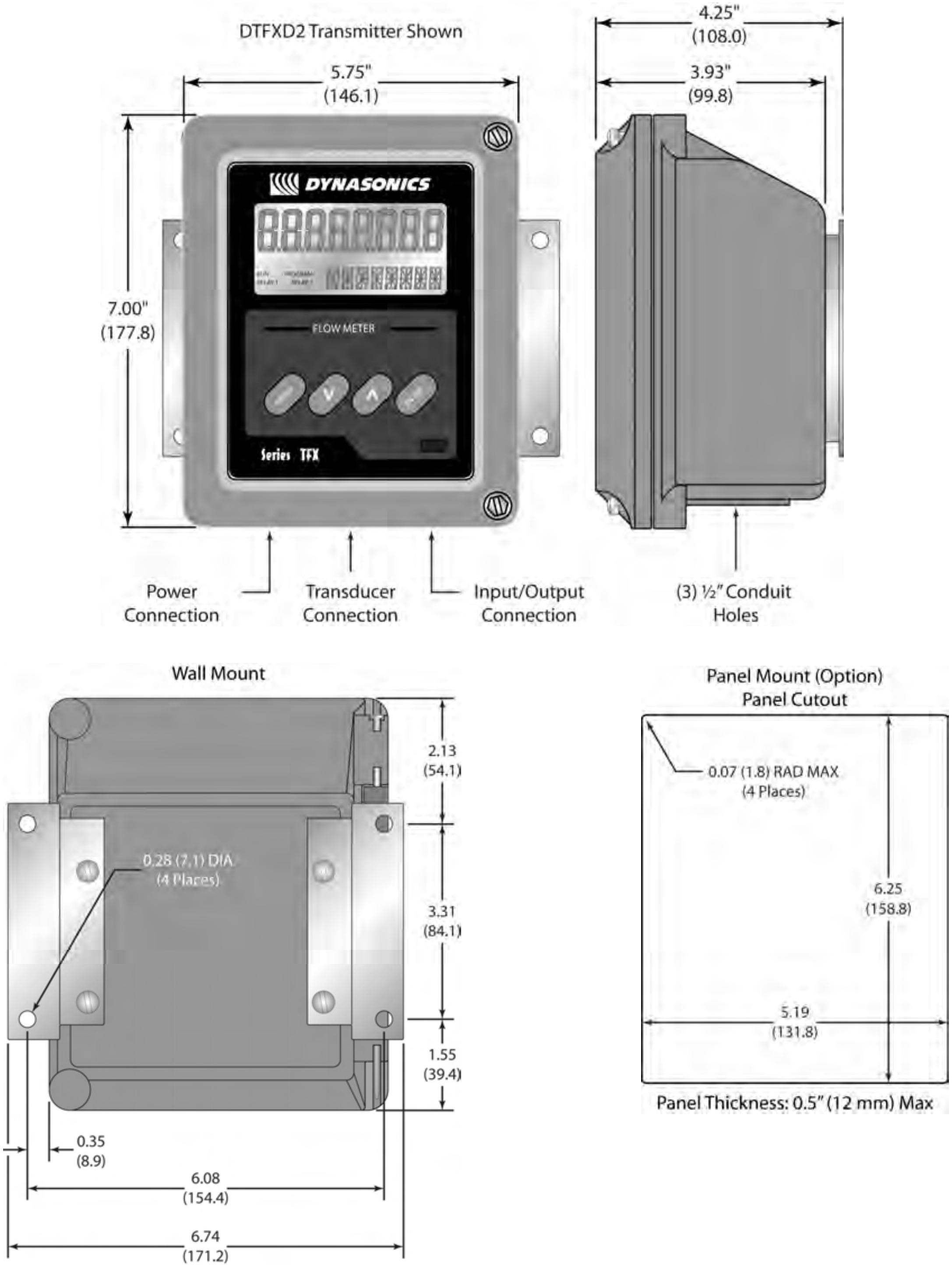


Figure 1.2
TFX Transmitter Installation Dimensions

NOTE: Use NEMA 4 [IP-65] rated fittings/plugs to maintain the watertight integrity of the enclosure. Generally, the left conduit hole (viewed from front) is used for line power; the center conduit hole for transducer connections and the right hole is utilized for ISO-MOD I/O wiring.

5. If additional holes are required, drill the appropriate size hole in the enclosure's bottom. Use extreme care not to run the drill bit into the wiring or circuit cards.

Transducer Connections

To access terminal strips for electronic connectors, loosen the two screws in the enclosure door and open the door.

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

2. The terminals within the TFX are a pluggable type – they can be removed, wired and then plugged back in. Connect the appropriate wires to J4 at the corresponding screw terminals in the transmitter. Observe UP/DN Str Xdcr orientation. See **Figure 1.3** on page 1.12 and **Figure 1.4** on page 1.13 or the wiring diagram located on the inner door of the transmitter.

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 or DTTS transducers. If additional cable is required, contact the Dynasonics factory to arrange an exchange for a transducer with the appropriate length of cable. Cables to 990 feet [300 meters] are available. If additional cable and connections are added, ensure that they are RG59 75 Ohm compatible.

Transmitter Power Connections

Connect power to the screw terminal block marked J2 in the TFX transmitter. See **Figure 1.3** and **Figure 1.4**. Utilize the conduit hole on the left side of the enclosure for this purpose. Use wiring practices that conform to local and national codes (e.g., The National Electric Code Handbook in the U.S.)

CAUTION: Any other wiring method may be unsafe or cause improper operation of the instrument.

NOTE: This instrument requires clean electrical line power. Do not operate this unit on circuits with noisy components (i.e., fluorescent lights, relays, compressors, or variable frequency drives). It is recommended not to run line power with other signal wires within the same wiring tray or conduit.

AC POWER CONNECTIONS

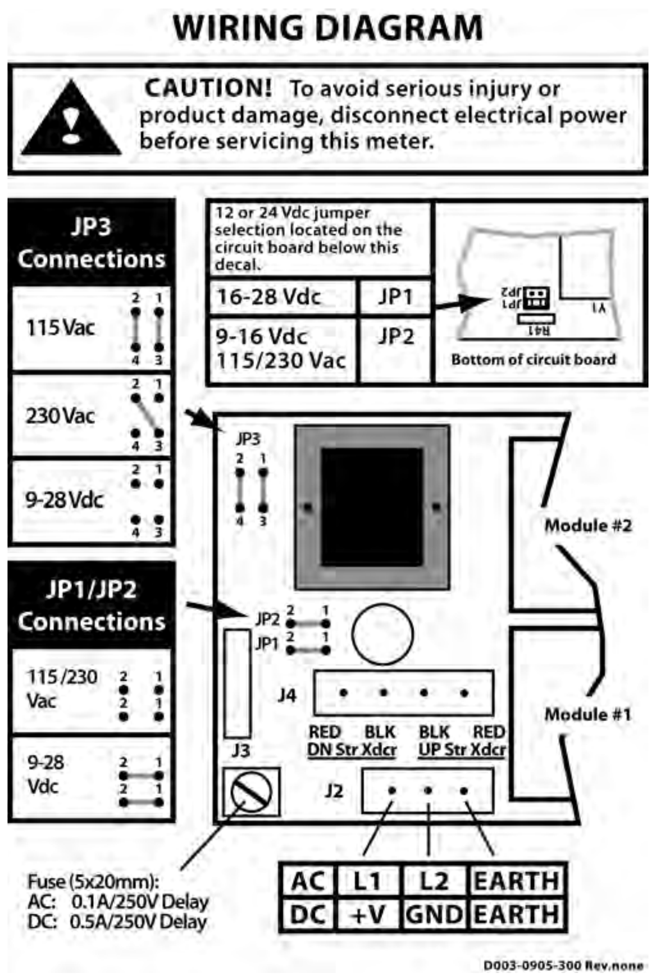


Figure 1.3
TFXD Wiring Diagram

AC Power Supply

1. Verify that the jumpers at JP3 are properly oriented for the power supply. Verify that the jumpers at JP1 and JP2 are <u>not</u> present.
2. Connect L1, L2 and earth to the terminals referenced in **Figure 1.3** on page 1.12. Phase and neutral connections to L1 and L2 are not polarized. Do not operate without an earth ground connection.
3. See **Figure 1.4** for AC connection schematic. Wire gauges up to 14 AWG can be accommodated in the TFX terminal blocks.

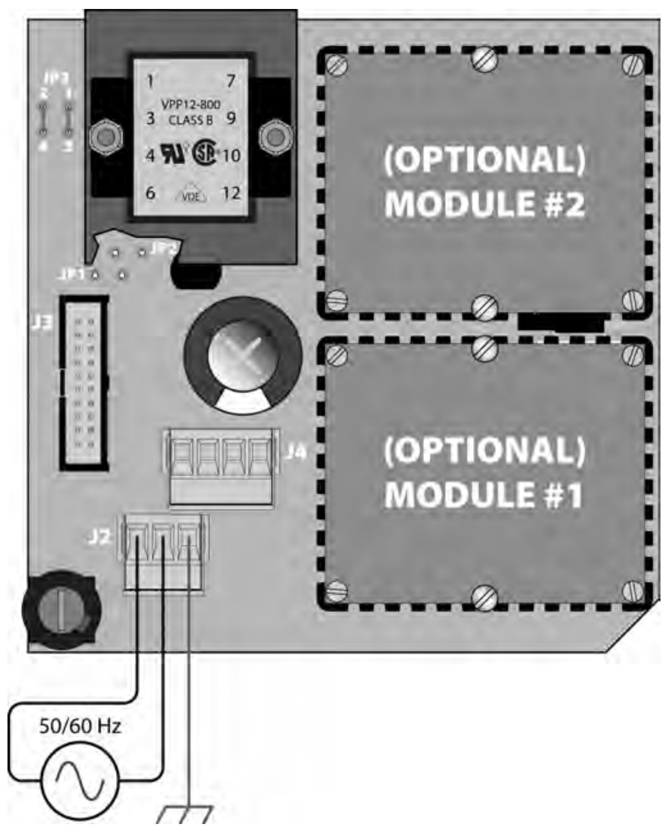


Figure 1.4
AC Power Connection

DC Power Supply

DC POWER CONNECTIONS

The TFX may be operated from a 9-28 Vdc source, as long as the source is capable of supplying a minimum of 3 Watts.

1. Verify that the jumpers are properly placed. See the wiring diagram located on the inside door of the TFX enclosure or see **Figure 1.3** on page 1.12. The jumpers at JP3 should not be present and the jumpers at JP1 and JP2 will be in place. The jumper located beneath the microprocessor protection shield – the panel with the wiring diagram label mounted on it – should be positioned at JP2 for 9-16 Vdc input power and in JP1 position for 16-28 Vdc input power.
2. Connect the DC power source as illustrated in the schematic in **Figure 1.5**. Wire up to 14 AWG can be accommodated in the TFX terminal blocks.

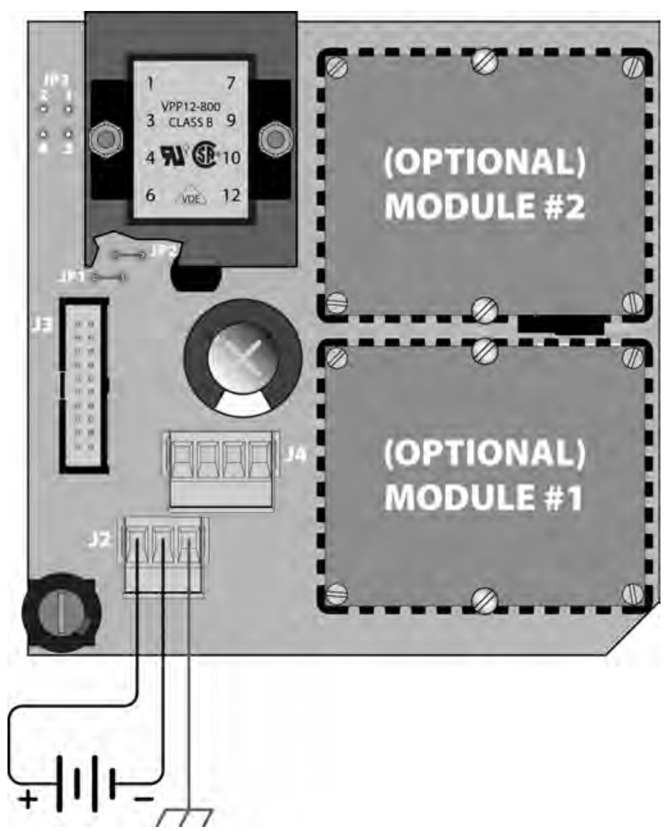


Figure 1.5
DC Power Connection

PART 1 - INPUT/OUTPUT CONNECTIONS

General

The TFXD utilizes ISO-MODs for input and output functions. ISO-MODs are epoxy encapsulated electronic input/output modules that are simple to install and replace in the field. See **Figure 1.6**. All modules are 2,500 V optically isolated from TFXD power and earth grounds. This eliminates the potential for ground loops and reduces the chance of severe damage in the event of an electrical surge.

Seven ISO-MOD options are available, including: 4-20 mA, dual-relay, rate pulse, RS232C, RS485, BTU and 200k point data logger. The TFXD supports any two ISO-MOD input/output modules. All modules are field configurable by utilizing the keyboard or *UltraLink*™ interface. Field wiring connections to ISO-MODs are quick and easy using removable plug-in terminals. Configuration and connection of the various ISO-MODs are described on the following pages.

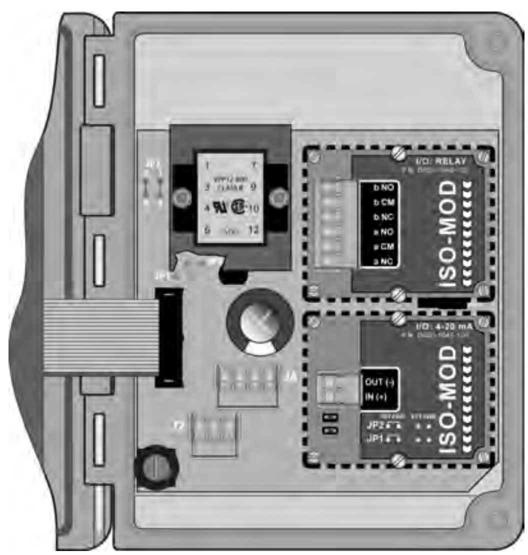


Figure 1.6
Two ISO-MOD I/O Modules Installed

ISO-MOD Replacement

To remove an ISO-MOD, remove the two machine screws that secure the module in place and pull the module straight out of the enclosure. A 10-pin connection is on the bottom of the module that mates with the circuit board underneath. Installation of a module is simply the reverse operation of removal. 4-20 mA modules will require calibration parameters to be entered if the module is replaced. See Part 3 of this manual for instructions on entry of calibration parameters.

4-20 mA Output

The 4-20 mA Output Module interfaces with most recording and logging systems by transmitting an analog current signal that is proportional to system flow rate. The 4-20 mA ISO-MOD may be configured via jumper selections for either an internally powered mode (current sourcing) **Figure 1.7A** or externally powered mode (current sinking) **Figure 1.7B**.

Internal Power Configuration: Ensure that jumpers are in place at JP1 and JP2 on the module. See **Figure 1.7A**. In this configuration the 4-20 mA output is driven from a +24 Vdc source located within the TFX flow meter. The 24 Vdc source is isolated from DC ground and earth ground connections within the TFX instrument. The module can accommodate loop loads up to 800 Ohms in this configuration.

NOTE: The +24 internal supply, if configured to power the 4-20 mA output, shares a common ground with another ISO-MOD (if installed). If another module is connected to earth ground, as is the case with a PC connection to an RS232 module or data logger, a ground loop may occur. The solution to this problem is to configure the 4-20 mA module for external power and utilize an external isolated supply to power the 4-20 mA loop.

External Power Configuration: Remove the two jumpers located at JP1 and JP2 on the module. See **Figure 1.7B**. In this configuration the 4-20 mA module requires power from an external DC power supply. The voltage of the external power source must

Figure 1.7A
Internally Powered
4-20mA

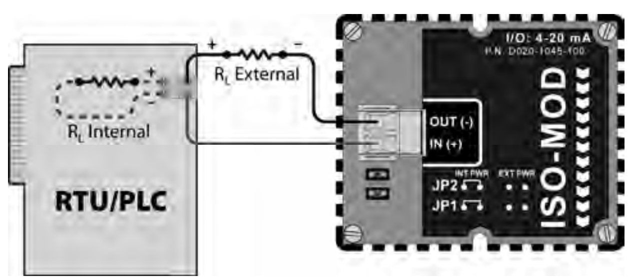
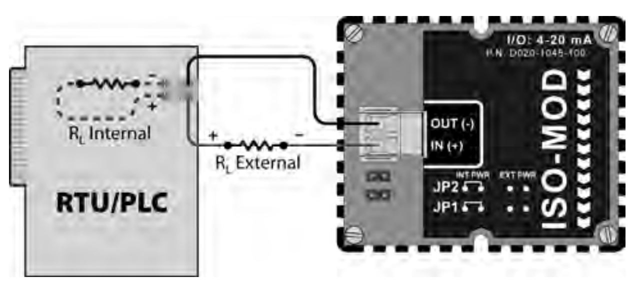


Figure 1.7B
Externally Powered
4-20mA



be sufficient to power the module and drive the loop load. The loop loss attributed to the ISO-MOD is 7 Vdc, so the minimum voltage required to power a loop can be calculated using the following formula:

Loop voltage (min) = (loop load Ohms x 0.02) + 7

Control Relays

Two independent SPDT (single-pole, double-throw) Form C relays are contained in this module. The relay operations are user configured via software to act in either a flow rate alarm, signal strength alarm or totalizer/batching mode. The relays are rated for 200 Vac maximum and have a current rating of 0.5 A resistive load [175 Vdc @ 0.25 A resistive]. It is highly recommended that a secondary relay be utilized whenever the Control Relay ISO-MOD is used to control inductive loads such as solenoids and motors.

Typical relay connections are illustrated in **Figure 1.8A**. The reed relays located within the relay module can interface directly with small pilot lights, PLCs, electronic counters and SCADA systems.

Figure 1.8B describes the connection of an external power relay to the Relay ISO-MOD. It is recommended that external power relays are utilized whenever the load to be switched exceeds the switch rating of the reed relays, or if the load is inductive in nature.

Figure 1.8A
Typical Relay Connections

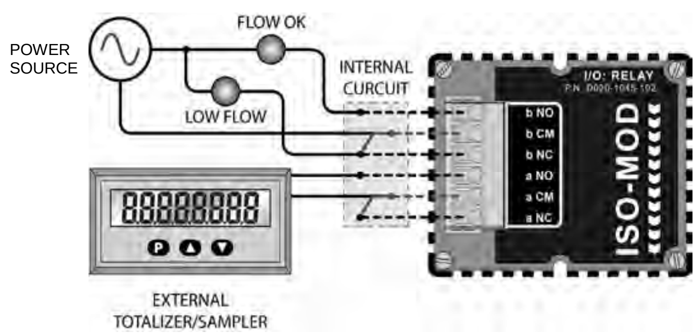
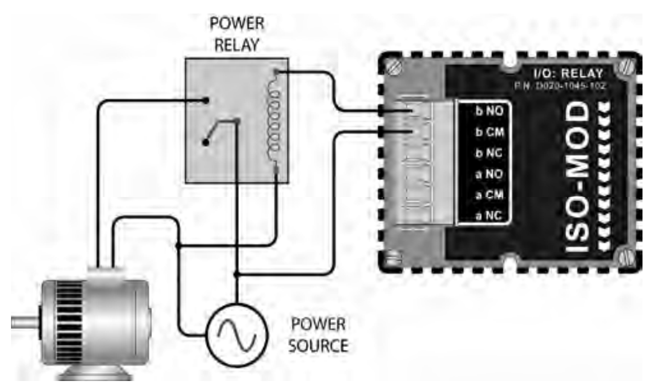


Figure 1.8B
Slave Relay Connections



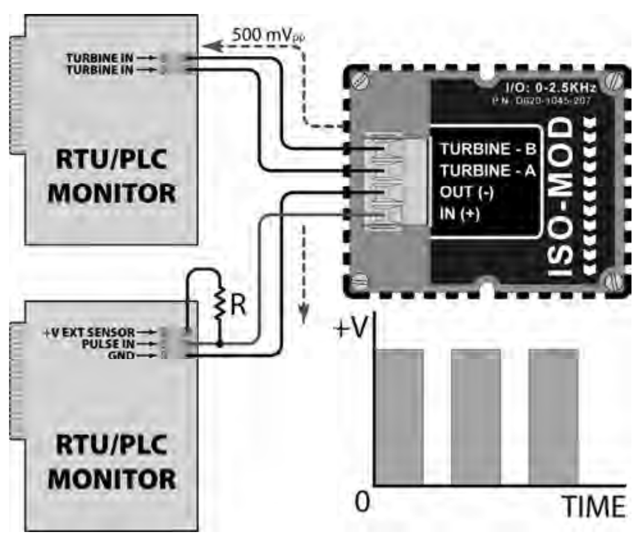
Rate Pulse

The Rate Pulse Output Module is utilized to transmit information to external counters and PID systems via a frequency output that is proportional to system flow rate. The frequency output range of the Rate Pulse Module is 0–2,500 Hz. This module has two types of outputs: one simulates the output of the coil of a turbine flow meter, and the other is an open-collector type that does not source voltage at its output. Both outputs may be connected simultaneously.

The turbine meter output creates a 500 mV peak-to-peak saw-tooth waveform that is not referenced to ground. This output can be run to electronic monitors that are compatible with variable reluctance outputs from coils, such as those found in turbine and paddle-wheel flow meters. The input impedance of the receiving device should not be smaller than 2,000 Ohms.

The standard pulse output does not output a voltage, but acts as an "open-collector" output requiring an external power source and pull-up resistor. See **Figure 1.9**. The MOSFET in the Rate Pulse Module can support loads of 100 V @ 1A. Resistor selection is based on the input impedance of the receiving device. Select a resistor that is a maximum of 10% of the input impedance of the receiving device, but do not exceed 10k Ohms.

Figure 1.9
Rate Pulse Module



RS232C

The RS232C Module will interface with the serial communication ports of PCs, PLCs and SCADA systems that are used to monitor flow rate information in piping systems. A proprietary digital communications protocol is used for this communication. An explanation of the command structure is detailed in the Appendix of this manual. Flow rate, total, signal strength and temperature (if so equipped) can be monitored over the digital communications module. The RS232C Module may also be used to form a hardwire connection to a PC that is running the *UltraLink*™ software utility. Baud rates up to 19.2k are supported. **Figure 1.10** illustrates typical connections.

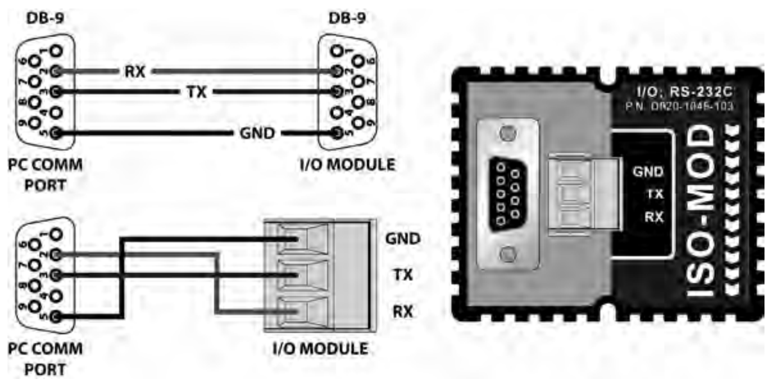


Figure 1.10
RS232 Connections

RS485

The RS485 Module allows up to 128 TFX systems to be placed on a single three-wire cable bus. All meters are assigned a unique one byte serial number that allows all of the meters on the cable network to be independently accessed. A proprietary digital communications protocol is used for this communication. An explanation of the command structure is detailed in the Appendix of this manual. Flow rate, total, signal strength and temperature (if so equipped) can be monitored over the digital communications bus. Baud rates up to 9600 and cable lengths to 5,000 feet [1,500 meters] are supported without repeaters or “end of line” resistors. *UltraLink*™ is also compatible with a multiple TFX network, allowing individual meters to be accessed, programmed, diagnosed and calibrated.

To interconnect meters, utilize three-wire shielded cable such as Belden 9939 or equal. In noisy environments the shield should be connected on one end to a good earth ground connection. An RS232 to RS485 scond, such as B&B electronics p/n 485SD9TB (illustrated in **Figure 1.11**) is required to interconnect the RS485 network to a communication port on a PC. If more than 128 meters must be monitored, an additional scond and communication port is required.

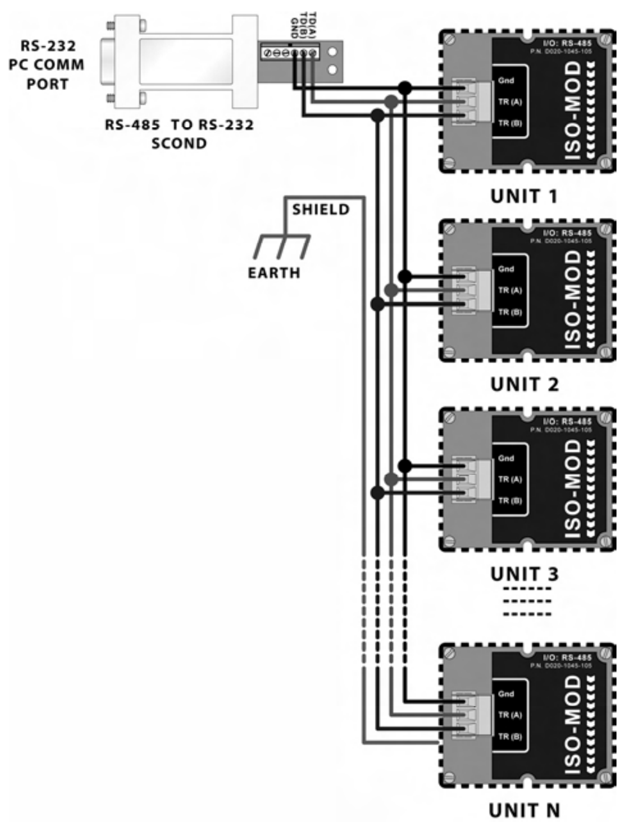


Figure 1.11
RS485 Network Connections

Data Logger

The 200,000 event data logger/electronic stripchart recorder can be configured to match most user applications. The logger stores time-stamped, high resolution (16-bit) data at user selected intervals ranging from 1 to 1,000 seconds. Configuration of and data retrieval from the logger are detailed in Sections 3 and 4 of this manual.

The module can be carried in a shirt pocket back to the office and plugged into a PC serial port via the module's integral DB-9 connector. See **Figure 1.12**. This eliminates the requirement to carry a computer to the flow meter site. The data in the logger can also be accessed without removing the module from the flow meter. Open the door of the flow meter and interconnect the 9-pin cable between the data logger and the PC serial communications port.

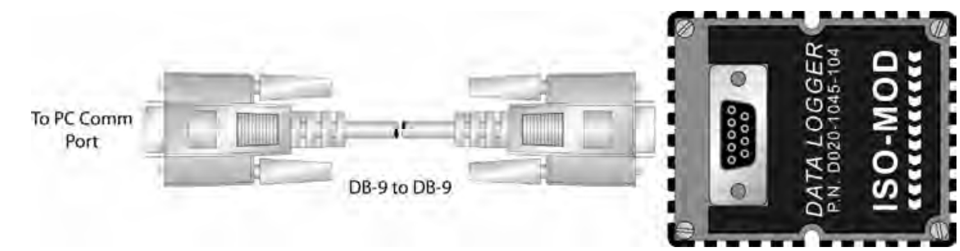


Figure 1.12
Data Logger Connection

The logger is capable of storing up to 200,000 measurements. The measurements are broken into 16 blocks or pages with a maximum number of data points per block of 30,000.

If each block (page) is filled to the maximum 6-2/3 blocks would be used:

$$\frac{200{,}000 \text{ Points}}{30{,}000 \text{ Points}} = 6\text{-}2/3 \text{ Pages}$$

If all 16 blocks are to be used, each block could hold 12,500 data points:

$$\frac{200{,}000 \text{ Points}}{16 \text{ Pages}} = 12{,}500 \text{ Points per page}$$

NOTE: The logger will not automatically go to the next page if the previous page is filled. In this case when the page exceeds 30,000 data points the oldest points will be discarded in favor of new points. This is the classic FIFO memory stack.

Up to 16 separate logging sessions are possible with up to 12,500 points each but for each new measurement session the logger must be stopped, a new page selected using the data logger utility, and then the logging must be started again. Similarly if a single point data acquisition session were to exceed 30,000 points the logger must be stopped, a new page selected using the data logger utility, and then the logging must be started again.

NOTE: The data logger is not accessible using the TFXD's infrared adapter. Communications between the data logger and computer must be accomplished using a directly connected RS232C or RS485 connection.

NOTE: When a PC is connected to the data logger, it inhibits the logger from collecting additional data.

Heat Flow

The RTD Module allows integration of two 1000 Ohm, platinum RTDs with the TFXD flow meter, effectively providing an instrument for measuring energy delivered in liquid cooling and heating systems. The RTD Module is installed in the base of the TFX flow transmitter. Each module is factory configured and encapsulated; it cannot be altered. The configuration of the module will be indicated by a factory mark in the box next to the module part number (see **Figure 1.13**). If the module is not configured for the appropriate temperature range for the installation, please contact the Dynasonics factory to arrange for a replacement.

Module	Temperature Range
D020-1045-106	-40 to +200 °C [-40 to +400 °F]
D020-1045-112	0 to +50 °C [+32 to +122 °F]
D020-1045-113	0 to +100 °C [+32 to +212 °F]

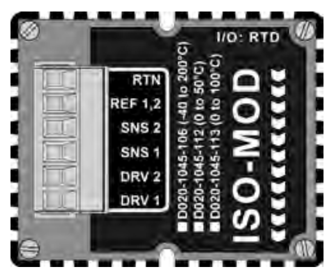


Figure 1.13
RTD Module Configuration

If RTDs were ordered with the TFXD flow meter they have been factory calibrated and shipped connected to the module as they were calibrated. If necessary, the green terminal block on the module can be disconnected from the RTD module and the plug routed out through the conduit hole in the bottom of the enclosure. Simply turn the plug lengthwise and guide it through the hole. If the

RTDs must be disconnected from the terminal block, it is recommended that the RTDs and the wires be marked so that they may be returned to their respective terminals – retaining the factory calibration.

Dynasonics offers two types of RTDs:

SURFACE MOUNT RTDS	
D010-3000-102	set of two, 130 °C Maximum Temperature
D010-3000-105	set of two, 200 °C Maximum Temperature
INSERTION RTDS	
D010-3000-103	single, 3 inch [75 mm], 0.25 inch OD
D010-3000-104	single, 6 inch [150 mm], 0.25 inch OD

All RTDs are 1,000 Ohm platinum, three-wire connection and have 20 feet [6 meters] of shielded cable attached. Additional wire may be attached so long as the wiring convention is retained. **Figure 1.14** illustrates the connection of surface mount RTDs, D010-3000-105 and D010-3000-102. The wire color code on the insertion RTDs is identical to the surface mount types. A schematic of the RTD connections is illustrated in **Figure 1.15**.

Figure 1.14
RTD
Connections

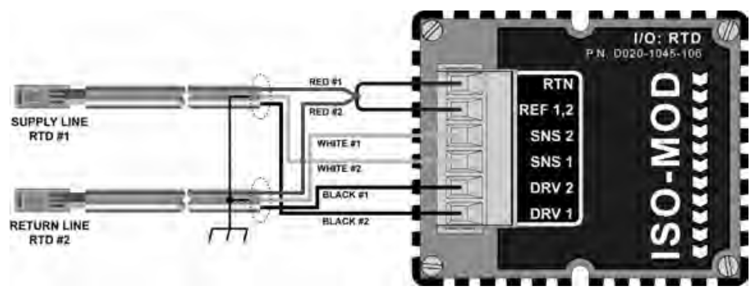
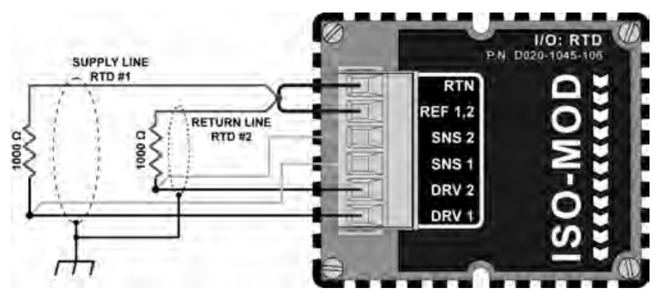


Figure 1.15
RTD
Connection
Schematic



NOTE: Connect the shield to earth ground of the power connector J2 (see **Figure 1.15**).

Before Starting the Instrument

NOTE: <u>The TFX flow meter system requires a full pipe of liquid before a successful startup can be completed.</u> Do not attempt to make adjustments or change configurations until a full pipe is verified.

NOTE: If Dow 732 RTV was utilized to couple the transducers to the pipe, the adhesive must fully cure before power is applied to the instrument. Dow 732 requires 24 hours to cure satisfactorily. If Dow 111 silicone grease was utilized as a couplant, the curing time is not required.

Instrument Startup

<u>Procedure:</u>

1. Verify that all wiring is properly connected and routed, as described in Part 1 of this manual.
2. Verify that the transducers are properly mounted, as described in Part 2 of this manual.
3. Apply power. The display of a TFXD2 will display a software version number and then all of the segments will illuminate in succession. (TFXD1 systems do not have a display or keypad, so *UltraLink*™ or an electronic I/O module must be monitored.) The meter will then enter run mode.

Important!

<u>In order to complete the installation of the TFX flow meter, the pipe must be full of liquid.</u>

To verify proper installation and flow measurement operation:

1. Go to the SER MENU. Confirm that signal strength (**SIG STR**) is between 2.0% and 195%. If the signal strength is lower than 2.0%, verify that proper transducer mounting methods and liquid/ pipe characteristics have been entered. To increase signal strength, if a W-Mount transducer installation has been selected, reconfigure for a V-Mount installation; if V-Mount has been selected, reconfigure for Z-Mount.
2. Verify that the actual measured liquid sound speed is very close to the expected value (see page 2.11 for further details). The measured liquid sound speed (SSPD FPS and MPS) is displayed in the **SERVICE Menu.** Verify that the measured sound speed is within 2% of the value entered as **FLUID SS** in the **BASIC Menu**. **<u>The pipe must be full of liquid in order to make this measurement.</u>**
3. Once the meter is properly operating, refer to Part 3 of this manual for additional programming features.

PART 2 - TRANSDUCER & RTD INSTALLATION

General

The transducers that are utilized by the TFXD contain piezoelectric crystals for transmitting and receiving ultrasound 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, small-pipe transducers, have integrated transmitter and receiver elements that eliminate the requirement for spacing measurement and alignment.

Mounting of the DTTN/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 either the optional software utility (*UltraLink*™) or keying the parameters into the TFXD keypad. (TFXD systems that do not have an integral keypad will require the use of *UltraLink*™ and a PC computer.) The software embedded in *UltraLink*™ and the TFXD firmware will calculate proper transducer spacing based on these entries.
3. Pipe preparation and transducer mounting.

TFXD transmitters with an RTD ISO-MOD module installed require either one or two RTDs to measure heat flow (one RTD) or heat usage (two RTDs). The Dynasonics flow meter utilizes 1,000 Ohm, three-wire, platinum RTDs in two mounting styles. Surface mount RTDs are available for use on well insulated pipe. If the area where the RTD will be located is not insulated, inconsistent temperature readings will result and insertion (wetted) RTDs should be utilized. Instructions for the installation of the RTDs begin on page 2.17.

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 is 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 an error code being displayed on the flow meter while the pipe is empty. Error codes 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** on page 2.4. 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.
- **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 cavitation in the pipe.

2. Transducer Spacing

TFX transit time flow meters are sold with three different transducer types: DTTN, DTTH and DTTS. Meters that utilize DTTN and DTTH transducers consist of two separate sensors that function as both ultrasonic transmitters and receivers. DTTS transducers integrate both the transmitter and receiver into one assembly that fixes the separation of the piezoelectric elements. DTTN and DTTH 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 twice, W-Mount where the sound transverses the pipe four times, or in Z-Mount where the transducers are mounted on opposite sides of the pipe and the sound crosses the pipe once. For further details, reference pictures located under **Table 2.2** on page 2.5. 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 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 or poor piping conditions are present. W-Mount provides the longest sound path length between the transducers - but the weakest signal strength. Z-Mount provides the strongest signal strength - but has the shortest sound path length. On pipes smaller than 3 inches [75 mm], it is desirable to have a longer sound path length, so that the differential time can be measured more accurately. Use of the TFX diagnostics in determining the optimum transducer mounting is covered later in this section.

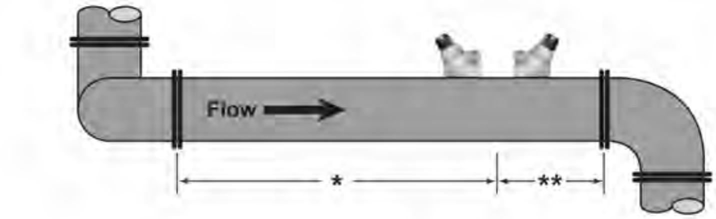
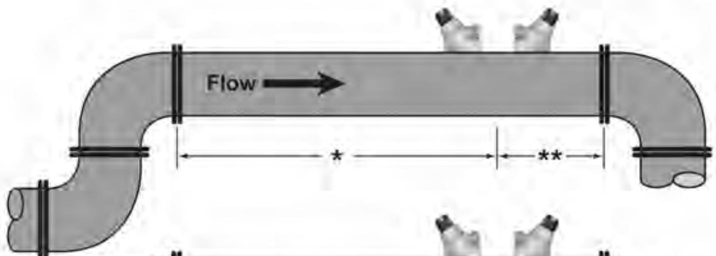
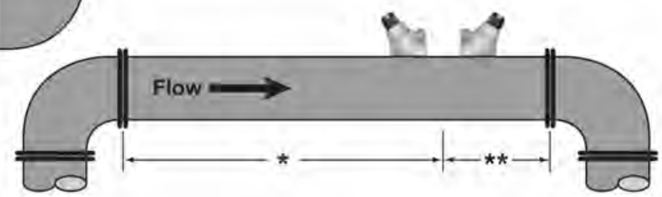
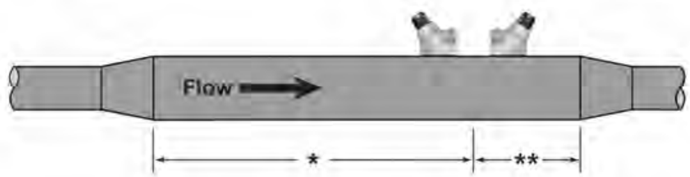
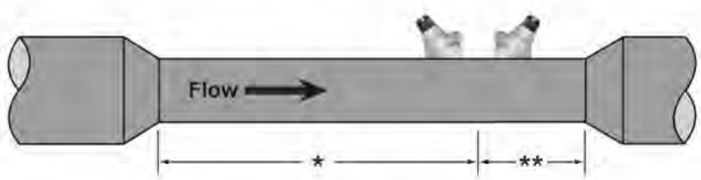
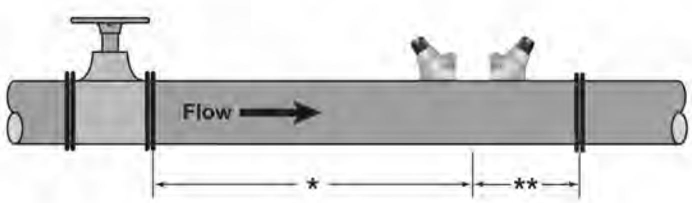
Piping Configuration and Transducer Positioning	Upstream Pipe Diameters	Downstream Pipe Diameters
	*	**
	24	5
	14	5
	10	5
	10	5
	10	5
	24	5

Table 2.1
Straight Pipe Requirements

Table 2.2
Transducer Mounting Modes – DTTN / DTTH

Transducer Mounting Mode	Pipe Material	Pipe Size	Liquid Composition
W-Mount	Plastic (all types) Carbon Steel Stainless Steel Copper Ductile Iron Cast Iron1	2-4 in (50-100 mm) 2-4 in (50-100 mm) 2-4 in (50-100 mm) 2-4 in (50-100 mm) Not recommended Not recommended	Low TSS; non-aerated Low TSS; non-aerated Low TSS; non-aerated Low TSS; non-aerated
V-Mount	Plastic (all types) Carbon Steel Stainless Steel Copper Ductile Iron Cast Iron	4-12 in (100-300 mm) 4-12 in (100-300 mm) 4-12 in (100-300 mm) 4-30 in (100-750 mm) 2-12 in (50-300 mm) 2-12 in (50-300 mm)	Low TSS; non-aerated Low TSS; non-aerated Low TSS; non-aerated Low TSS; non-aerated Low TSS; non-aerated Low TSS; non-aerated
Z-Mount	Plastic (all types) Carbon Steel Stainless Steel Copper Ductile Iron Cast Iron	> 30 in (> 750 mm) > 12 in (> 300 mm) > 12 in (> 300 mm) > 30 in (> 750 mm) > 12 in (> 300 mm) > 12 in (> 300 mm)	Low TSS; non-aerated Low TSS; non-aerated Low TSS; non-aerated Low TSS; non-aerated Low TSS; non-aerated Low TSS; non-aerated

TSS = Total Suspended Solids

Table 2.3
Transducer Mounting Modes – DTTS

Size	Frequency	Transducer	Mounting Mode
1/2	2 MHz	DTTSnP	**W**
		DTTSnC	
		DTTSnT	
3/4	2 MHz	DTTSnP	**W**
		DTTSnC	
		DTTSnT	
1	2 MHz	DTTSnP	**W**
		DTTSnC	
		DTTSnT	
1-1/4	2 MHz	DTTSnP	**W**
		DTTSnC	
		DTTSnT	
1-1/2	2 MHz	DTTSnP	**W**
		DTTSnC	
		DTTSnT	
2	1 MHz	DTTSnP	**V**
		DTTSnC	
	2 MHz	DTTSnT	**W**

Entering Pipe and Liquid Data

The TFX system calculates proper transducer spacing by utilizing piping and liquid information entered by the user. This information can be entered via the four-key keypad on TFXD2 units or via the optional *UltraLink*™ software utility. The software utility is required for programming the TFXD1 blind instruments.

NOTE: Transducer spacing is calculated on "ideal" pipe. Ideal pipe is almost never found so the transducer spacing distances should be considered as starting points. 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 TFX before mounting transducers

The following of information is required before programming the instrument.

Note that much of the data relating to material sound speed, viscosity and specific gravity are preprogrammed into the TFXD flow meter. This data only needs to be modified if it is known that a particular liquid data varies from the reference value. Refer to Part 3 of this manual for instructions on entering configuration data into the TFXD flow meter via the meter keypad. Refer to Part 4 for data entry via *UltraLink*™ software.

1. Transducer mounting configuration. See **Table 2.2** on page 2.5
2. Pipe O.D. (outside diameter)
3. Pipe wall thickness
4. Pipe material
5. Pipe sound speed [1]
6. Pipe relative roughness [1]
7. Pipe liner thickness
8. Pipe liner material
9. Pipe liner sound speed [1]
10. Fluid type
11. Fluid sound speed [1]
12. Fluid viscosity [1]
13. Fluid specific gravity [1]

[1] Nominal values for these parameters are included within the TFX 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 TFXD will calculate proper transducer spacing for the particular data set. This distance will be in inches if the TFXD is configured in English units, or millimeters if configured in metric units.

3. Transducer Mounting

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

Pipe Preparation

Before the transducers are mounted onto the pipe surface, two areas slightly larger than the flat surface of the transducer heads 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 ground flat. 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 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 2.1**. On vertical pipes the orientation does not apply.

DTTS transducers should be mounted with the cable exiting within ±45 degrees of the side of a horizontal pipe. **See Figure 2.1.** On vertical pipes the orientation does not apply.

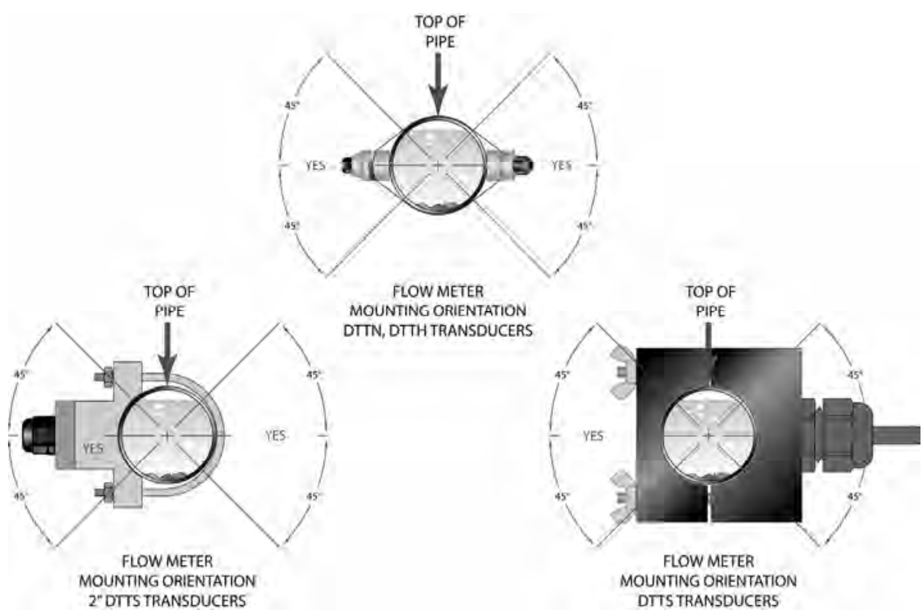


Figure 2.1
Transducer Orientation — Horizontal Pipes

V-Mount and W-Mount Installation

Application of Couplant

1. For DTTN transducers, place a single bead of couplant, approximately 1/2 inch [12 mm] thick, on the flat face of the transducer. See **Figure 2.2**. 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.

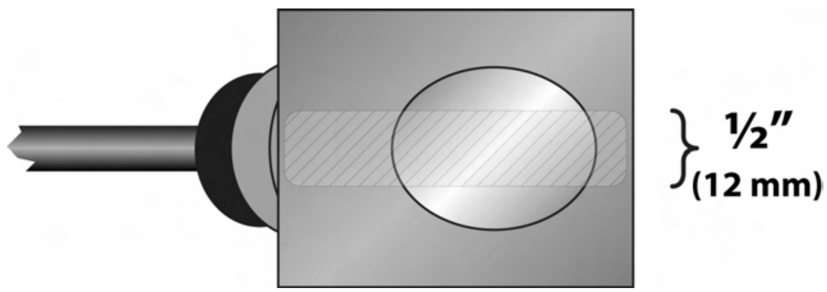
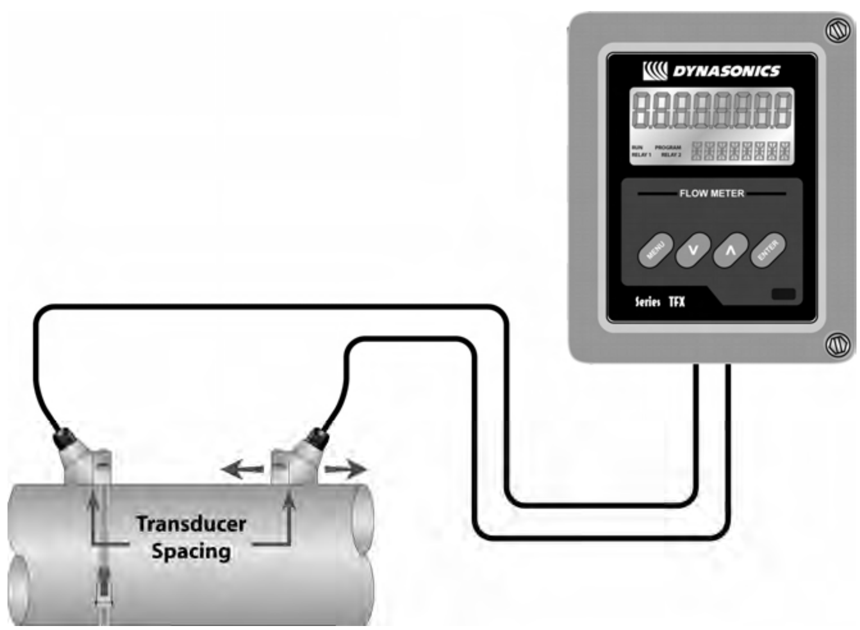


Figure 2.2
Application of Couplant

2. 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 – adjust as necessary. Tighten the transducer strap securely.
3. Place the downstream transducer on the pipe at the calculated transducer spacing. See **Figure 2.3** on page 2.10. Using firm hand pressure, slowly move the transducer both towards and away from the upstream transducer while observing signal strength. Signal strength can be displayed on the TFXD2 display or on the main data screen in *UltraLink*™. See Part 4 of this manual for details regarding the *UltraLink*™ software utility. Clamp the transducer at the position where the highest signal strength is observed. A signal strength between 2 and 195 percent is acceptable.

Transducer Position

4. If after adjustment of the transducers the signal strength does not rise to above 5 percent, then an alternate transducer mounting method should be selected. If the mounting method was W-Mount, then reconfigure the TFXD for V-Mount, reset the TFXD, move the downstream transducer to the new location and repeat Step 3 on page 2.9.
5. Certain pipe and liquid characteristics may cause signal strength to rise to greater than 195 percent. The problem with operating a TFXD with very high signal strength is that the signals may saturate the input amplifiers and cause erratic readings. To decrease the signal strength, move one transducer a small distance radially around the pipe, as shown in **Figure 2.4** on page 2.11.



(Top view of pipe)

Figure 2.3
Transducer Position

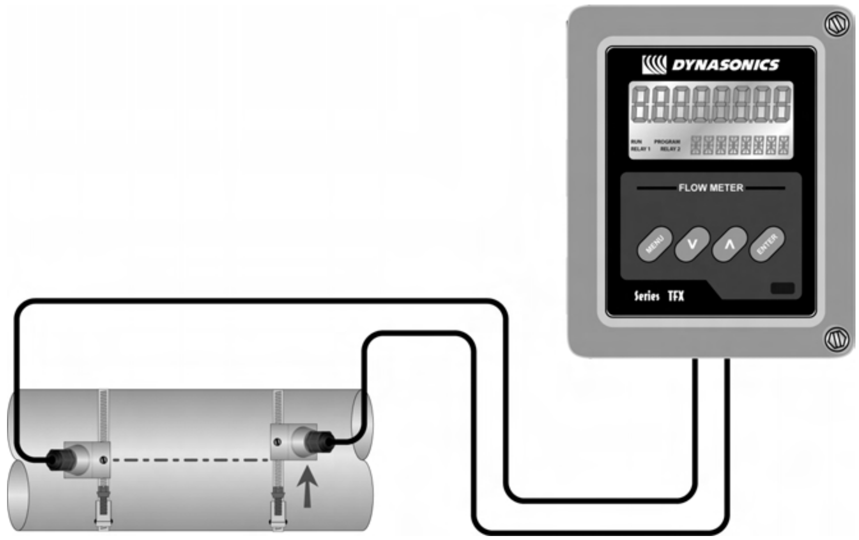


Figure 2.4
High Signal Strength Condition

DTTH Transducers for High Temperature

DTTH High Temperature Transducers

Mounting of high temperature transducers is similar to standard DTTN transducers, except that an insulative pad is placed between the transducer and the pipe wall. High temperature installations also require acoustic couplant that is rated not to “flow” at the temperature that will be present on the pipe surface. **Figure 2.5** should be referenced for insulative pad installation.

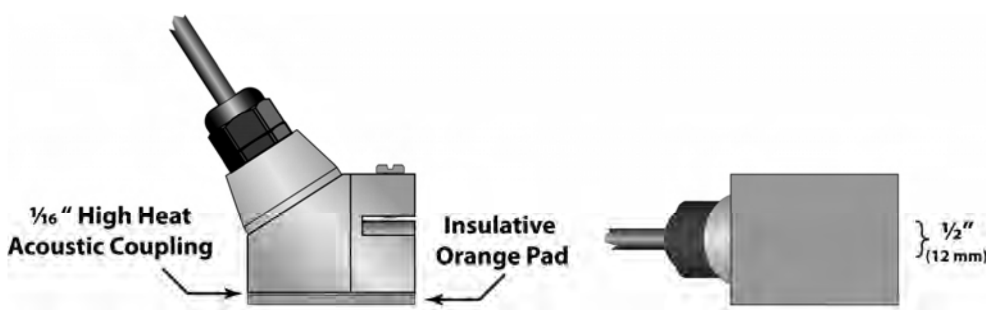


Figure 2.5
Insulative Pad Installation

Installation of the insulative pads consists of the following steps:

1. Apply a thin coating of high temperature grease to the entire surface of the transducer face. The thickness of the application should be approximately 1/16 inch [1.5 mm].
2. Place the orange insulative pad onto the prepared surface of the transducer. Press into place from the center out to remove all air pockets.
3. Apply a 1/2 inch [12 mm] wide bead of grease to the exposed surface of the insulative pad that will contact the pipe.
4. Install the two transducers following the procedures detailed in the DTTN instructions on page 2.8 of this manual.

DTTS Small Pipe Transducer Installation

DTTS Small Pipe Transducer Installation

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

DTTS installation consists of the following steps:

1. Apply a thin coating of silicone grease to both halves of the transducer housing where the housing will contact the pipe. See **Figure 2.6** on page 2.13.
2. On horizontal pipes, mount the transducer in an orientation such that the cable exits at ±45° 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 2.1** on page 2.8.
3. Tighten the wing nuts so that the grease begins to flow out from the edges of the transducer and from the gap between the transducer halves. Do not over tighten.
4. If signal strength is less than 2%, remount the transducer at another location on the piping system.
5. If signal strength is greater than 195%, contact the Dynasonics factory to obtain a lower power strategy to load into the TFXD flow meter.

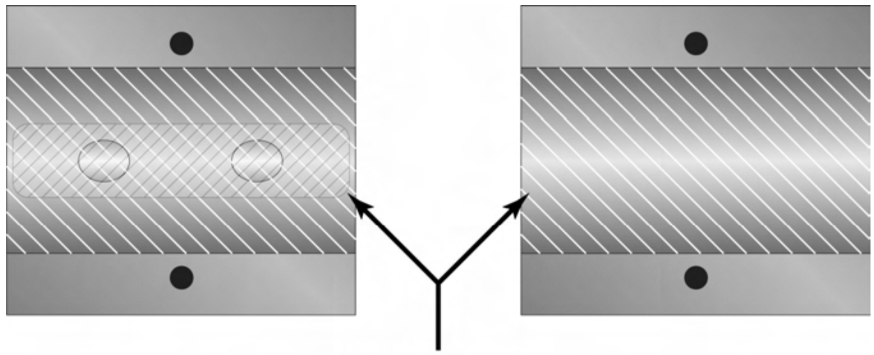


Figure 2.6
Application of Grease — DTTS Transducer

Z-Mount Transducer Installation

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. The section below 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 2.7** on page 2.14. Align the paper ends to within 1/4 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 2.8** on page 2.15.
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 2.1** on page 2.8 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.

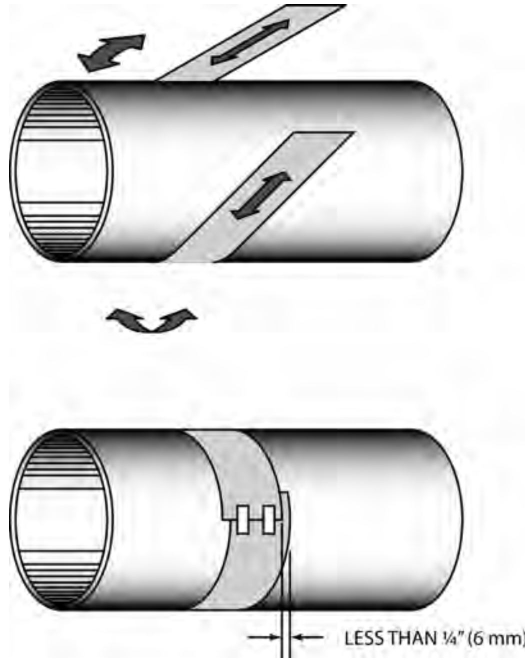


Figure 2.7
Paper Template Alignment

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 to these dimensions and lay it over the top of the pipe.

   Length = Pipe O.D. x 1.57

   Width = Spacing determined on page 2.7

   Mark opposite corners of the paper on the pipe. Apply transducers to these two marks.

5. For DTTN transducers, place a single bead of couplant, approximately 1/2 inch [12 mm] thick, on the flat face of the transducer. See **Figure 2.2** on page 2.9. Generally, a silicone-based grease is used as an acoustic couplant, but any 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. 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.

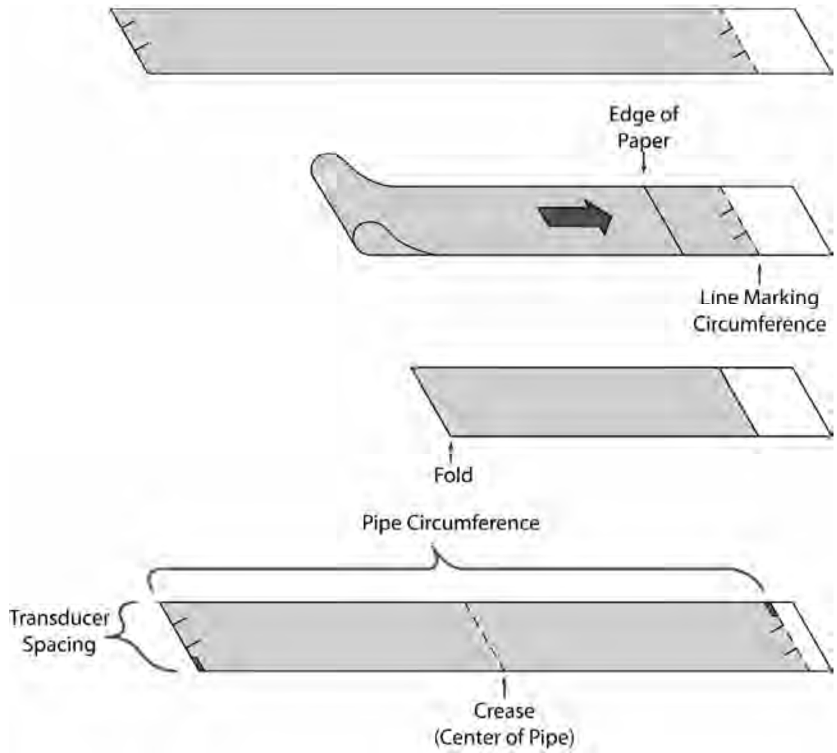


Figure 2.8
Bisecting the pipe circumference

7. Place the downstream transducer on the pipe at the calculated transducer spacing. See **Figure 2.9** on page 2.16. 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 2 and 195 percent is acceptable. 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 195 percent. The problem with operating a TFXD with very high signal strength is that the signals may saturate the input amplifiers and cause erratic readings. To decrease the signal strength one transducer can be offset radially, as illustrated in **Figure 2.4** on page 2.11, or a V-Mount transducer mounting method may be chosen.
9. Secure the transducer with a stainless steel strap or other fastener.

Figure 2.9
Z-Mount Transducer Placement

Mounting Track Installation

D010-2102-010 Mounting Track Installation

1. The D010-2102-010 transducer mounting track is used for pipes that have outside diameters between 2 and 10 inches [50-250 mm]. If the pipe is outside of that range, select a standard 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, 5 inch [125 mm] mark, on the mounting rail.
4. Place a single bead of couplant, approximately 1/2 inch [12 mm] thick, on the flat face of the transducer. See **Figure 2.2** on page 2.9.
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 2.10** on page 2.17.
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.

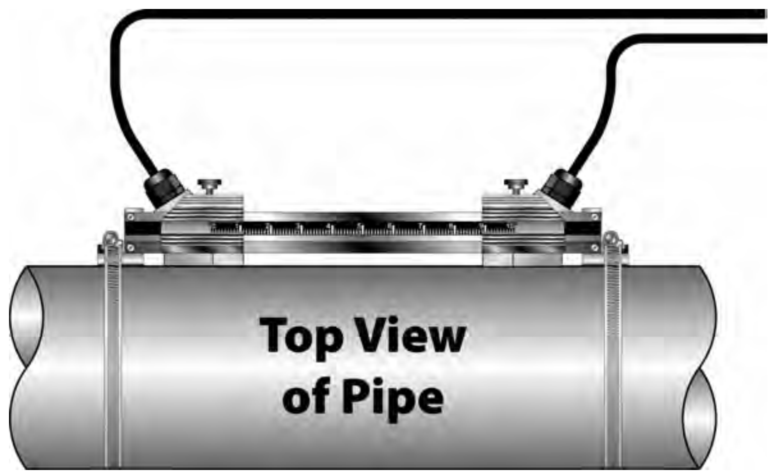


Figure 2.10
D010-2102-010 Mounting Track Installation

4. RTD INSTALLATION

For typical installations, the length of RTD wire should equal the length of the flow transducer cable. Ensure that the length of wire included with the RTDs is adequate to reach from the supply and return pipes to the location of the TFX transmitter. If the length of wire is insufficient wire can be added on, but a small temperature offset will result. If additional RTD wire is added, utilize Belden 9939 or equivalent cable and provide proper connections to the shield wires – maintain the color coding. Adjusting the resulting offset is covered in Part 3 - ISO-MOD: RTD on page 3.19.

Surface mount RTDs should only be utilized on well insulated pipe. If the area where the RTD is located is not insulated, inconsistent temperature readings will result and insertion (wetted) RTDs should be utilized.

Surface Mount RTD Installation

Installation of Surface Mount RTDs

1. Select areas on the supply and return pipes where the RTDs will be mounted and peel back the insulation all the way around the pipe in the installation area.
2. Clean an area slightly larger than the RTD down to bare metal on the pipe.
3. Place a small amount of heat sink compound on the pipe in the RTD installation location. See **Figure 2.11**.
4. Press the RTD firmly into the compound. Fasten the RTD to the pipe with the included stretch tape.
5. Route the RTD cables back to the TFX flow meter. If the cables are not long enough to reach the TFX, route the cables to an electrical junction box and add additional cable from that point. Use 3-wire shielded cable, such as Belden 9939 or equal, for this purpose.
6. Secure the RTD cable such that it will not be pulled on or abraded inadvertently.
7. Replace the insulation on the pipe, ensuring that the RTD is not exposed to air currents.

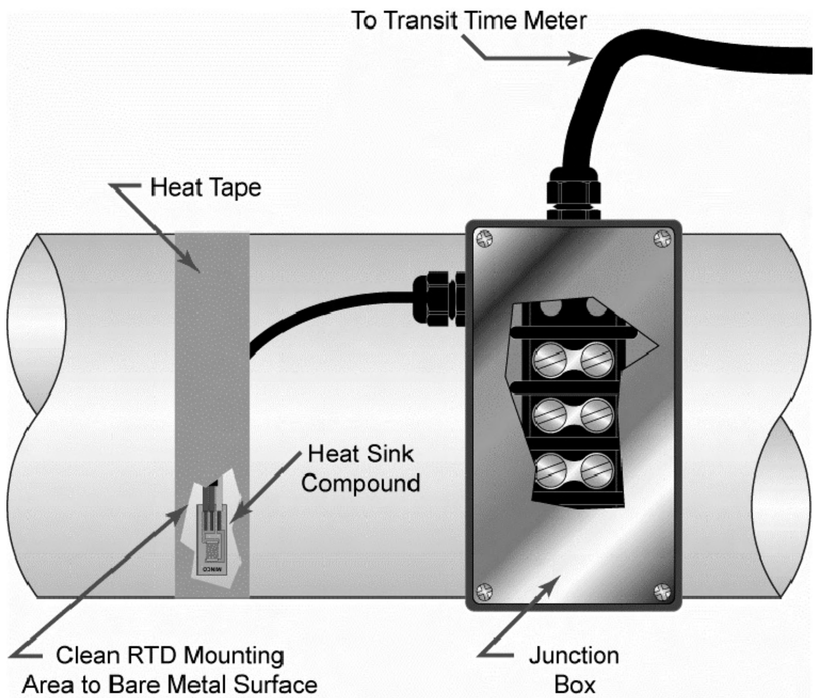


Figure 2.11
Surface Mount RTD Installation

Insertion RTD Installation

Insertion RTD Installation

Insertion RTDs are typically installed through 1/4" compression fittings and isolation ball valves.

1. It is recommended that insertion RTDs be mounted downstream of the flow measurement transducer to avoid causing flow instability in the flow measurement region.
2. Insert the RTD sufficiently into the flow stream such that a minimum of 0.25" of the probe tip protrudes into the pipe diameter. See **Figure 2.12**.
3. Route the RTD cables back to the TFX flow meter. If the cables are not long enough to reach the TFX, route the cables to an electrical junction box and add additional cable from that point. Use 3-wire shielded cable, such as Belden 9939 or equal, for this purpose.
4. Secure the RTD cable such that it will not be pulled on or abraded inadvertently.

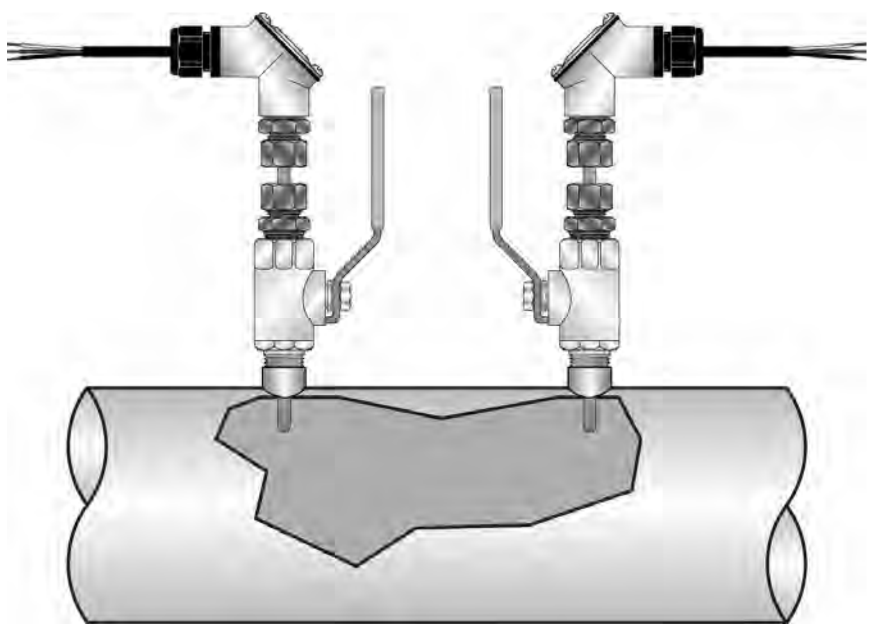


Figure 2.12
Insertion RTD Installation

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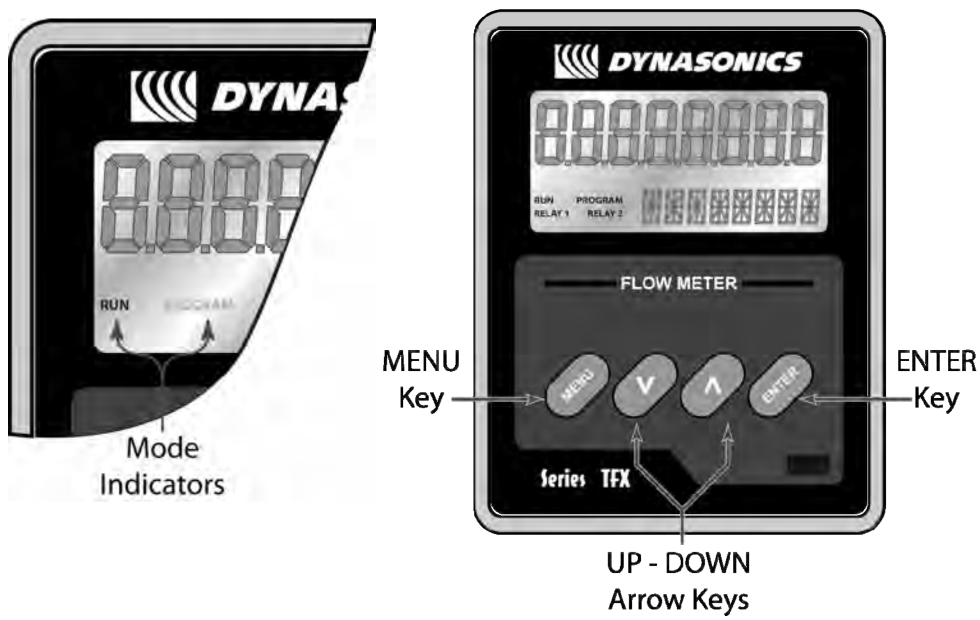
PART 3 - PROGRAMMING

General

The TFXD2 can be configured through the keypad interface or by using the *UltraLink*™ Windows® software utility. (The TFXD1 does not contain a keypad or display, so the *UltraLink*™ software must be used for configuration. See Part 4 of this manual for software details.) Of the two methods of configuration, the *UltraLink*™ software utility provides more advanced features and offers the abililty to store and transfer meter configurations between TFXD meters. All entries are saved in non-volatile FLASH memory and will be retained indefinitely in the event of power loss.

Keypad Operation

The TFXD2 contains a four-key tactile feedback keypad interface that allows the user to view and change configuration parameters used by the TFXD operating system.



1. The MENU key is pressed from RUN mode to enter PROGRAM mode. The MENU key is pressed in PROGRAM mode to exit configuration parameters and menus. If changes to any configuration parameters have been made, the user will be prompted with a SAVE?YES when returning to RUN mode.

2. The ARROW keys are used to scroll through menus and configuration parameters. The ARROW keys are also used to adjust parameter numerical values.
3. The ENTER key is:
   - Pressed from the RUN mode to view the current software version operating in the instrument.
   - Used to access the configuration parameters in the various menus.
   - Used to initiate changes in configuration parameters.
   - Used to accept configuration parameter changes.

Menu Structure

The TFXD2 software is structured using menus. A map of the user interface is included in the Appendix of this manual. The map provides a visual path to the configuration parameters that users can access. This tool should be employed each time configuration parameters are accessed or revised.

The seven menus used in the TFXD2 software are as follows:

1. **BSC MENU** -- BASIC operations menu contains all of the configuration parameters necessary to program the meter to measure flow.
2. **OUT1 MEN** -- OUTPUT 1 configures the type and operating parameters of the ISO-MOD located in Module #1 position.
3. **OUT2 MEN** -- OUTPUT 2 configures the type and operating parameters of the ISO-MOD located in Module #2 position.
4. **SEN MENU** -- SENSOR MENU is used to select the sensor type (i.e. DTTN, DTTH, etc.)
5. **SEC MENU** -- SECURITY MENU is utilized for resetting totalizers, resetting the operating system and revising security passwords.
6. **SER MENU** -- SERVICE MENU contains system settings that may be used by service personnel for troubleshooting.
7. **DSP MENU** -- DISPLAY MENU is used to configure meter display functions.

The following sections define the configuration parameters located in each of the menus.

1. BSC MENU -- BASIC MENU

The BASIC Menu contains all of the configuration parameters necessary to make the TFXD operational.

UNITS Selection

UNITS (Choice)

ENGLSH
METRIC

Installs a global measurement standard into the memory of the instrument. The choices are either English or Metric units.

- Select ENGLSH if all configurations (pipe sizes, etc.) are to be made in inches. Select METRIC if the meter is to be configured in millimeters.
- The ENGLSH/METRIC selection will also configure the TFX to display sound speeds in pipe materials and liquids as either feet per second or meters per second, respectively.

IMPORTANT!

NOTE: If the UNITS entry has been changed from ENGLSH to METRIC or from METRIC to ENGLSH, the entry must be saved and the instrument reset (power cycled or System Reset entered) in order for the TFX to initiate the change in operating units. Failure to save and reset the instrument will lead to improper transducer spacing calculations and an instrument that may not measure properly.

Transducer Mount

XDCR MNT -- Transducer Mounting Method (Choice)

V
W
Z

Selects the mounting orientation for the transducers. The selection of an appropriate mounting orientation is based on pipe and liquid characteristics. See Part 2 - Transducer Installation in this manual.

Pipe Diameter

PIPE OD -- Pipe Outside Diameter Entry (Value)

ENGLSH	*(Inches)*
METRIC	*(Millimeters)*

Enter the pipe outside diameter in inches if ENGLSH was selected as UNITS; in millimeters if METRIC was selected.

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.

Pipe Wall Thickness

PIPE WT -- Pipe Wall Thickness Entry (Value)

ENGLSH	*(Inches)*
METRIC	*(Millimeters)*

Enter the pipe wall thickness in inches if ENGLSH was selected as UNITS; in millimeters if METRIC was selected.

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.

Pipe Material

PIPE MAT -- Pipe Material Selection (Choice)

Acrylic	*(ACRYLIC)*
Aluminum	*(ALUMINUM)*
Brass [Naval]	*(BRASS)*
Carbon Steel	*(CARB ST)*
Cast Iron	*(CAST IRN)*
Copper	*(COPPER)*
Ductile Iron	*(DCTL IRN)*
Fiberglass-Epoxy	*(FBRGLASS)*
Glass Pyrex	*(PYREX)*
Nylon	*(NYLON)*
HD Polyethylene	*(HDPE)*
LD Polyethylene	*(LDPE)*
Polypropylene	*(POLYPRO)*
PVC CPVC	*(PVC/CPVC)*
PVDF	*(PVDF)*

St Steel 302/303	*(SS 303)*
St Steel 304/316	*(SS 316)*
St Steel 410	*(SS 410)*
St Steel 430	*(SS 430)*
PFR	*(PFR)*
Titanium	*(TITAMN)*
Other	*(OTHER)*

This list is provided as an example. Additional pipe materials are being added continuously. Select the appropriate pipe material from the list or select OTHER if the material is not listed.

Pipe Sound Speed

PIPE SS -- Speed of Sound in the Pipe Material (Value)

ENGLSH	*(Feet per Second)*
METRIC	*(Meters per Second)*

Allows adjustments to be made to the speed of sound in the pipe wall. If the UNITS value was set to ENGLSH, the entry is in FPS (feet per second). METRIC entries are made in MPS (meters per second).

If a pipe material was chosen from the PIPE MAT list, a nominal value for speed of sound in that material will be automatically loaded. If the actual sound speed rate is known for the application piping system and that value varies from the automatically loaded value, the value can be revised.

If OTHER was chosen as PIPE MAT, then a PIPE SS must also be entered.

Pipe Roughness

PIPE R -- Pipe Material Relative Roughness (Value)

Unitless

The TFXD provides Reynolds number compensation in its flow measurement calculation. The ratio of average surface imperfection as it relates to the pipe internal diameter is used in this compensation.

$$\text{PIPE R} = \frac{\text{Linear RMS measurement, pipe internal wall surface}}{\text{Internal Diameter of the pipe}}$$

If a pipe material was chosen from the PIPE MAT list, a nominal value for relative roughness in that material will be automatically loaded. If the actual roughness is known for the application piping system and that value varies from the automatically loaded value, the value can be revised.

If OTHER was chosen as PIPE MAT, then a PIPE R must also be entered.

Liner Thickness

LINER T -- Pipe Liner Thickness Entry (Value)

ENGLSH	*(Inches)*
METRIC	*(Millimeters)*

Enter the pipe liner thickness. Enter this value in inches if ENGLSH was selected as UNITS; in millimeters if METRIC was selected.

Liner Type

[If a LINER Thickness was selected]
LINER MAT -- Liner Material (Choice)

Ebonite	*(EBONITE)*
Mortar	*(MORTAR)*
HD Polyethylene	*(HDPE)*
LD Polyethylene	*(LDPE)*
Polypropylene	*(POLYPRO)*
Polystyrene	*(POLYSTY)*
Rubber	*(RUBBER)*
Tar Epoxy	*(TAR EPXY)*
Teflon	*(TEFLON)*
Other	*(OTHER)*

This list is provided as an example. Additional materials are being added continuously. Select the appropriate material from the list or select OTHER if the liner material is not listed.

Liner Sound Speed

LINER SS -- Speed of Sound in the Liner (Value)

ENGLSH	*(Feet per Second)*
METRIC	*(Meters per Second)*

Allows adjustments to be made to the speed of sound in the liner. If the UNITS value was set to ENGLSH, the entry is in FPS (feet per second). METRIC entries are made in MPS (meters per second).

If a liner was chosen from the LINER MAT list, a nominal value for speed of sound in that media will be automatically loaded. If the actual sound speed rate is known for the pipe liner and that value varies from the automatically loaded value, the value can be revised.

Fluid Type

FL TYPE -- Fluid/Media Type (Choice)

Water Tap	*(WATER)*
Sewage	*(SEWAGE)*
Acetone	*(ACETONE)*
Alcohol	*(ALCOHOL)*
Ammonia	*(AMMONIA)*
Benzene	*(BENZENE)*
Brine	*(BRINE)*
Ethanol	*(EHTANOL)*
Ethylene Glycol	*(ETH-GLYC)*
Gasoline	*(GASOLINE)*
Glycerin	*(GLYCERIN)*
Isopropyl Alcohol	*(ISO-ALC)*
Kerosene	*(KEROSENE)*
Methanol	*(METHANOL)*
Oil Diesel	*(DIESEL)*
Oil Hydraulic [Petro-based]	*(HYD OIL)*
Oil Lubricating	*(LUBE OIL)*
Oil Motor [SAE 20/30]	*(MTR OIL)*
Water Distilled	*(WATR-DST)*
Water Sea	*(WATR-SEA)*
Other	*(OTHER)*

This list is provided as an example. Additional liquids are being added continuously. Select the appropriate liquid from the list or select OTHER if the liquid is not listed.

Fluid Sound Speed

FLUID SS -- Speed of Sound in the Fluid (Value)

ENGLSH	*(Feet per Second)*
METRIC	*(Meters per Second)*

Allows adjustments to be made to the speed of sound in the liquid. If the UNITS value was set to ENGLSH, the entry is in FPS (feet per second). METRIC entries are made in MPS (meters per second).

If a fluid was chosen from the FL TYPE list, a nominal value for speed of sound in that media will be automatically loaded. If the actual sound speed rate is known for the application fluid and that value varies from the automatically loaded value, the value can be revised.

If OTHER was chosen as FL TYPE, a FLUID SS will need to be entered. A list of alternate fluids and their associated sound speeds is located in the Appendix of this manual.

Fluid sound speed may also be found using the Target DBg Data screen available in the *UltraLink*™ software utility.

Fluid Viscosity

FLUID VI -- Absolute Viscosity the Fluid (Value in cP)

cP

Allows adjustments to be made to the absolute viscosity of the liquid.

If a fluid was chosen from the FL TYPE list, a nominal value for viscosity in that media will be automatically loaded. If the actual viscosity is known for the application fluid and that value varies from the automatically loaded value, the value can be revised.

If OTHER was chosen as FL TYPE, then a FLUID VI must also be entered. A list of alternate fluids and their associated viscosities is located in the Appendix of this manual.

Fluid Specific Gravity

SP GRVTY -- Fluid Specific Gravity Entry (Value)

Unitless

Allows adjustments to be made to the specific gravity (density) of the liquid.

If a fluid was chosen from the FL TYPE list, a nominal value for specific gravity in that media will be automatically loaded. If the actual specific gravity is known for the application fluid and that value varies from the automatically loaded value, the value can be revised.

If OTHER was chosen as FL TYPE, a SP GRVTY may need to be entered if mass flows are to be calculated. A list of alternate fluids and their associated specific gravities is located in the Appendix of this manual.

Fluid Specific Heat Capacity

SP HEAT -- Fluid Specific Heat Capacity (Value)
(only visible when RTD Module is activated)
Nominal Heat Capacity

Allows adjustments to be made to the specific heat capacity of the liquid.

If a fluid was chosen from the FL TYPE list, a default specific heat will be automatically loaded. This default value is displayed as SP HEAT in the BASIC MENU. If the actual specific heat of the liquid is known or it differs from the default value, the value can be revised. See **Tables 3.1, 3.2, 3.3 and 3.4** on pages 3.9 and 3.10 for specific values. Enter a value that is the mean of both pipes.

TABLE 3.1 — Specific Heat Capacity Values for Water

Temperature °F	Temperature °C	Specific Heat BTU/lb °F
32-212	0-100	1.00
250	121	1.02
300	149	1.03
350	177	1.05

TABLE 3.2 — Specific Heat Capacity Values for Ethylene Glycol/Water

Specific Heat Capacity BTU/lb °F								
Temperature		Ethylene Glycol Solution (% by Volume)						
°F	°C	25	30	40	50	60	65	100
-40	-40	n/a	n/a	n/a	n/a	0.68	0.70	n/a
0	-17.8	n/a	n/a	0.83	0.78	0.72	0.70	0.54
40	4.4	0.91	0.89	0.845	0.80	0.75	0.72	0.56
80	26.7	0.92	0.90	0.86	0.82	0.77	0.74	0.59
120	84.9	0.93	0.92	0.88	0.83	0.79	0.77	0.61
160	71.1	0.94	0.93	0.89	0.85	0.81	0.79	0.64
200	93.3	0.95	0.94	0.91	0.87	0.83	0.81	0.66
240	115.6	n/a	n/a	n/a	n/a	n/a	0.83	0.69

TABLE 3.3 — Specific Heat Capacity Values for Propylene Glycol/Water

Specific Heat Capacity BTU/lb °F Polypropylene Glycol Solution (% by Volume)						
0	10	20	30	40	50	60
1.00	0.98	0.96	0.94	0.90	0.85	0.81

TABLE 3.4 — Specific Heat Capacity Values for Other Common Fluids

Fluid	Temperature °F	Temperature °C	Specific Heat BTU/lb °F
Alcohol, ethyl	32	0	0.65
Alcohol, methyl	54	12	0.60
Brine	32	0	0.71
Brine	60	15	0.72
Sea Water	63	17	0.94

Transducer Spacing

XDCR SPAC -- Transducer Spacing Calculation (Value)

ENGLSH *(Inches)*
METRIC *(Millimeters)*

This value represents the one-dimensional linear measurement between the transducers (the upstream/downstream measurement that runs parallel to the pipe). This value is in inches if ENGLSH was selected as UNITS; in millimeters if METRIC was selected. This measurement is taken between the lines which are scribed into the side of the transducer blocks.

If the transducers are being mounted using the transducer track assembly, a measuring scale is etched into the track. Place one transducer at 0 and the other at the appropriate measurement.

Engineering Units RATE

RATE UNT -- Engineering Units for Flow Rate (Choice)

Gallons	*(GALLONS)*
Liters	*(LITERS)*
Millions of Gallons	*(MGAL)*
Cubic Feet	*(CUBIC FT)*
Cubic Meters	*(CUBIC ME)*
Acre Feet	*(ACRE FT)*
Oil Barrels [42 Gallons]	*(OIL BARR)*
Liquid Barrels [31.5 Gallons]	*(LIQ BARR)*
Feet	*(FEET)*
Meters	*(METERS)*
Pounds	*(LB)*
Kilograms	*(KG)*
British Thermal Units	*(BTU)*
Thousands of BTUs	*(MBTU)*
Millions of BTUs	*(MMBTU)*
Tons	*(TON)*

Select a desired engineering unit for flow rate measurements.

Engineering Units RATE INTERVAL

RATE INT -- Time Interval for Flow Rate (Choice)

Seconds	*(SEC)*
Minutes	*(MIN)*
Hour	*(HOUR)*
Day	*(DAY)*

Select a desired engineering unit for flow rate measurements.

Engineering Units TOTALIZER

TOTL UNT -- Engineering Units for Flow Totalizer (Choice)

Gallons	*(GALLONS)*
Liters	*(LITERS)*
Millions of Gallons	*(MGAL)*
Cubic Feet	*(CUBIC FT)*
Cubic Meters	*(CUBIC ME)*
Acre Feet	*(ACRE FT)*
Oil Barrels [42 Gallons]	*(OIL BARR)*

Liquid Barrels [31.5 Gallons]	*(LIQ BARR)*
Pounds	*(LB)*
Kilograms	*(KG)*
British Thermal Units	*(BTU)*
Thousands of BTUs	*(MBTU)*
Millions of BTUs	*(MMBTU)*
Tons	*(TON)*

Select a desired engineering unit for flow accumulator (totalizer) measurements.

Engineering Units TOTAL Exponent

TOTL E -- Flow Totalizer Exponent Value (Choice)

E-1 to E6

Utilized for setting the flow totalizer exponent. This feature is useful for accommodating a very large accumulated flow. The exponent is a $x10^n$ multiplier, where "n" can be from -1 (x0.1) to +6 (x1,000,000). **Table 3.5** should be referenced for valid entries and their influence on the TFXD display.

TABLE 3.5 — Totalizer Exponent Values

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

Minimum Flow Rate

MIN RATE -- Minimum Flow Rate Settings (Value)

Rate Unit/Rate Interval

A minimum volumetric flow rate setting is entered to establish filter software settings. Volumetric entries will be in the Engineering Rate Units and Interval selected on pages 3.9 and 3.10 of this manual. For unidirectional measurements, set MIN RATE to zero. For bi-directional measurements, set MIN RATE to the highest negative (reverse) flow rate expected in the piping system.

Maximum Flow Rate

MAX RATE -- Maximum Flow Rate Settings (Value)

Rate Unit/Rate Interval

A maximum volumetric flow rate setting is entered to establish filter software settings. Volumetric entries will be in the Engineering Rate Units and Interval selected on pages 3.9 and 3.10 of this manual. Set MAX RATE to the highest (positive) flow rate expected in the piping system.

Low Flow Cut-off

FL C-OFF -- Low Flow Cut-off (Value)

Percent of the range between MIN RATE and MAX RATE
Relative Percent Entry: 0-100%

A Low Flow Cut-off entry 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 RATE and MAX RATE.

System Damping

DAMP PER -- System Damping (Value)

Relative Percent Entry: 0-100%

Flow Filter Damping establishes a maximum adaptive filter value. Under stable flow conditions (flow varies less than 10% of reading) 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 10% window, the flow filter adapts by decreasing and allows the meter to react faster. Increasing this value tends to provide smoother steady-state flow readings and outputs. If very erratic flow conditions are present or expected, other, more advanced filters are available for use in the *UltraLink*™ software utility. See Part 4 of this manual for further information.

2. OUT1 MEN -- OUTPUT #1 MENU

OUT1 MEN -- OUTPUT #1 MENU (Choice)

4-20 mA Output	*(4-20MA)*
Rate	*(RATE)*
Relay	*(RELAY)*
Heat Flow	*(RTD)*
RS232C Communications	*(RS232)*
RS485 Communications	*(RS485)*
Data Logger	*(DATALOG)*
Power	*(PRWCOM)*

4-20 mA

ISO-MOD: 4-20 mA Output (Values)

Flow at 4 mA	*(FL 4MA)*
Flow at 20 mA	*(FL 20MA)*
4 mA Calibration	*(CAL 4MA)*
20 mA Calibration	*(CAL 20MA)*
4-20 mA Test	*(4-20 TST)*

Configured via jumper selections for either a passive or active transmission mode (see Section 2 for details), the 4-20 mA Output Module interfaces with virtually all recording and logging systems by transmitting an analog current signal that is proportional to system flow rate. Independent 4 mA and 20 mA span settings are established in software using the Flow Measuring Range entries. These entries can be set anywhere in the –40 to +40 FPS [-12 to +12 MPS] measuring range of the instrument. Output resolution of the module is 12-bits (4096 discrete points) and the module can drive up to 800 Ohms of load with its internal 24 V isolated power source.

4-20 mA Span

The FL 4MA and FL 20MA entries are used to set the span of the 4-20 mA analog output. These entries are volumetric rate units that are equal to the volumetric units configured as Engineering Rate Units and Engineering Units Time Interval discussed on pages 3.11 and 3.12.

For example, to span the 4-20 mA output from –100 GPM to +100 GPM, with 12 mA being 0 GPM, set the FL 4MA and FL 20MA inputs as follows:

FL 4MA = –100.0
FL 20MA = 100.0

For example, to span the 4-20 mA output from 0 GPM to +100 GPM, with 12 mA being 50 GPM, set the FL 4MA and FL 20MA inputs as follows:

FL 4MA = 0.0
FL 20MA = 100.0

4-20mA Calibration

The 4-20 mA ISO-MOD is factory calibrated and should not require adjustment unless it is replaced.

The CAL 4MA entry allows fine adjustments to be made to the "zero" of the 4-20 mA output. To adjust the 4 mA output, an ammeter or reliable reference connection to the 4-20 mA output must be present.

NOTE: The CAL 4MA and CAL 20MA entries should not be used in an attempt to set the 4-20 mA range. Utilize FL 4MA and FL 20MA, detailed above, for this purpose.

Procedure:

1. Disconnect one side of the current loop and connect the ammeter in series (disconnect either wire at the terminals labeled +/- on the ISO-MOD 4-20 mA Module).
2. Using the arrow keys, increase the numerical value to increase the current in the loop to 4 mA. Decrease the value to decrease the current in the loop to 4 mA. Typical values range between 40-80 counts.

Reconnect the 4-20 mA output circuitry as required.

Calibration of the 20 mA setting is conducted much the same way as the 4 mA adjustments.

Procedure:

1. Disconnect one side of the current loop and connect the ammeter in series (disconnect either wire at the terminals labeled +/- on the ISO-MOD 4-20 mA Module).
2. Using the arrow keys, increase the numerical value to increase the current in the loop to 20 mA. Decrease the value to decrease the current in the loop to 20 mA. Typical values range between 3700-3900 counts.

Reconnect the 4-20mA output circuitry as required.

4-20mA Test

4-20 TST - 4-20mA Output Test

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

Rate Pulse

ISO-MOD: RATE PULSE (Value)

Flow at 0 Hz (*FL 0H)*
Flow at 2.5k Hz *(FL 25KH)*

The Rate Pulse Output Module is utilized to transmit information to external counters and PID systems via a frequency output that is proportional to system flow rate. Independent Zero and Span settings are established in software using the Flow Measuring Range entries. Output resolution of the module is 12-bits (4096 discrete points) and the maximum output frequency setting is 2,500 Hz. The module has two output modes, turbine meter simulation and “open collector”. The turbine meter simulation sources a non-ground referenced saw-tooth waveform with a maximum amplitude of approximately 500 mV p-p. The open collector output utilizes a 0.21 Ohm FET output that is rated to operate at 100 V and 1 A maximum. If the open collector output is utilized, an external voltage source and limit resistor must be present. See Part 1 of this manual for connection information.

Rate Pulse Span

The FL 0H and FL 25KH entries are used to set the span of the 0 to 2.5k Hz frequency output. These entries are volumetric rate units that are equal to the volumetric units configured as Engineering Rate Units and Engineering Units Time Interval entered on pages 3.11 and 3.12 of this manual.

For example, in a bi-directional system, to span the 0 to 2.5k Hz output from –100 GPM to +100 GPM, with 1.25k Hz being 0 GPM, set the FL 100H and FL 10KH inputs as follows:

FL 0H = –100.0
FL 25KH = 100.0

For example, to span the 0 to 2.5k Hz output from 0 GPM to +100 GPM, with 1.25k Hz being 50 GPM, set the FL 0H and FL 25KH inputs as follows:

FL 0H = 0.0
FL 25KH = 100.0

Dual Relay

ISO-MOD: Dual Relay (Choices and Values)

RELAY 1 AND RELAY 2

None	*(NONE)*
Totalizer	*(TOTALIZE)*
Totalizer Multiplier	*(TOT MULT)*
Flow	*(FLOW)*
On Setting	*(ON)*
Off Setting	*(OFF)*
Signal Strength Setting	*(SIG STR)*
Errors	*(ERRORS)*

Two independent SPDT (single-pole, double-throw) Form C relays are contained in this module. The relay operations are user configured via software to act in either a flow rate alarm, signal strength alarm, error alarm or totalizer/batching mode. The relays are rated for 200 Vac maximum and a have current rating of 0.5 A resistive load [175 Vdc @ 0.25 A resistive]. It is highly recommended that a secondary relay be utilized whenever the Control Relay ISO-MOD is used to control inductive loads such as solenoids and motors.

Batch/Totalizer Relay

TOTALIZE mode configures the relay to output a 50 mSec pulse (contact changeover) 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 is set to E0 (x1) and the Relay Multiplier is set to 1, then the relay will pulse each time the totalizer increments one count, or each single, whole measurement unit totalized.

If the Totalizer Exponent is set to E2 (x100) and the Relay Multiplier is set to 1, then the relay will pulse each time the display totalizer increments or once per 100 measurement units totalized.

If the Totalizer Exponent is set to E0 (x1) and the Relay Multiplier is set to 2, the relay will pulse once for every two counts that the totalizer increments.

Flow Rate Relay

Flow Rate Relay configuration permits relay changeover at two separate flow rates allowing operation with an adjustable switch deadband. **Figure 3.1** illustrates how the setting of the two set points influences rate alarm operation.

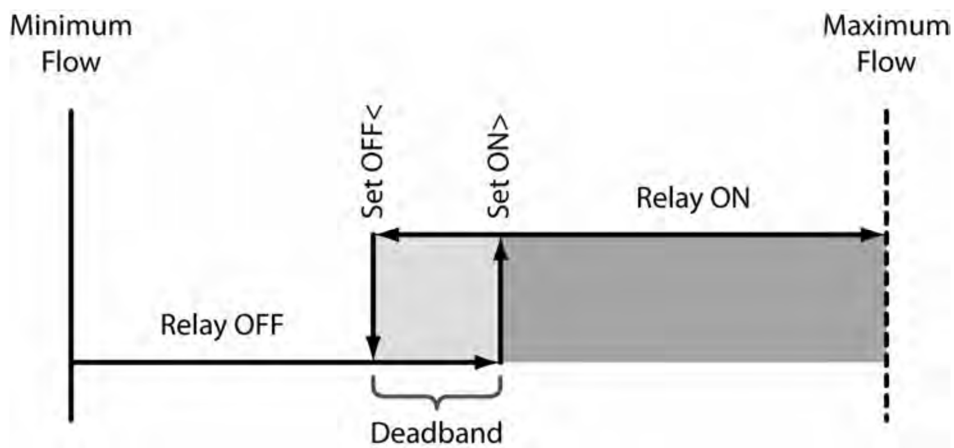


Figure 3.1
Single Point Alarm Operation

A single-point flow rate alarm would place the ON> setting slightly higher than the OFF< setting – allowing a switch deadband to be established. If a deadband is not established, switch chatter (rapid switching) may result if the flow rate is very close to the switch point.

Signal Strength Alarm

The SIG STR alarm will provide an indication that the flow meter signals between the transducers have fallen to a point where flow measurements may not be possible. It can also be used to indicate that the pipe has emptied. Like the Flow Rate alarm described above, the Signal Strength alarm requires that two points be entered, establishing an alarm deadband. A valid switch point exists when the ON> is a value lower than OFF<. If a deadband is not established and the signal strength decreases to approximately the value of the switch point, the relay may chatter.

Error Alarm Relay

When a relay is set to ERROR mode, the relay will activate when any error occurs in the flow meter that has caused the meter to stop measuring reliably. See the Appendix of this manual for a list of potential error codes.

Heat Flow Module

ISO-MOD: RTD (Value)

Calibration
Value for:

RTD1 A	*(RTD1 A)*
RTD1 B	*(RTD1 B)*
RTD2 A	*(RTD2 A)*
RTD2 B	(RTD2 B)

Inputs from one or two 1000 Ohm RTD temperature sensors allows measurements of heat flow (one RTD) or heat usage (two RTDs).

The values used to calibrate the RTD temperature sensors are derived in the laboratory and are specific to a specific RTD. The RTDs on new units come already attached to the RTD Module and should not be changed.

Field replacement of RTDs without ISO module replacement is possible using *UltraLink*™. See Part 4.

RS232C Module

ISO-MOD: RS232C (Choice)

Baud Rate	*(RS232 BA)*
1200 Baud	*(1200)*
2400 Baud	*(2400)*
9600 Baud	*(9600)*
19,200 Baud	*(19200)*

The RS232C Module can be interfaced with serial communication ports of PCs, PLCs and SCADA systems. This module runs a proprietary digital protocol, detailed in the Appendix of this manual, that is used to monitor flow rate information in piping systems. The RS232C Module may also be used to form a hardwire connection to a PC that is running the *UltraLink*™ software utility. Baud rates up to 19.2k are supported.

RS485 Module

ISO-MOD: RS485 (Choices and Values)

RS485 Mode	*(RS485 MO)*
Slave	*(SLAVE)*
Master	*(MASTER)*
Baud Rate	*(RS485 BA)*
1200 Baud	*(1200)*
2400 Baud	*(2400)*
9600 Baud	*(9600)*
19,200 Baud	*(19200)*
Device Address	*(1-127)*

The RS485 Module allows up to 126 TFX systems to be daisy-chained on a single three-wire cable network. Communications are through a proprietary digital protocol, detailed in the Appendix of this manual. All meters are assigned a unique one byte serial number that allows all of the meters on the cable network to be accessed independently. Baud rates up to 19.2k and cable lengths to 5,000 feet [1,500 meters] are supported without the need for repeaters.

RS485 MO

Select SLAVE for all of the TFXD meters connected to the unit designated as MASTER.

RS485 BA

Select a Baud rate that is compatible with the operating system.

ADDRESS

Each TFX connected on the communications bus must have an unique address number assigned. Address 127 is a universal address that will result in all TFX instruments on the network responding simultaneously – regardless of address – resulting in CRC errors. Only select address location 127 if one meter is on the network.

Data Logger

ISO-MOD: DATALOGGER (Value)

LOGGING INTERVAL

From the OUTPUT 1 menu, select the time INTERVAL between readings. INTERVAL values between 1 and 30,000 seconds are acceptable.

For reference there are:

60 seconds in 1 minute
300 seconds in 5 minutes
1,800 seconds in 30 minutes
3,600 seconds in 1 hour
30,000 seconds in 8.33 hours

Table 3.6 describes some typical configurations of the INTERVAL and DURATION times with what the expected data samples collected count will be.

Table 3.6 — Interval and Duration Times

Example No.	INTERVAL Seconds	DURATION Hours Operated	Samples Collected
1	1	24 (1 day)	86,400
2	10	168 (7 days)	60,480
3	60 (1min)	720 (30 days)	43,200
4	300 (5 min)	8,760 (1 yr)	105,120
5	1,800 (30 min)	8,760 (1 yr)	17,520
6	3,600 (1 hr)	8,760 (1 yr)	8,760
7	18,000 (5 hr)	26,280 (3 yr)	17,520

3. **OUT2 MEN** -- OUTPUT #2 MENU

The I/O configurations for OUT2 MEN are identical to those detailed in OUT1 MEN.

4. **SEN MENU** -- SENSOR MENU

The SEN MENU is utilized to select the type of transducer that will be interfaced with the TFXD. Select the appropriate transducer from the list and save the configuration. If the transducer selection is modified, a system reset is required.

5. **SEC MENU** -- SECURITY MENU

The SEC MENU allows the user to make password revisions, reset the flow totalizer and reset the transmitter microprocessor.

Totalizer RESET

TOT RES

NO
YES

Select YES to reset all flow totalizers/accumulators to zero.

System RESET

SYS RSET

NO
YES

Select YES to initiate a microprocessor reset.

NOTE: All system configurations and totalizer values will be retained.

Change Password

CH PSWD? -- Change the Security Password

0-9999

By changing the Security Password from 0 to some other value (any value between 1 to 9999), configuration parameters will not be accessible without first entering that value when prompted. If the value is left at 0, no security is invoked and unauthorized changes could be made.

6. SER MENU -- SERVICE MENU

The SER MENU makes available two different system measurements that are used for troubleshooting and fine tuning of the instrument. Actual liquid sound speed and system signal strength readings can be accessed through this menu.

The SERVICE Menu also has features that allow adjustment of Signal Strength Cutoff, Error-Mode outputs, Zero Flow Rate Set and entry of a universal correction factor.

Liquid Sound Speed

SSPD MPS -- Sound Speed in the Liquid Metric
SSPD FPS -- Sound Speed in the Liquid U.S.

The TFXD performs an actual speed of sound calculation for the liquid it is measuring. This speed of sound calculation will vary with temperature, pressure and fluid composition.

The value indicated in SSPD measurement should be within 10% of the value entered/indicated in the BASIC menu item FLUID SS. (The SSPD value itself cannot be edited.) If the actual measured value is significantly different (>±10%) than the BASIC menu's FLUID SS value, it typically indicates a problem with the instrument setup. An entry such as Fluid Type, PIPE O.D. or wall thickness may be in error, the pipe may not be round, or the transducer spacing is not correct.

Table 3.7 on page 3.24 lists sound speed values for water at varying temperatures. If the TFXD is measuring sound speed within 2% of the table values, then the installation and setup of the instrument is correct.

Signal Strength

SIG STR -- Signal Strength

The measurement of signal strength assists service personnel in troubleshooting the TFX system. In general, expect the signal strength readings to be greater than 2% on a full pipe with the transducers properly mounted. Signal strength readings that are less than 2% may indicate a need to choose an alternative mounting method for the transducers, or that an improper pipe size has been entered.

TABLE 3.7 — Sound Speed in Liquid Water Vs. Temperature

Deg. C	Deg. F	Vs (m/s)	Vs (f/s)
0	32	1402	4600
10	50	1447	4747
20	68	1482	4862
30	86	1509	4951
40	104	1529	5016
50	122	1543	5062
60	140	1551	5089
70	158	1555	5102
80	176	1554	5098
90	194	1550	5085
100	212	1543	5062
110	230	1532	5026
120	248	1519	4984
130	266	1503	4931
140	284	1485	4872
150	302	1466	4810
160	320	1440	4724
170	338	1412	4633
180	356	1390	4560
190	374	1360	4462
200	392	1333	4373
220	428	1268	4160
240	464	1192	3911
260	500	1110	3642

Signal strength below the Low Signal Cutoff value will generate an Error 0010 (Low Signal Strength) and require either a change in the Low Signal Cutoff value or transducer mounting changes.

Signal strength readings in excess of 195% may indicate that a mounting method with a longer path length may be required. For example, if transducers mounted on a 3 inch PVC pipe in V-Mount cause the measured signal strength value to exceed 195%, change the mounting method to W-Mount for greater stability in readings.

Because signal strength is not an “absolute” indication of how well a TFX meter is functioning, there is no real advantage to signal strength of say 50% over a signal strength of 10%.

Temperature Values

TEMP 1 -- Temperature Read for RTD1
TEMP 2 -- Temperature Read for RTD2
TEMPDIFF -- Absolute Temperature Difference
(only visible if the RTD Module is activated)

Three values can be displayed that may aid in troubleshooting the heat flow instrument. In this menu, the temperature being read by RTD1 is indicated as TEMP1 (all values are degrees Celsius), RTD2 as TEMP2 and the absolute difference as TEMPDIFF.

If an RTD is replaced or if the RTD cable length was significantly altered from the factory supplied length, it may be necessary to adjust the RTD “Offset” value. This adjustment can be made from the TFX keypad or via the *UltraLink*™ software utility. It is typically not required to conduct a complete RTD module calibration unless calibration values entered into the TFX have been significantly altered, lost or the ISO-MOD has been changed with another TFX and calibration values have been lost. If values have been lost for a particular TFX flow meter, contact the Dynasonics factory, tell technical support the serial number for the flow meter and factory calibration values can be supplied.

Use the following procedure to calibrate the RTD:

1. Remove the RTD from the piping system.
2. Press the MENU key and then press the arrow keys to view SER MENU, press ENTER. Press the arrow keys until TEMP 1 (supply line) or TEMP 2 (return line) are visible on the lower line of the TFX display.
3. Place the RTD into an ice bath (a quart/liter of water with 50% ice cubes). After 2 minutes, record the temperature displayed on the TFX display. If the display reads within 0.2 degrees of zero, no further adjustments are required.
4. If adjustment is required, press the MENU key, press the arrow keys until OUT1 MEN is displayed, press ENTER. Press the arrow keys until RTD1 B (for the supply line) or RTD2 B (for the return line) is displayed. Press the ENTER key and subtract the value recorded in Step 3 from the displayed “B” value. Press the ENTER key to store.
5. Press the MENU key twice and SAVE the value.
6. Repeat for the other RTD.

Signal Strength Cutoff

SIG C-OF -- Signal Strength Cutoff

Signal Strength Cutoff (SIG C-OF) is used to drive the flow meter and its outputs to the SUB FLOW (Substitute Flow – described below) state if conditions occur that cause low signal strength. A signal strength indication below 2% is inadequate for measuring flow reliably, so minimum setting for SIG C-OF is 2%. A good practice is to set the SIG C-OF at approximately 60-70% of actual measured signal strength (described above).

NOTE: The factory default "Signal Strength Cutoff" is 5%.

If the measured signal strength is lower than the SIG C-OF setting, an ERROR 0010 will be displayed on the TFXD display until the measured signal strength becomes greater than the cutoff value.

Signal strength indication below 0.8 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 Entry

SUB FLOW -- Substitute Flow

Substitute Flow or SUB 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.

TABLE 3.8 lists some typical settings to achieve "Zero" with respect to MIN and MAX FLOW settings.

TABLE 3.8 — Substitute Flow Entry

MIN RATE SETTING	MAX RATE SETTING	SUB FLOW SETTING	DISPLAY READING DURING ERRORS
0.0	1,000.0	0.0	0.000
-500.0	500.00	50.0	0.000
-100.0	200.0	33.3	0.000
0.0	1,000.0	-5.0*	-50.00

**UltraLink*™ is required to set values outside of 0.0-100.0.

Setting/ Calibrating Zero Flow

SET ZERO -- Calibrating Zero Flow

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 meter:

1. The pipe must be full of liquid.
2. Flow must be absolute zero – securely close any valves and allow time for any settling to occur.
3. Press ENTER, use the arrow keys to make the display read YES.
4. Press ENTER.

The procedure is complete.

Factory Default Zero Calibration

D-FLT 0 -- Reverting to Factory Default Zero

If the flow in a piping system cannot be shut off, allowing the SET ZERO procedure described above to be performed, then the factory default zero should be utilized. To utilize the D-FLT 0 function, simply press ENTER, then press an ARROW key to display YES on the display and then press ENTER. This function can also be utilized to correct an inadvertently entered or erroneous SET ZERO entry.

Correction Factor

COR FTR -- Universal Correction Factor

This function can be used to make the TFXD system agree with a different or reference flow meter by applying a correction factor/ multiplier to the readings and outputs. A factory calibrated system should be set to 1.000. The range of settings for this entry is 0.500 to 1.500. The following examples describe two uses for the COR FTR entry.

- The TFXD meter is indicating a flow rate that is 4% higher than another flow meter located in the same pipe line. To make the TFXD indicate the same flow rate as the other meter, enter a COR FTR of 0.960 to lower the readings by 4%.
- An out-of-round pipe, carrying water, causes the TFXD to indicate a measured sound speed that is 7.4% lower than the value in **TABLE 3.6** on page 3.21. This pipe condition will cause the flow meter to indicate flow rates that are 7.4% lower than actual flow. To correct the flow readings, enter 1.074.

7. **DSP MENU** -- DISPLAY MENU

Flow Display Mode

T/R SCAN -- Totalizer and Rate Display Scan

FLOW
TOTAL
BOTH

The TFXD will only display flow rate with the DISPLAY set to FLOW – it will not display the TOTAL FLOW. TFXD will only display the total flow with the DISPLAY set to TOTAL – it will not display the flow rate. By selecting BOTH, the display will scan between RATE and TOTAL at the interval selected in SCN DWL (see below).

Totalizer Display Mode

TOTAL -- Totalizer Mode

NET
POS
NEG
BATCH

Select POS to only view the positive direction totalizer. Select NEG to only view the negative direction totalizer. Select the BATCH totalizer to configure the totalizer to count up to a value that is entered as BTCH MUL (described below). After reaching the BTCH MUL value, the display will return to zero and will repeat counting to the BTCH MUL value. Select NET to display the net difference between the positive direction and negative direction totalizers.

Rate/Total Scan Time

SCN DWL -- Display Scan Dwell Time

1-10 Seconds

Adjustment of SCN DWL sets the time interval that the display will dwell at RATE and then alternately TOTAL values. This adjustment range is from 1 second to 10 seconds.

Display Batch Quantity

BTCH MUL -- Totalizer Batch Quantity

If BATCH was chosen for the totalizer mode, a value for batch accumulation must be entered. This is the value to which the totalizer will accumulate before resetting to zero and repeating the accumulation. This value includes any exponents that were entered in the BASIC menu as TOTAL E. For example:

- If BTCH MUL is set to **1,000**, RATE UNT to **LITERS** and TOTL E to **E0** (liters x1), then the BATCH totalizer will accumulate to 1,000 liters, return to zero and repeat indefinitely. The totalizer will increment 1 count for every 1 liter that has passed.
- If BTCH MUL is set to **1,000**, RATE UNT to **LITERS** and TOTL E to **E2** (liters x100), then the BATCH totalizer will accumulate to 100,000 liters, return to zero and repeat indefinitely. The totalizer will only increment 1 count for every 100 liters that has passed.

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PART 4 - SOFTWARE UTILITIES

Important Notice!

The TFX flow meter is available with a software utility called ***UltraLink*™**. The *UltraLink*™ utility is used for configuration, calibration and communication with the TFX flow meter.

UltraLink™ has been designed to provide the TFX user with a powerful and convenient way to configure and calibrate all TFX flow meters. A PC running *UltraLink*™ can be hardwired to a TFX flow meter through an RS232 or RS485 module or, more commonly, the communications link is through an infrared communicator. The infrared communicator is available from Dynasonics as part number D005-2115-001. If the infrared communicator is to interface with a USB port on a PC, a USB-to-DB-9 interface adapter is required (Dynasonics part number D005-2116-004).

System Requirements

PC-type computer, running Windows® 95/98/2000/XP operating system, a communications port (USB ports require a USB-to-DB-9 adapter, Dynasonics p/n D005-2116-004), a hard disk.

Installation

1. ***UltraLink*™** can be found on the Dynasonics website for no charge or a CD can be purchased by contacting Dynasonics sales.
2. Backup/Copy all files from the website link to a folder on the computer hard disk.
3. From the "Start" command, RUN **UlSetup.exe** from the hard disk folder.
4. **UlSetup** will automatically extract and install on the hard disk and place a short-cut icon on the desktop.
5. Most PCs will require a restart after a successful installation.

Initialization

1. Connect communications cable, Dynasonics p/n D005-2115-001, to a PC communication port and point the communicator at the TFX infrared window, located in the lower right-hand corner of the meter front panel. Alternately, connect the PC communications port directly to an optionally installed RS232C or RS485 module located within the TFX flow meter.
2. Double-click on the *UltraLink*™ icon. The first screen is the "RUN-mode" screen (see **Figure 4.1**), which contains real-time information regarding flow rate, totalizer accumulation, system signal strength, diagnostic data and the flow meter's serial number. The indicator in the lower right-hand corner will indicate communications status. If a red **ERROR** is indicated, click on the Communications button on the top bar. Click on **Communications/Initialize**. Choose the appropriate COM port and interface type. Proper communications are established when a green **OK** is indicated in the lower right-hand corner of the PC display.

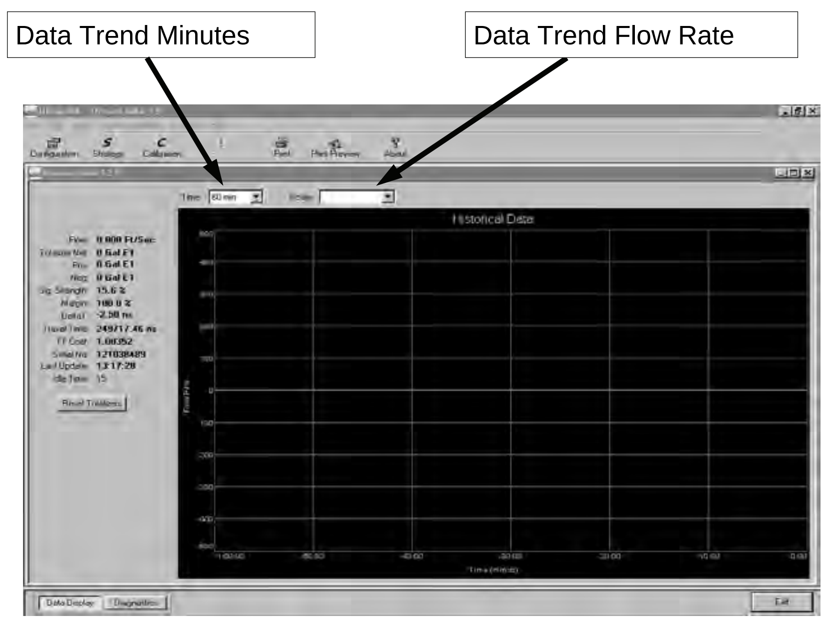


Figure 4.1
***UltraLink*™ Data Screen**

Pipe and Liquid Configuration

Click on the button labeled **Configuration** for updating flow range, liquid, pipe and I/O operating information. The first screen that appears after clicking the **Configuration** button is the **BASIC** tab. See **Figure 4.2**.

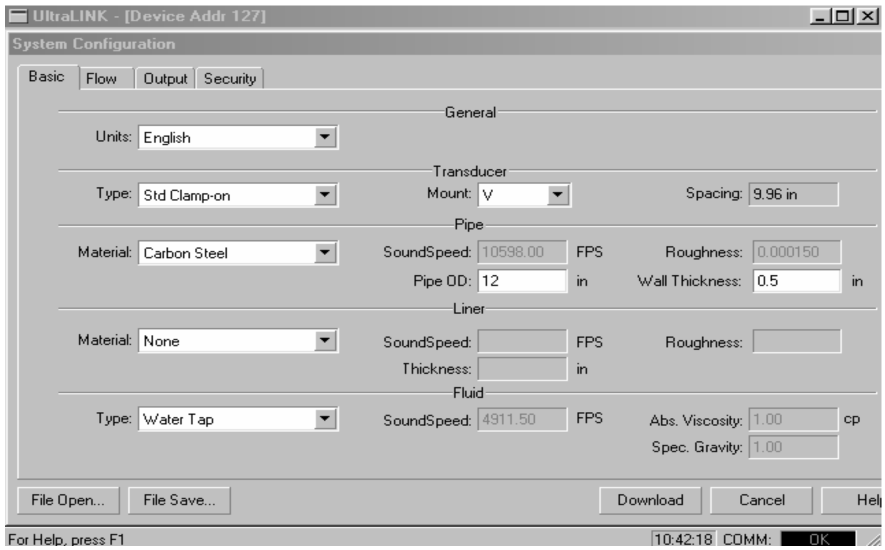


Figure 4.2
Basic Tab

1. **BASIC** TAB - see **Figure 4.2**

- **General Units** allows selection of either English (U.S.) or Metric units of measure. If measurements of the pipe are to be entered in inches, select English. If pipe measurements are to be entered in millimeters, select Metric. If the General Units are altered from those at instrument startup, then click on the Download button on the lower right-hand portion of the screen and recycle power to the TFX.
- **Transducer Type** selects the transducer that will be connected to the TFX flow meter. Select from DTTN, DTTH, DTTS or DT15 models. This selection will influence transducer spacing and flow meter performance. If you are unsure about the type of transducer to which the TFX will be connected, consult the shipment packing list or call the Dynasonics factory for assistance. A change of Transducer Type will cause a System Configuration Error 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** on page 2.5 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.
- **Transducer Spacing** is a value calculated by the TFX flow meter 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 mm for Metric. This value is the lineal distance that must be between the transducer centers.
- **Pipe Material** is selected from the pull-down list. If the pipe material utilized is not located on the list, select Other and enter pipe material sound speed (much of this information is available at websites such as www.ultrasonic.com) and relative roughness (rms internal surface regularities/the pipe internal diameter) of the pipe.
- **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.
- **Liner Material** is selected from the pull-down list. If the pipe liner material utilized is not located on the list, select Other and enter liner material sound speed (much of this information is available at websites such as www.ultrasonic.com) and relative roughness (rms internal surface regularities/the pipe internal diameter) of the pipe liner.
- **Fluid Type** is selected from a pull-down list. If the liquid is not located on the list, select Other and enter the liquid sound speed and viscosity into the appropriate boxes. Liquid Specific Gravity is required if mass measurements are to be made, and Specific Heat is required for energy measurements.

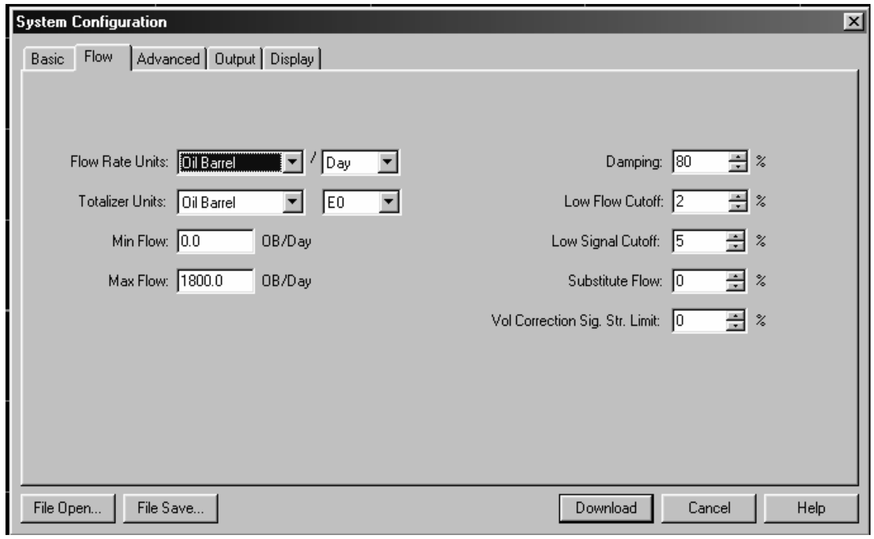


Figure 4.3
Flow Tab

Flow Units Configuration

2. **FLOW** TAB - see **Figure 4.3**

- **Flow Rate Units** are selected from the pull-down lists. Select an appropriate rate unit and time from the two lists.
- **Totalizer Units** are selected from pull-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 4.1** on page 4.6 illustrates the Scientific Notation values and their respective decimal equivalents.
- **MIN Flow** is used by the TFX to establish filter settings in its operating system. Enter a flow rate that is the minimum flow rate anticipated within the system. For unidirectional systems, this value is typically zero. For bi-directional systems this value is set to a negative number that is equal to the maximum negative flow rate that is anticipated within the system.
- **MAX Flow** is used by the TFX to establish filter settings in its operating system. Enter a flow rate that is the maximum, positive flow rate anticipated within the system.
- 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.

TABLE 4.1 — Totalizer Exponent Values

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

- **Low Flow Cutoff** is entered as a percentage between MAX Flow and MIN Flow and influences how the flow meter will act at flows very close to zero. Generally, an entry of 1% provides for a stable zero indication, while providing a 100:1 turndown ratio for measurements.
- **Low Signal Cutoff** is a relative value that should be entered after a successful flow meter startup. For an initial value, enter 5% (Signal Strength indications below 2% are considered to be below the noise ceiling and should not be indicative of a successful flow meter startup). The entry has three purposes: It provides an error indication – Low Signal Strength (Error 0010 on the TFX display) when liquid conditions within the pipe have changed to the point where flow measurements may not be possible. It warns if the pipe's liquid level has fallen below the level of the transducers. It can also signal that something with the flow meter installation or configuration may have changed. For example, the couplant used to mount the transducer has become compromised, a cable has become disconnected or a pipe size setting has been altered.
- **Substitute Flow** is used to provide an indication and output that signifies that an error exists with the flow meter or its setup. It 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 bi-directional 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 bi-directional system, perform the following operation:

$$\text{Substitute Flow} = 100 - \left(\frac{100 \times \text{MAX Flow}}{\text{MAX Flow} - \text{MIN Flow}} \right)$$

Downloading the Configuration

- 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 TFX instrument.

Meter Filter Configuration

3. **ADVANCED** TAB - see **Figure 4.4**

The Advanced tab contains several filter settings for the TFX flow meter. These filters can be adjusted to match response times and data “smoothing” performance to a particular application. The factory settings are suitable for most installations.

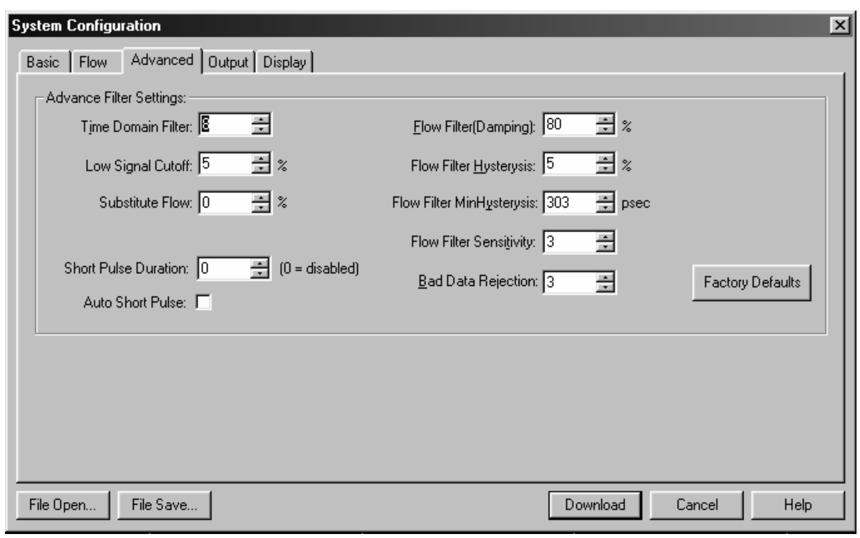


Figure 4.4
Advanced Tab

- **Time Domain Filter** adjusts the number of raw data sets (the wave forms viewed on the *UltraLink*™ 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. This filter is not adaptive – it is operational to the value set at all times.
- **Low Signal Cutoff** is a duplicate entry from page 4.6. Adjusting this value adjusts the value on the Flow TAB.
- **Substitute Flow** is a duplicate entry from page 4.6. Adjusting this value adjusts the value on the Flow TAB.
- **Short Pulse Duration** is a function used on pipes larger than 8 inches [200 mm]. If the pipe has an outer diameter of 8 inches or more, make sure that the Auto Short Pulse box is checked. Set this value to zero to disable the function.
- **Flow Filter Damping** establishes a <u>maximum</u> 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 Flow Filter adapts by decreasing and allows the meter to react faster. 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 whereby if the flow varies within that window, greater **Flow Filter Damping** will occur. The filter also establishes a flow rate window where measurements outside of the window are captured by the **Bad Data Rejection Filter**. The value is entered as a percentage of actual flow rate.

  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 entry is entered in picoseconds 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** and **Flow Filter MinHysteresis** windows before the flow meter will use that flow value. Larger values are entered into the 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 Configuration

4. **OUTPUT** TAB - see **Figure 4.5**

The entries made in the Output tab establish input and output calibration and ranges for ISO-MOD modules installed in the TFX flow meter. If a module was ordered from and installed at the Dynasonics factory, then the Output tab will contain information and configuration for that module. If a module is to be installed in the

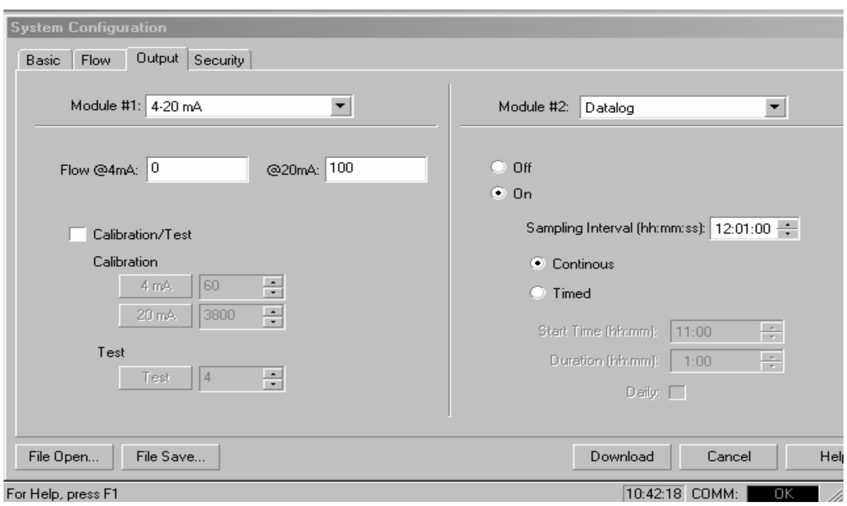


Figure 4.5
Output Tab

field, place the module into either Module #1 or Module #2 position and secure with screws. Select the appropriate module from the pull-down menu and press the Download button. If a module has been changed from the factory setting, a Configuration error will result. This error will be cleared by resetting the TFX microprocessor from the Communications/Commands/Reset Target button or by cycling power on the TFX flow meter. Once the proper output modules are selected and the microprocessor is reset, calibration and configuration of the modules can be completed. If a module slot is empty in the TFX enclosure, select NONE as the module type.

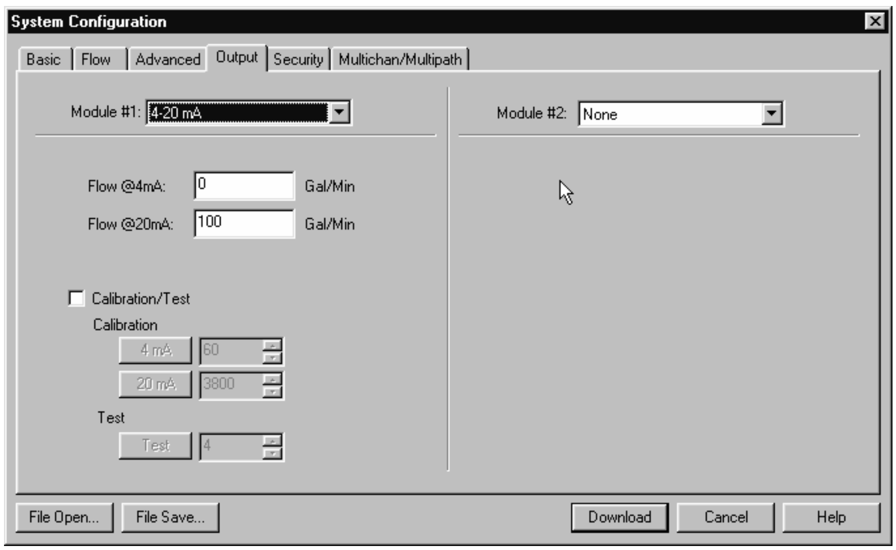


Figure 4.6
4-20mA Configuration

4-20 mA Module Configuration

If the 4-20 mA output has been installed, the screen shown in **Figure 4.6** will appear in *UltraLink*™ at the OUTPUT tab:

- **Flow @4mA** and **Flow @20mA** set the span of the 4-20 mA output. The entry is made in the same flow measurement units that were entered in the Flow tab. The output can be set to span across zero (4 mA can be set to a negative flow value) so that the module will output bi-directional flow. For example, if a flow range spans from –100 to +100, the TFX will output 4 mA at –100 and 20 mA at +100 and output 12 mA (50% of the output) at 0.

- **Calibration/Test** is used to adjust the factory calibration span of the 4-20 mA output and to test (simulate) the output. The 4-20 mA output is factory calibrated and should not require adjustment in the field. Should the module be replaced or if recalibration is required, the following procedure is used to calibrate the span of the module:

  1. Connect a milliamp meter serially within the 4-20 mA module output.
  2. Check the Calibration/Test box.
  3. Select the 4 mA Calibration box.
  4. Adjust the count value to the right of the 4 mA button until the milliamp meter registers 4.00 mA.
  5. Select the 20 mA Calibration box.
  6. Adjust the count value to the right of the 20 mA button until the milliamp meter registers 20.00 mA.
  7. Press the Test button.
  8. Adjust the count value to 12.
  9. Verify that the milliamp meter registers 12.00 mA.
  10. Uncheck the Calibration/Test box.

Relay Module Configuration

If the Dual Relay output has been installed into the TFX flow meter, the screen shown in **Figure 4.7** on page 4.12 will appear in *UltraLink*™ at the OUTPUT tab. Each relay can be configured separately for one of four operations: Batch/Totalizer, Flow Rate, Signal Strength or Error.

- **Batch/Total** mode configures the relay to output a 50 mSec pulse (contact changeover) each time the display totalizer increments divided by the Multiplier. The Multiplier value must be a whole, positive, numerical value.

  For example, if the Totalizer Exponent is set to E0 (x1) and the Relay Multiplier is set to 1, then the relay will pulse each time the totalizer increments one count, or each single, whole measurement unit totalized.

  If the Totalizer Exponent is set to E2 (x100) and the Relay Multiplier is set to 1, the relay will pulse each time the display totalizer increments or once per 100 measurement units totalized.

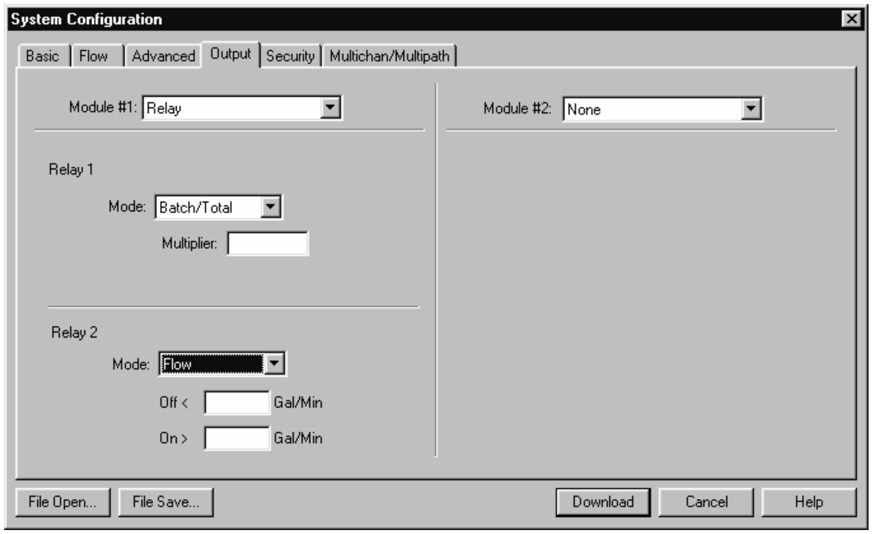


Figure 4.7
Dual Relay Configuration

If the Totalizer Exponent is set to E0 (x1) and the Relay Multiplier is set to 2, the relay will pulse once for every two counts that the totalizer increments.

- **Flow Rate Relay** configuration permits relay changeover at two separate flow rates allowing operation with an adjustable switch deadband. **Figure 4.8** on page 4.13 illustrates how the setting of the two set points influences Rate Alarm operation.

  A single-point flow rate alarm utilizes the ON> setting slightly higher than the OFF< setting – allowing a switch deadband to be established. If a deadband is not established, switch chatter (rapid switching) may result if the flow rate is very close to the switch point.

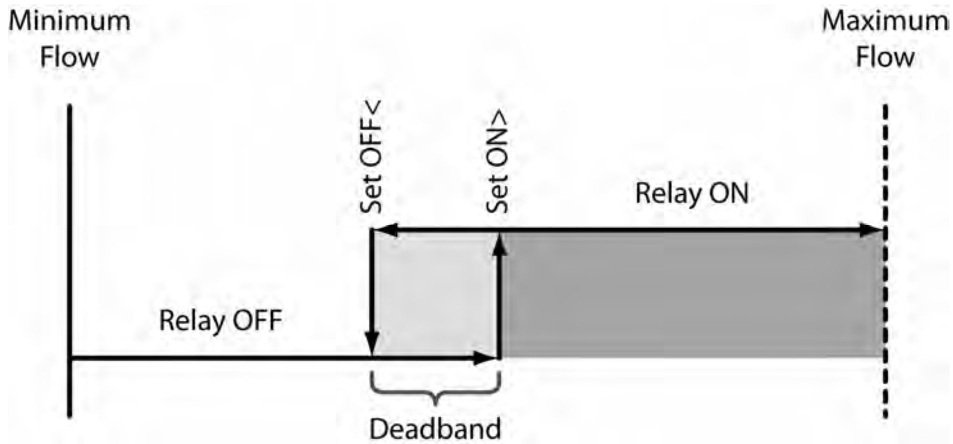


Figure 4.8
Single-point Alarm Operation

- The **Signal Strength** alarm will provide an indication that the flow meter signals between the transducers have fallen to a point where flow measurements may not be possible. It can also be used to indicated that the pipe has emptied. Like the Flow Rate alarm described above, the Signal Strength alarm requires that two points be entered, establishing an alarm deadband. A valid switch point exists when the ON> is a value lower than OFF<. If a deadband is not established and the signal strength decreases to approximately the value of the switch point, the relay may chatter.
- **Error Alarm** will cause contact changeover whenever an error is displayed on the TFX flow meter. See the Appendix of this manual for a listing of potential error codes.

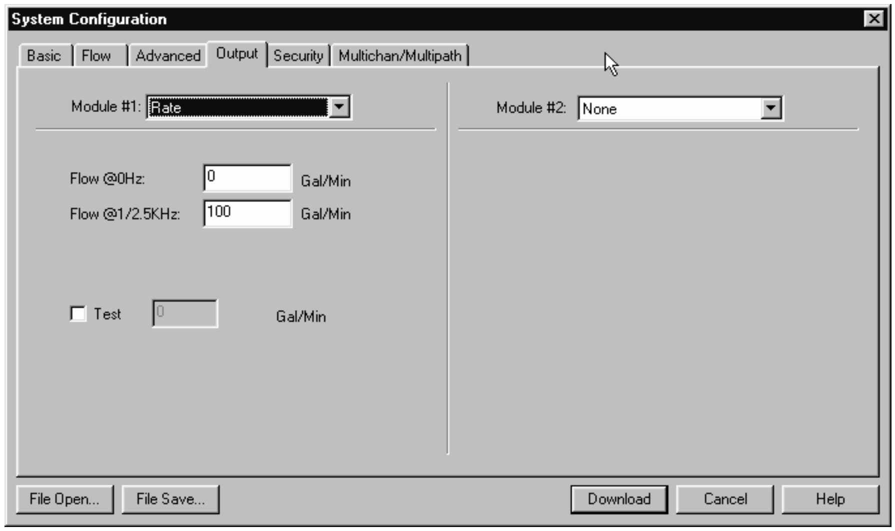


Figure 4.9
Rate Pulse Configuration

Rate Pulse Module Configuration

The Rate Module is utilized to transmit information to external counters and PID systems via a frequency output that is proportional to flow rate. The standard output of the module is 0-2,500 Hz, which corresponds to the flow rate span entered by the user. The Rate module configuration screen is shown in **Figure 4.9**.

- **Flow @0Hz** and **Flow @1/2.5KHz** set the span of the Rate pulse output. The entry is made in the same flow measurement units that were entered in the Flow Tab. The output can be set to span across zero (0 Hz can be set to a negative flow value) so that bi-directional flow can be output from the module. For example, if a flow rate range spans from –100 to +100, the TFX will output 0 Hz at –100 and 2,500 Hz at +100 and output 1,250 Hz (50% of the output) at 0.
- **Test** allows the user to output/simulate a particular output by entering a flow rate in the Test box. To have the TFX output a particular pulse frequency, select the Test box and enter a flow rate into the Test box. The TFX will output a pulse train at a frequency that is equal to the flow rate indicated in the test box. After testing is complete, unselect the Test box.

Heat Flow Module Configuration

If an RTD Module is replaced and calibration values are unknown, utilize the following procedure to calibrate the temperature measurements before installing the flow meter on the piping system. A precision temperature measuring instrument, *UltraLink*™ software utility and an IR communicator will be required to perform this procedure.

The RTD Module allows the TFX to read data from two separate 1,000 Ohm RTDs. **Figure 4.10** shows the base RTD window. The four boxes contain slope and offset information that is collected during the RTD calibration process. The program allows an individual RTD calibration or allows both RTDs to be calibrated simultaneously. Since differential temperature measurement is more critical than absolute measurement, it is recommended to calibrate RTDs simultaneously.

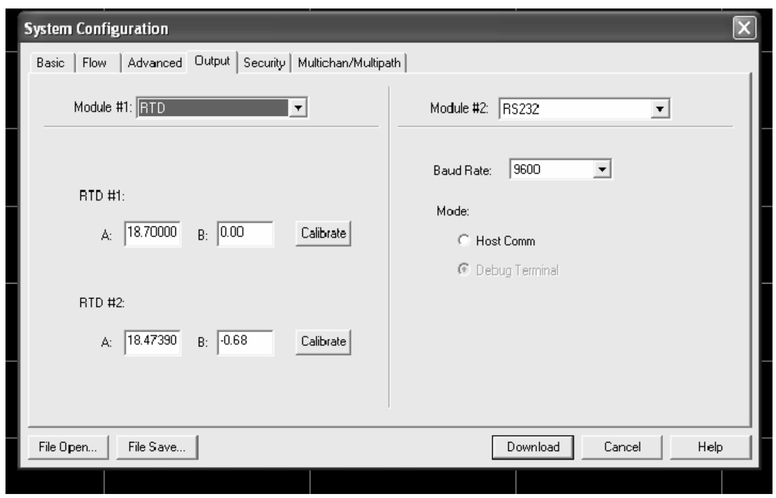


Figure 4.10
Heat Flow Configuration

Calibration of the RTD Module is accomplished by:

1. Pressing either of the RTD calibration buttons. If a single RTD is to be calibrated, press the calibration button adjacent to the RTD to be calibrated. RTD#1 is typically on the supply line and RTD#2 is typically on the return line. If both RTDs are to be calibrated simultaneously, then either button can be pressed.

2. If a single RTD is to be calibrated, unselect the “Both RTDs at the same temperature” box at the bottom of the window.
3. Place the RTD(s) into a temperature controlled, cold water bath and wait several seconds for the temperature to stabilize. Measure the temperature with a reference instrument and enter the measured value into the Reference Temperature (deg C) / First Cal Point box.
4. Click the Next button.
5. Place the RTD(s) into a temperature controlled, hot water bath (within the limits of the RTD module configuration – see Part 1 under Heat Flow on page 1.22) and wait for several seconds for the temperature to stabilize. Measure the temperature with a reference instrument and enter the measured value into the Reference Temperature (deg C) / Second Cal Point box.
6. Click OK.
7. Verify the calibration by placing the TFX in Differential Temperature measurement mode (Service MENU / TEMP DIFF).
8. Place both RTDs into the cold water bath and verify that the temperature differential does not vary by more than 0.3 degrees C as the temperature measurements drop. The absolute temperature of both RTDs will be decreasing during this time and a minimal amount of differential can result from temperature differences in the bath.

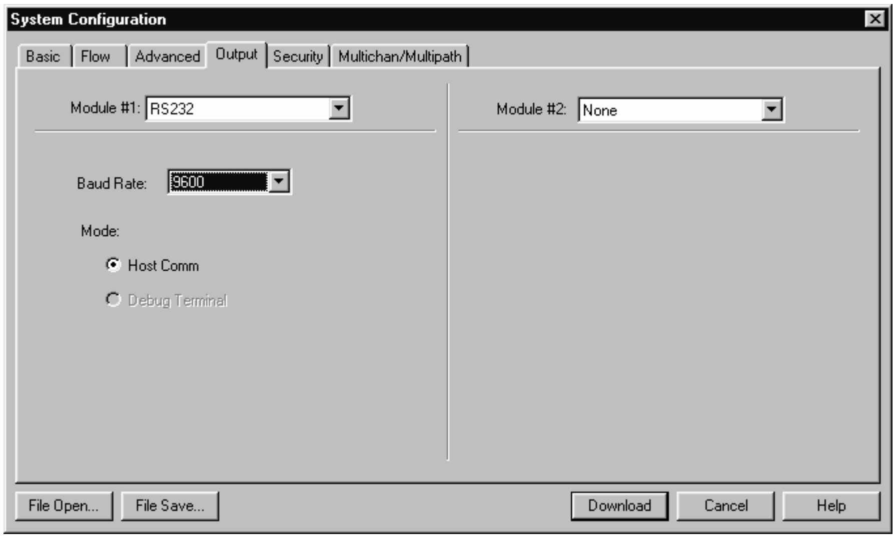


Figure 4.11
RS232 Configuration

RS232 Configuration

The RS232 configuration window permits the selection of communications baud rate. Match this baud rate to that of the instrument with which the TFX will be required to communicate. **Figure 4.11** shows the RS232 configuration screen.

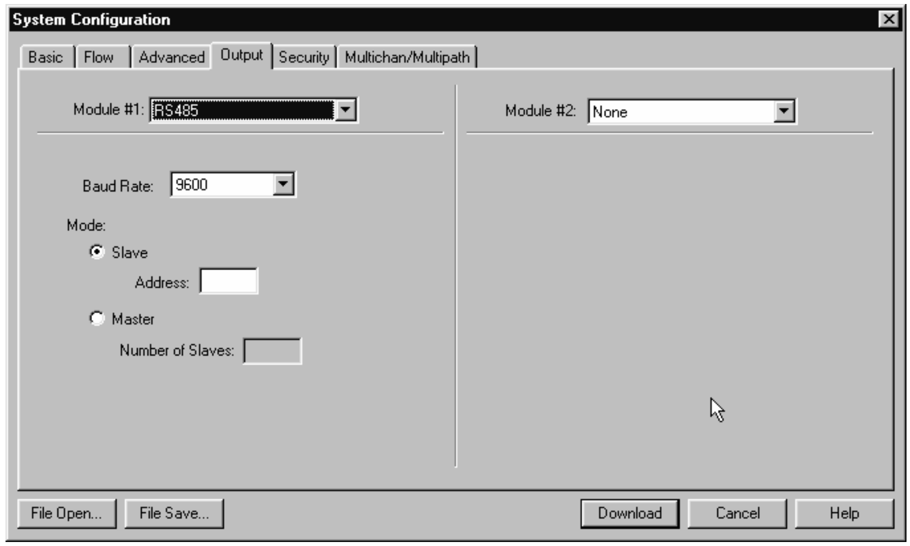


Figure 4.12
RS485 Configuration

RS485 Configuration

The RS485 configuration window permits the selection of communications baud rate and mode of the particular TFX instrument in the network. **Figure 4.12** shows the RS485 configuration screen.

- All TFX instruments on a single network must operate at the same Baud rate – 9600 baud is typical.
- Select the Mode of the TFX – either Master or Slave. Each network may have one Master and as many as 126 Slaves.

Flow Meter Calibration

Setting Zero and Calibration

UltraLink™ contains a powerful multi-point calibration routine that can be used to calibrate the TFX 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 ***UltraLink*™ Data Screen**. The display shown in **Figure 4.13** will appear. The first step (Page 1 of 3) in the calibration process is the selection of the engineering units with which the calibration will be performed. Select the units and click the **Next** button at the bottom of the window.

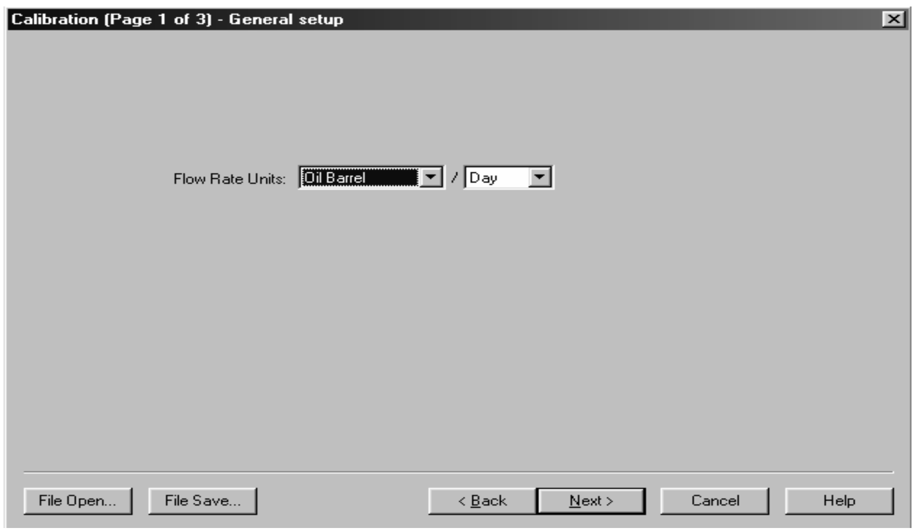


Figure 4.13
Calibration Units

The second screen (Page 2 of 3), **Figure 4.14** on page 4.20, establishes a baseline zero flow rate measurement for the instrument. To zero the flow meter, establish zero flow in the pipe (turn off all pumps and close a dead-heading valve). Wait until the delta-time interval shown in **Figure 4.14** is stable (and typically very close to zero). Click the **Set** button. Click the **Next** button when prompted, then click the **Finish** button on the Calibration Screen.

Important!

*If the **Set** button was clicked, do not proceed with Flow Rate Calibration before clicking the **Finish** button to save the Zero setting.*

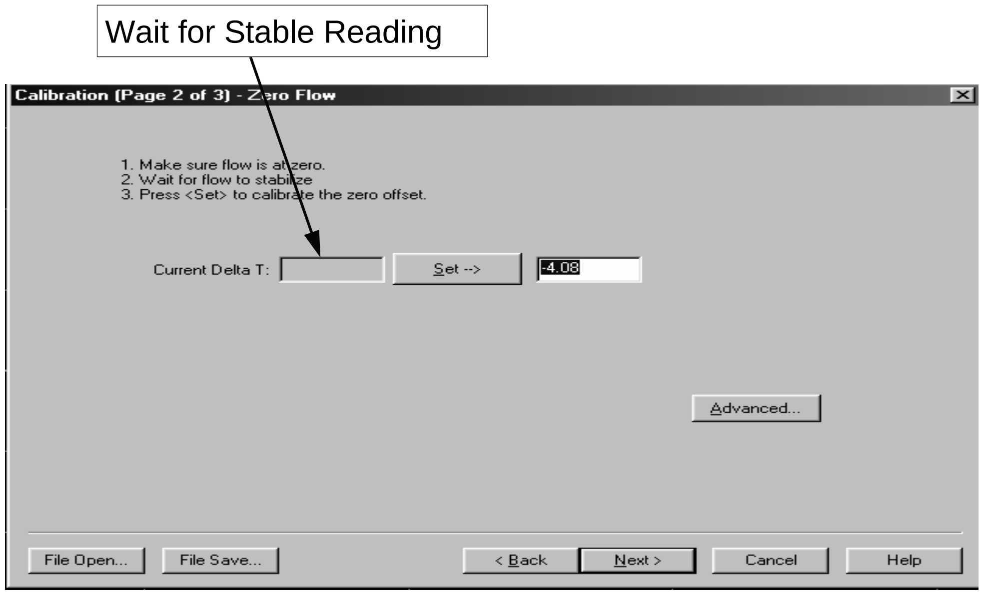


Figure 4.14
Setting Zero Flow

The final screen (Page 3 of 3) shown in **Figure 4.15** on page 4.21 allows multiple actual flow rates to be recorded by the TFX. 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 4.15** 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.

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

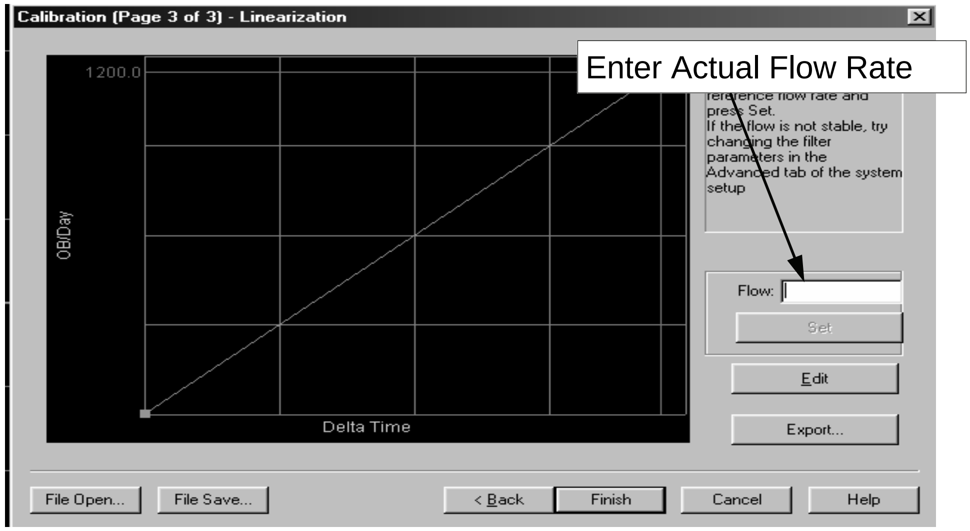


Figure 4.15
Flow Rate Calibration

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 Out a Flow Meter Configuration and Calibration Report

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

Using the Data Logger Software

During the installation of *UltraLink*™, a file called **DatLog** was installed and its icon will appear on the Desktop of the computer. Double-click on the icon to start the utility. The screen shown in **Figure 4.16** will appear as the computer is attempting to establish communications with the logger module.

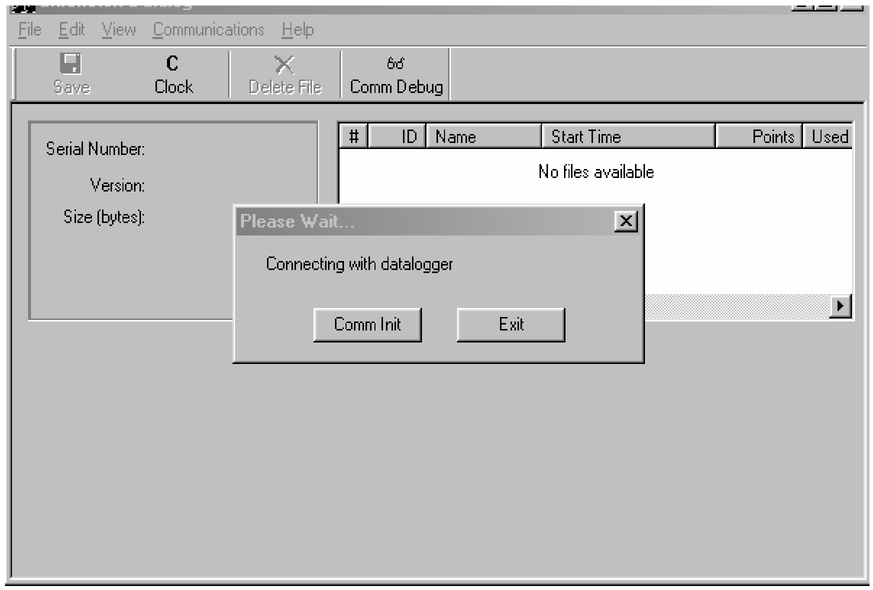


Figure 4.16
Logger Communication

Connect the logger to the computer's serial communications port with the enclosed DB-9 cable. After a few moments, the Please Wait window will disappear and a green OK will appear in the lower right-hand corner of the window. After communications are established (and the OK is displayed) the utility will scan the logger for all existing files. If the logger module is very full, uploading of the file data may take several minutes. A bar graph showing upload progress will provide status. The files will appear on the table (see **Figure 4.17** on page 4.23). Information regarding starting time, date and points collected will appear.

If a file is selected, the time-stamped data will appear on the strip chart located on the bottom of the window. The mouse can be used to select a small portion of the graph and expand the data to the width of the screen. To revert to the entire data file, right-click the graph.

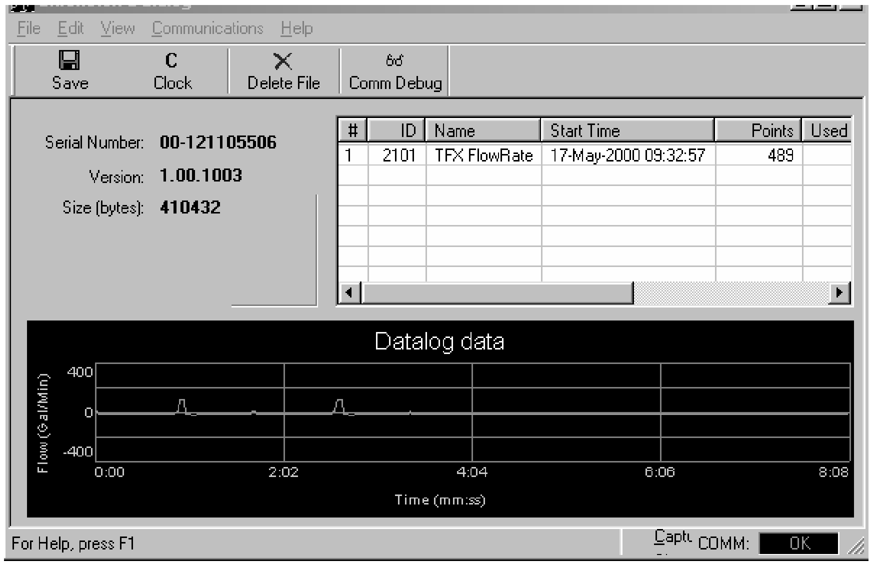


Figure 4.17
Logger Files

To save the file to a computer, select the file from the file table and click the Save button located on the top task bar (see **Figure 4.18** on page 4.24). Datalog saves the files in .csv (comma separated value) format. These files can be opened in programs such as Microsoft Excel® or Corel® Quattro Pro® for manipulation or graphical purposes.

NOTE: The spreadsheet programs listed above are limited to the number of lines of data that can be imported. Very large files may need to opened in a program such as Microsoft WordPad and/or saved in two or more sections.

The data logger module contains a real-time clock that can be set by clicking the Clock button on the top task bar (see **Figure 4.19** on page 4.24). Activating the window compares the data logger clock to the clock located in the PC. Adjustments can be made and uploaded to the logger.

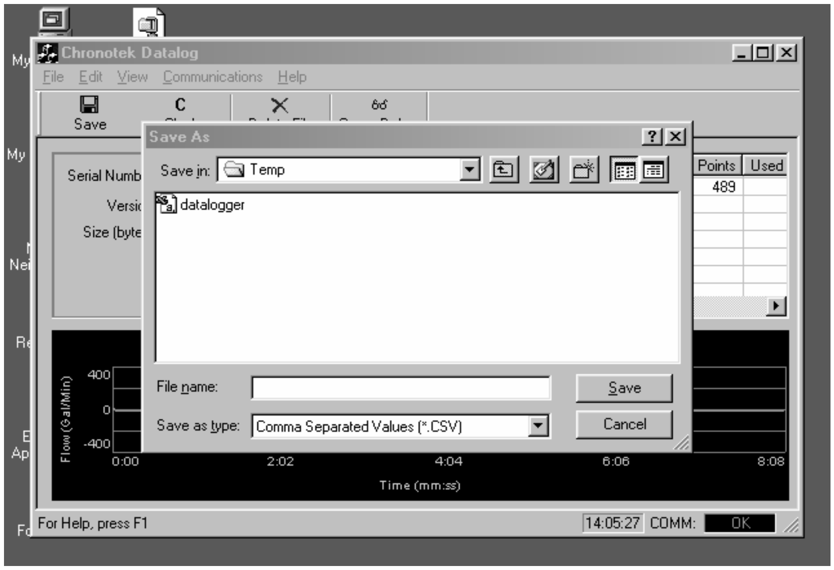


Figure 4.18
Saving Data Files

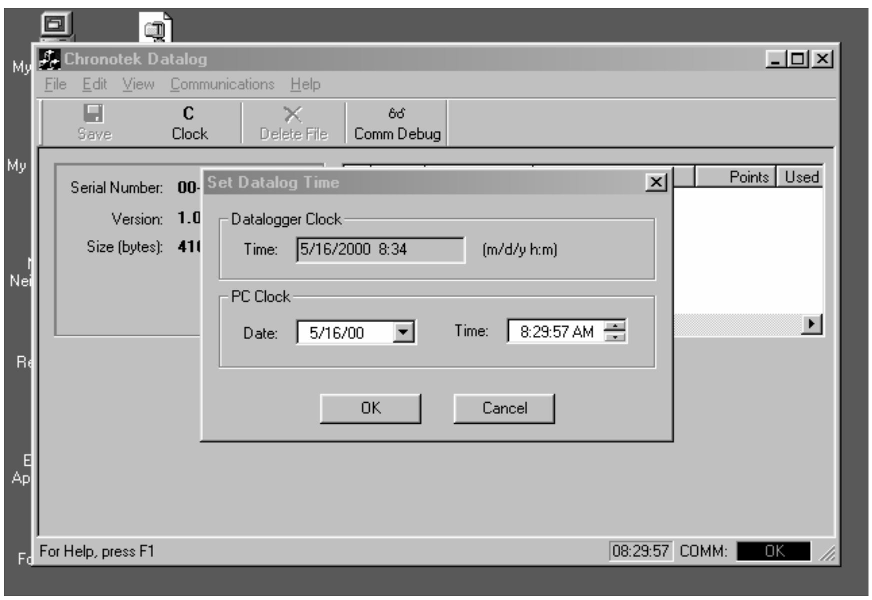
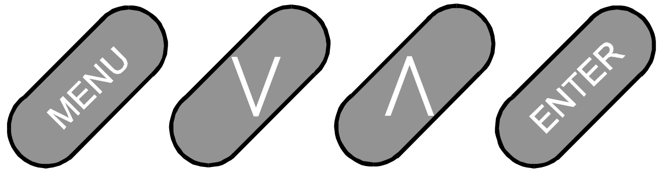


Figure 4.19
Setting the Clock

APPENDIX



TFX USER INTERFACE MAP

DYNASONICS

BSC MENU

UNITS
- *ENGLSH*
- *METRIC*

XDCR MNT
- *V*
- *W*
- *Z*

PIPE OD
- *ENGLSH (INCHES)*
- *METRIC (MM)*

PIPE WT
- *ENGLSH (INCHES)*
- *METRIC (MM)*

PIPE MAT *
- *CARB ST*
- *SS 303*
- *SS 316*
- *CAST IRN*
- *DCTL IRN*
- *COPPER*
- *PVC/CPVC*
- *PVDF*
- *HDPE*
- *LDPE*
- *ALUMINUM*
- *FBRGLASS*
- *OTHER*

PIPE SS
- *ENGLSH (FPS)*
- *METRIC (MPS)*

PIPE R
- (RELATIVE ROUGHNESS)

LINER T
- *ENGLSH (INCHES)*
- *METRIC (MM)*

LINER TYPE *
- *TAR EPXY*
- *RUBBER*
- *MORTAR*
- *POLYPRO*
- *POLYSTY*
- *HDPE*
- *LDPE*
- *TEFLON*
- *EBONITE*
- *OTHER*

LINER SS
- *ENGLSH (FPS)*
- *METRIC (MPS)*

FL TYPE *
- *WATER*
- *SEWAGE*
- *ACETONE*
- *BRINE*
- *ETHANOL*
- *GASOLINE*
- *KEROSENE*
- *HYD OIL*
- *LUBE OIL*
- *PROPANE*
- *BUTANE*
- *OTHER*

FLUID SS
- *ENGLSH (FPS)*
- *METRIC (MPS)*

FLUID VI
- *CPS*

SP GRVTY
- *UNITLESS*

[1]SP HEAT
- *NOMINAL*
- *HEAT CAPACITY*

XDC SPAC
- *ENGLSH (INCHES)*
- *METRIC (MM)*

RATE UNT
- *GALLONS*
- *LITERS*
- *MGAL*
- *CUBIC FT*
- *CUBIC ME*
- *ACRE FT*
- *OIL BARR*
- *LIQ BARR*
- *FEET*
- *METERS*
- *LB*
- *KG*
- *[1]BTU*
- *[1]MBTU*
- *[1]MMBTU*
- *[1]TON*

RATE INT
- *MIN*
- *HOUR*
- *DAY*
- *SEC*

TOTL UNT
- *GALLONS*
- *LITERS*
- *MGAL*
- *CUBIC FT*
- *CUBIC ME*
- *ACRE FT*
- *OIL BARR*
- *LIQ BARR*
- *LB*
- *KG*
- *[1]BTU*
- *[1]MBTU*
- *[1]MMBTU*
- *[1]TON*

TOTL E
- *E-1 TO E6*

MIN RATE
- *RATE/INT*

MAX RATE
- *RATE/INT*

FL C-OFF
- *% of Full Scale*

DAMP PER
- *PERCENT*

OUT1 MEN

OUT1 → ***OPTIONS***

4-20MA
- *FL 4MA*
- *FL 20MA*
- *4-20 TST*

RATE
- *FL 0H*
- *FL 2.5KH*

RELAY
- *RELAY 1*
- *RELAY 2*

RTD
- *RTD1 A*
- *RTD1 B*
- *RTD2 A*
- *RTD2 B*

RS232
- *RS232 BA*
  - *1200*
  - *2400*
  - *9600*
  - *19200*

RS485
- *RS485 MO*
  - *SLAVE*
  - *MASTER*
- *RS485 BA*
  - *1200*
  - *2400*
  - *9600*
  - *19200*
- *ADDRESS*
  - *1-127*

DATALOG
- INTERVAL
  - *1-30,000*

NONE

OUT2 MEN

OUT2 → ***OPTIONS***

4-20MA
- *FL 4MA*
- *FL 20MA*
- *4-20 TST*

RATE
- *FL 0H*
- *FL 2.5KH*

RELAY
- *RELAY 1*
- *RELAY 2*

RTD
- *RTD1 A*
- *RTD1 B*
- *RTD2 A*
- *RTD2 B*

RS232
- *RS232 BA*
  - *1200*
  - *2400*
  - *9600*
  - *19200*

RS485
- *RS485 MO*
  - *SLAVE*
  - *MASTER*
- *RS485 BA*
  - *1200*
  - *2400*
  - *9600*
  - *19200*
- *ADDRESS*
  - *1-127*

DATALOG
- INTERVAL
  - *1-30,000*

NONE

SEN MENU

XDC TYPE
- *DTTN*
- *DTTH*
- *DT1500*
- *COP PIPE*
- *ASA PIPE*

SEC MENU

TOT RES
- *NO*
- *YES*

SYS RSET
- *NO*
- *YES*

CH PSWD?
- *0-9999*

SER MENU

SSPD MPS

SSPD FPS

SIG STR

[1]TEMP 1

[1]TEMP 2

[1]TEMPDIFF

SIG C-OFF

SUB FLOW

SET ZERO

D-FLT 0

COR FTR

DSP MENU

DISPLAY
- *FLOW*
- *TOTAL*
- *BOTH*

TOTAL
- *NET*
- *POS*
- *NEG*
- *BATCH*

SCN DWL
- *1-10*

BTCH MUL
- *TOTALIZER UNIT W/ TOTAL E*

*List provided for example only. Additional entries may be available.
[1]Selection only visible when RTD output module is activated

<u>Keypad Operations</u>

1. The MENU key is pressed from RUN mode to enter PROGRAM mode. The MENU key is pressed in PROGRAM mode to exit configuration parameters and menus. If changes to any configuration parameters have been made, the user will be prompted with a SAVE?YES when returning to RUN mode.
2. The ARROW keys are used to scroll through menus and configuration parameters. The ARROW keys are also used to adjust parameter numerical values.
3. The ENTER key is

- pressed from the RUN mode to view the current software version operating in the instrument.
- used to access the configuration parameters in the various menus.
- Used to initiate changes in configuration parameters.
- Used to accept configuration parameter changes.

Date Created: 3/21/2000
Revision: G Revision Date: 3/1/2007
Software Version: 1.50.7043

Fluid Properties

Original Date: 7/30/1999
Revision: A
Revision Date: 9/10/2003
File: I:/dynasonics/dyna_code/tables/fluid_ss.xls

Fluid	Specific Gravity 20 degrees C	Sound Speed m/s	Sound Speed ft/s	delta-v/degree C m/s/degree C	Kinematic Viscosity Centistokes	Absolute Viscosity Centipoise
Acetate, Butyl		1270	4163.9			
Acetate, Ethyl	0.901	1085	3559.7	4.4	0.489	0.441
Acetate, Methyl	0.934	1211	3973.1		0.407	0.380
Acetate, Propyl		1280	4196.7			
Acetone	0.79	1174	3851.7	4.5	0.399	0.316
Alcohol	0.79	1207	3960.0	4.0	1.396	1.101
Alcohol, Butyl	0.83	1270	4163.9	3.3	3.239	2.688
Alcohol, Ethyl	0.83	1180	3868.9	4	1.396	1.159
Alcohol, Methyl	0.791	1120	3672.1	2.92	0.695	0.550
Alcohol, Propyl		1170	3836.1			
Alcohol, Propyl	0.78	1222	4009.2		2.549	1.988
Ammonia	0.77	1729	5672.6	6.7	0.292	0.225
Anlline	1.02	1639	5377.3	4.0	3.630	3.710
Benzene	0.88	1306	4284.8	4.7	0.711	0.625
Benzol, Ethyl	0.867	1338	4389.8		0.797	0.691
Bromine	2.93	889	2916.7	3.0	0.323	0.946
n-Butane	0.60	1085	3559.7	5.8		
Butyrate, Ethyl		1170	3836.1			
Carbon dioxide	1.10	839	2752.6	7.7	0.137	0.151
Carbon tetrachloride	1.60	926	3038.1	2.5	0.607	0.968
Chloro-benezene	1.11	1273	4176.5	3.6	0.722	0.799
Chloroform	1.49	979	3211.9	3.4	0.550	0.819
Diethyl ether	0.71	985	3231.6	4.9	0.311	0.222
Diethyl Ketone		1310	4295.1			
Diethylene glycol	1.12	1586	5203.4	2.4		
Ethanol	0.79	1207	3960.0	4.0	1.390	1.097
Ethyl alcohol	0.79	1207	3960.0	4.0	1.396	1.101
Ether	0.71	985	3231.6	4.9	0.311	0.222
Ethyl ether	0.71	985	3231.6	4.9	0.311	0.222
Ethylene glycol	1.11	1658	5439.6	2.1	17.208	19.153
Freon R12		774.2	2540			
Gasoline	0.7	1250	4098.4			
Glycerin	1.26	1904	6246.7	2.2	757.100	953.946
Glycol	1.11	1658	5439.6	2.1		
Isobutanol	0.81	1212	3976.4			
Iso-Butane		1219.8	4002			
Isopentane	0.62	980	3215.2	4.8	0.340	0.211
Isopropanol	0.79	1170	3838.6		2.718	2.134
Isopropyl alcohol	0.79	1170	3838.6		2.718	2.134
Kerosene	0.81	1324	4343.8	3.6		
Linalool		1400	4590.2			
Linseed Oil	.925-.939	1770	5803.3			
Methanol	0.79	1076	3530.2	2.92	0.695	0.550
Methyl alcohol	0.79	1076	3530.2	2.92	0.695	0.550
Methylene chloride	1.33	1070	3510.5	3.94	0.310	0.411
Methylethyl Ketone		1210	3967.2			
Motor Oil (SAE 20/30)	.88-.935	1487	4875.4			
Octane	0.70	1172	3845.1	4.14	0.730	0.513

Oil, Castor	0.97	1477	4845.8	3.6	0.670	0.649
Oil, Diesel	0.80	1250	4101			
Oil (Lubricating X200)		1530	5019.9			
Oil (Olive)	0.91	1431	4694.9	2.75	100.000	91.200
Oil (Peanut)	0.94	1458	4783.5			
Paraffin Oil		1420	4655.7			
Pentane	0.626	1020	3346.5		0.363	0.227
Petroleum	0.876	1290	4229.5			
1-Propanol	0.78	1222	4009.2			
Refrigerant 11	1.49	828.3	2717.5	3.56		
Refrigerant 12	1.52	774.1	2539.7	4.24		
Refrigerant 14	1.75	875.24	2871.5	6.61		
Refrigerant 21	1.43	891	2923.2	3.97		
Refrigerant 22	1.49	893.9	2932.7	4.79		
Refrigerant 113	1.56	783.7	2571.2	3.44		
Refrigerant 114	1.46	665.3	2182.7	3.73		
Refrigerant 115		656.4	2153.5	4.42		
Refrigerant C318	1.62	574	1883.2	3.88		
Silicone (30 cp)	0.99	990	3248		30.000	29.790
Toluene	0.87	1328	4357	4.27	0.644	0.558
Transformer Oil		1390	4557.4			
Trichlorethylene		1050	3442.6			
1,1,1-Trichloro-ethane	1.33	985	3231.6		0.902	1.200
Turpentine	0.88	1255	4117.5		1.400	1.232
Water, distilled	0.996	1498	4914.7	-2.4	1.000	0.996
Water, heavy	1	1400	4593			
Water, sea	1.025	1531	5023	-2.4	1.000	1.025
Wood Alcohol	0.791	1076	3530.2	2.92	0.695	0.550
m-Xylene	0.868	1343	4406.2		0.749	0.650
o-Xylene	0.897	1331.5	4368.4	4.1	0.903	0.810
p-Xylene		1334	4376.8		0.662	

TFX Error Codes

Revised 2-22-2002

Code Number	Description	Correction
Warnings		
0001	Serial number not present	Hardware serial number has become inoperative – system performance will not be influenced.
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 the 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.
0020	Heat Flow Units of measure have been selected and an RTD module has not been installed	Verify that RTD Module PN D020-1045-106 has been installed in one of the I/O meter slots. Verify that OUTPUT1 or OUTPUT 2 has been configured for RTD measurements.
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	Recalibrate the system
3005	Invalid speed of sound calibration data	Upload new data
3006	Bad system tables	Upload new table data
3007	Data Logger is off or not present	If desired, insert data logger and configure within the Datalog Operations Menu. If logger is not present, configure I/O port for no logger.
3010	One or more channels are not responding (Multi-channel meters only)	Display indicates which secondary units are not communicating with Master meter. Verify wiring, configuration and address of secondary instrument.
3011	All channels are not responding (Multi-channel meters only)	Verify wiring, configuration and address of secondary instruments.
Class A Errors		
4001	Flash memory full	Return unit to factory for evaluation

Digital Communications Protocol for TFX Flow Meters

Host protocol

A digital communications protocol is utilized. Each message is guarded with the standard CRC-16 error detection (C source code is included)

The host protocol is a master-slave type protocol with the flowmeter being the slave. The messages have the following format:

<addr><command><data>…<data><crc-16>

A unit may be assigned an address that responds to (valid addresses are 1-7E). All devices respond to address 7F (ie. this address may not be used for multidrop) and all devices listen to address 0 but do not respond (this is the “broadcast” address).

The following special commands are defined:

Command	Description
65	Special “short” commands
66	Special “long” commands

Command 65 allows up to 255 data items to be transferred while command 66 allows up to 65535 items (The actual maximum size is limited by the memory allocated for the communication buffers and for TOF it is 2048 bytes). There is special encoding for the data for commands 65 and 66 as follows:

Command 65:

<size><code><data$_{1}$>…<data$_{N-1}$>   N = <size>

Command 66:

<size_h><size_l><code><data$_{1}$>…<data$_{N-1}$>   N = <size_h>*256 + <size_l>

The target device will respond the same for both 65 and 66 commands. The host program needs to make sure that the proper opcode will be used based on the data size requested.

In case of an error, the target will reject the message by replying with an error code. The target will not reply to an ill-formed command (ie. incomplete or CRC-16 error). The error reply is:

<addr><opcode><errorcode><crc-16>

where:

<opcode> is the requested opcode with the Most Significant bit turned on.

The following error codes are defined:

Error Code	Description
1	Bad Command (Invalid command)
2	Bad Command Data
71h	Command not allowed.
72h	Buffer overflow (data exceeded internal allocated memory)
73h	Command not implemented in this version

Special codes

The following special 65 and 66 codes are supported.

Code	Description
00	Echo (for comm debugging)
0A	Read run time data (signal strength, flow rate and totalizers)
0B	Reset Totalizers

Code 00 – Echo

Command: <addr>65<size>00<data$_1$>…<data$_n$><crc-16>
Reply: <addr>65<size>00<data$_1$>…<data$_n$><crc-16>

Code 0A – Read Flow data

Command: <addr>65010A<crc-16>
Reply: <addr>65210A<data$_1$>…<data$_n$><crc-16>

The data section of the reply contains the byte stream representation of the flow data as follows (all numbers use the Intel format – ie. Least significant byte first):

Byte	Type	Description
0-1	2 byte integer	Signal Strength (0-1000)
2-9	8 byte floating point	Current flow rate in the units programmed
10-17	8 byte floating point	Net Totalizer in the units programmed
18-25	8 byte floating point	Positive Totalizer
26-33	8 byte floating point	Negative Totalizer

Code 0A Extension 1 - Read Extra Flow data

Command: <addr>65020A01<crc-16>
Reply: <addr>65220A01<data$_1$>…<data$_n$><crc-16>

The data section of the reply contains the byte stream representation of the flow data as follows (all numbers use the Intel format – ie. Least significant byte first):

Byte	Type	Description
0-1	2 byte integer	Signal Strength (0-1000)
2-9	8 byte floating point	Current flow rate in the units programmed
10-17	8 byte floating point	Net Totalizer in the units programmed
18-25	8 byte floating point	Positive Totalizer
26-33	8 byte floating point	Negative Totalizer
34-41	8 byte floating point	Temp 1 in deg C
42-49	8 byte floating point	Temp 2 in deg C

Code 0B – Reset Totalizers

Command: <addr>65010B<crc-16>
Reply: <addr>65010B<crc-16>

C Source Code

Flow Data Definition

```
struct FLOWDATA
{
	short		sSignalStrength;
	double		dCurFlowRate;
	double		dNetTotalizer;
	double		dPositiveTotalizer;
	double		dNegativeTotalizer;
};
struct FLOWDATA_EX
{
	short		sSignalStrength;
	double		dCurFlowRate;
	double		dNetTotalizer;
	double		dPositiveTotalizer;
	double		dNegativeTotalizer;
	double		dTemp1;
	double		dTemp2;
};
```

CRC-16 Calculations

```
unsigned short crc_table[256] = {
   0x0000, 0xC0C1, 0xC181, 0x0140, 0xC301, 0x03C0, 0x0280, 0xC241,
   0xC601, 0x06C0, 0x0780, 0xC741, 0x0500, 0xC5C1, 0xC481, 0x0440,
   0xCC01, 0x0CC0, 0x0D80, 0xCD41, 0x0F00, 0xCFC1, 0xCE81, 0x0E40,
   0x0A00, 0xCAC1, 0xCB81, 0x0B40, 0xC901, 0x09C0, 0x0880, 0xC841,
   0xD801, 0x18C0, 0x1980, 0xD941, 0x1B00, 0xDBC1, 0xDA81, 0x1A40,
   0x1E00, 0xDEC1, 0xDF81, 0x1F40, 0xDD01, 0x1DC0, 0x1C80, 0xDC41,
   0x1400, 0xD4C1, 0xD581, 0x1540, 0xD701, 0x17C0, 0x1680, 0xD641,
   0xD201, 0x12C0, 0x1380, 0xD341, 0x1100, 0xD1C1, 0xD081, 0x1040,
   0xF001, 0x30C0, 0x3180, 0xF141, 0x3300, 0xF3C1, 0xF281, 0x3240,
   0x3600, 0xF6C1, 0xF781, 0x3740, 0xF501, 0x35C0, 0x3480, 0xF441,
   0x3C00, 0xFCC1, 0xFD81, 0x3D40, 0xFF01, 0x3FC0, 0x3E80, 0xFE41,
   0xFA01, 0x3AC0, 0x3B80, 0xFB41, 0x3900, 0xF9C1, 0xF881, 0x3840,
   0x2800, 0xE8C1, 0xE981, 0x2940, 0xEB01, 0x2BC0, 0x2A80, 0xEA41,
   0xEE01, 0x2EC0, 0x2F80, 0xEF41, 0x2D00, 0xEDC1, 0xEC81, 0x2C40,
   0xE401, 0x24C0, 0x2580, 0xE541, 0x2700, 0xE7C1, 0xE681, 0x2640,
   0x2200, 0xE2C1, 0xE381, 0x2340, 0xE101, 0x21C0, 0x2080, 0xE041,
   0xA001, 0x60C0, 0x6180, 0xA141, 0x6300, 0xA3C1, 0xA281, 0x6240,
   0x6600, 0xA6C1, 0xA781, 0x6740, 0xA501, 0x65C0, 0x6480, 0xA441,
   0x6C00, 0xACC1, 0xAD81, 0x6D40, 0xAF01, 0x6FC0, 0x6E80, 0xAE41,
   0xAA01, 0x6AC0, 0x6B80, 0xAB41, 0x6900, 0xA9C1, 0xA881, 0x6840,
   0x7800, 0xB8C1, 0xB981, 0x7940, 0xBB01, 0x7BC0, 0x7A80, 0xBA41,
   0xBE01, 0x7EC0, 0x7F80, 0xBF41, 0x7D00, 0xBDC1, 0xBC81, 0x7C40,
   0xB401, 0x74C0, 0x7580, 0xB541, 0x7700, 0xB7C1, 0xB681, 0x7640,
   0x7200, 0xB2C1, 0xB381, 0x7340, 0xB101, 0x71C0, 0x7080, 0xB041,
   0x5000, 0x90C1, 0x9181, 0x5140, 0x9301, 0x53C0, 0x5280, 0x9241,
   0x9601, 0x56C0, 0x5780, 0x9741, 0x5500, 0x95C1, 0x9481, 0x5440,
   0x9C01, 0x5CC0, 0x5D80, 0x9D41, 0x5F00, 0x9FC1, 0x9E81, 0x5E40,
   0x5A00, 0x9AC1, 0x9B81, 0x5B40, 0x9901, 0x59C0, 0x5880, 0x9841,
   0x8801, 0x48C0, 0x4980, 0x8941, 0x4B00, 0x8BC1, 0x8A81, 0x4A40,
   0x4E00, 0x8EC1, 0x8F81, 0x4F40, 0x8D01, 0x4DC0, 0x4C80, 0x8C41,
```

```
    0x4400, 0x84C1, 0x8581, 0x4540, 0x8701, 0x47C0, 0x4680, 0x8641,
    0x8201, 0x42C0, 0x4380, 0x8341, 0x4100, 0x81C1, 0x8081, 0x4040,
};

unsigned short    calculate_crc(const unsigned char *pv, int size)
{
      unsigned short crc = 0xFFFF;

      for ( ;size-- ; pv++)
      {
            crc = (crc >> 8) ^ crc_table[(crc ^ *pv) & 0xFF];
      }

      return crc;
}
```

"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

"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								

Ductile Iron Pipe (Standard Classes)

Size (Inches)		Class 50	51	52	53	54	55	56	Mortar Lining
3"	O.D.		3.96	3.96	3.96	3.96	3.96	3.96	Std. 0.123 Dbl. 0.250
	Wall		0.25	0.28	0.31	0.34	0.37	0.41	
	I.D.		3.46	3.40	3.34	3.28	3.22	3.14	
4"	O.D.		4.80	4.80	4.80	4.80	4.80	4.80	Std. 0.123 Dbl. 0.250
	Wall		0.26	0.29	0.32	0.35	0.38	0.42	
	I.D.		4.28	4.22	4.16	4.10	4.04	3.93	
6"	O.D.	6.90	6.90	6.90	6.90	6.90	6.90	6.90	Std. 0.123 Dbl. 0.250
	Wall	0.25	0.28	0.31	0.34	0.37	0.40	0.43	
	I.D.	6.40	6.34	6.28	6.22	6.16	6.10	6.04	
8"	O.D.	9.05	9.05	9.05	9.05	9.05	9.05	9.05	Std. 0.123 Dbl. 0.250
	Wall	0.27	0.30	0.33	0.36	0.39	0.42	0.45	
	I.D.	8.51	8.45	8.39	8.33	8.27	8.21	8.15	
10"	O.D.	11.10	11.10	11.10	11.10	11.10	11.10	11.10	Std. 0.123 Dbl. 0.250
	Wall	0.39	0.32	0.35	0.38	0.41	0.44	0.47	
	I.D.	10.32	10.46	10.40	10.34	10.28	10.22	10.16	
12"	O.D.	13.20	13.20	13.20	13.20	13.20	13.20	13.20	Std. 0.123 Dbl. 0.250
	Wall	0.31	0.34	0.37	0.40	0.43	0.46	0.49	
	I.D.	12.58	12.52	12.46	12.40	12.34	12.28	12.22	
14"	O.D.	15.30	15.30	15.30	15.30	15.30	15.30	15.30	Std . 0.1875 Dbl. 0.375
	Wall	0.33	0.36	0.39	0.42	0.45	0.48	0.51	
	I.D.	14.64	14.58	14.52	14.46	14.40	14.34	14.28	
16"	O.D.	17.40	17.40	17.40	17.40	17.40	17.40	17.40	Std . 0.1875 Dbl. 0.375
	Wall	0.34	0.37	0.40	0.43	0.46	0.49	0.52	
	I.D.	16.72	16.66	16.60	16.54	16.48	16.42	16.36	
18"	O.D.	19.50	19.50	19.50	19.50	19.50	19.50	19.50	Std . 0.1875 Dbl. 0.375
	Wall	0.35	0.38	0.41	0.44	0.47	0.50	0.53	
	I.D.	18.80	18.74	18.68	18.62	18.56	18.50	18.44	
20"	O.D.	21.60	21.60	21.60	21.60	21.60	21.60	21.60	Std . 0.1875 Dbl. 0.375
	Wall	0.36	0.39	0.42	0.45	0.48	0.51	0.54	
	I.D.	20.88	20.82	20.76	20.70	20.64	20.58	20.52	
24"	O.D.	25.80	25.80	25.80	25.80	25.80	25.80	25.80	Std . 0.1875 Dbl. 0.375
	Wall	0.38	0.41	0.44	0.47	0.50	0.53	0.56	
	I.D.	25.04	24.98	24.92	24.86	24.80	24.74	24.68	
30"	O. D.	32.00	32.00	32.00	32.00	32.00	32.00	32.00	Std. 0.250 Dbl. 0.500
	Wall	0.39	0.43	0.47	0.51	0.55	0.59	0.63	
	I.D.	31.22	31.14	31.06	30.98	30.90	30.82	30.74	
36"	O.D.	38.30	38.30	38.30	38.30	38.30	38.30	38.30	Std. 0.250 Dbl. 0.500
	Wall	0.43	0.48	0.62	0.58	0.45	0.68	0.73	
	I.D.	37.44	37.34	37.06	37.14	37.40	36.94	36.48	
42"	O.D.	44.50	44.50	44.50	44.50	44.50	44.50	44.50	Std. 0.250 Dbl. 0.500
	Wall	0.47	0.53	0.59	0.65	0.71	0.77	0.83	
	I.D.	43.56	43.44	43.32	43.20	43.08	42.96	42.84	
48"	O.D.	50.80	50.80	50.80	50.80	50.80	50.80	50.80	Std. 0.250 Dbl. 0.500
	Wall	0.51	0.58	0.65	0.72	0.79	0.86	0.93	
	I.D.	49.78	49.64	49.50	49.36	49.22	49.08	48.94	
54"	O.D.	57.10	57.10	57.10	57.10	57.10	57.10	57.10	Std. 0.250 Dbl. 0.500
	Wall	0.57	0.65	0.73	0.81	0.89	0.97	1.05	
	I.D.	55.96	55.80	55.64	55.48	55.32	55.16	55.00	

Nominal Diameter		COPPER TUBING			Copper & Brass Pipe	ALUMINUM
		Type				
		K	L	M		
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			Copper & Brass Pipe	ALUMINUM
		Type				
		K	L	M		
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		

Cast Iron Pipe (Standard Classes)

Size (Inches)		Class A	Class B	Class C	Class D	Class E	Class F	Class G	Class 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
	Wall	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)		Class A	Class B	Class C	Class D	Class E	Class F	Class G	Class 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						

DYNASONICS

FPS TO GPM CROSS - REFERENCE (Schedule 40)

Nominal Pipe (Inches)	I.D. INCH	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9
1	1.05	2.6989	4.0484	5.3978	6.7473	8.097	9.4462	10.796	12.145	13.490	14.844	16.190	17.540	18.890	20.240	21.590	22.941	24.290
1.25	1.38	4.6620	6.9929	9.3239	11.655	13.99	16.317	18.648	20.979	23.310	25.641	27.970	30.300	32.630	34.960	37.300	39.627	41.958
1.5	1.61	6.3454	9.5182	12.691	15.864	19.04	22.209	25.382	28.555	31.730	34.900	38.070	41.250	44.420	47.590	50.760	53.936	57.109
2	2.07	10.489	15.734	20.979	26.224	31.47	36.713	41.958	47.202	52.450	57.692	62.940	68.180	73.430	78.670	83.920	89.160	94.405
2.5	2.47	14.935	22.402	29.870	37.337	44.80	52.272	59.740	67.207	74.670	82.142	89.610	97.080	104.50	112.00	119.50	126.95	134.41
3	3.07	23.072	34.608	46.144	57.680	69.22	80.752	92.288	103.82	115.40	126.90	138.40	150.00	161.50	173.00	184.60	196.11	207.65
3.5	3.55	30.851	46.276	61.702	77.127	92.55	107.98	123.40	138.83	154.30	169.68	185.10	200.50	216.00	231.40	246.80	262.23	277.66
4	4.03	39.758	59.636	79.515	99.394	119.3	139.15	159.03	178.91	198.80	218.67	238.50	258.40	278.30	298.20	318.10	337.94	357.82
5	5.05	62.430	93.645	124.86	156.07	187.3	218.50	249.72	280.93	312.10	343.36	374.60	405.80	437.00	468.20	499.40	530.65	561.87
6	6.06	89.899	134.85	179.80	224.75	269.7	314.65	359.60	404.55	449.50	494.45	539.40	584.30	629.30	674.20	719.20	764.14	809.09
8	7.98	155.89	233.83	311.78	389.72	467.7	545.61	623.56	701.50	779.40	857.39	935.30	1013.0	1091.0	1169.0	1247.0	1325.1	1403.0
10	10.02	245.78	368.67	491.56	614.45	737.3	860.23	983.12	1106.0	1229.0	1351.8	1475.0	1598.0	1720.0	1843.0	1966.0	2089.1	2212.0
12	11.94	348.99	523.49	697.99	872.49	1047.0	1221.5	1396.0	1570.5	1745.0	1919.5	2094.0	2268.0	2443.0	2617.0	2792.0	2966.5	3141.0
14	13.13	422.03	633.04	844.05	1055.1	1266.0	1477.1	1688.1	1899.1	2110.0	2321.1	2532.0	2743.0	2954.0	3165.0	3376.0	3587.2	3798.2
16	15.00	550.80	826.20	1101.6	1377.0	1652.0	1927.8	2203.2	2478.6	2754.0	3029.4	3305.0	3580.0	3856.0	4131.0	4406.0	4681.8	4957.2

FPS TO GPM: GPM = $(\text{PIPE ID})^2$ X VELOCITY IN FPS X 2.45

GPM TO FPS: $\text{FPS} = \dfrac{\text{GPM}}{(\text{ID})^2 \times 2.45}$

FPS X .3048 = MPS

GPM X .0007 = GPD

GPM X 3.7878 = LPM

DYNASONICS

FPS TO GPM CROSS - REFERENCE (Schedule 40)

Nominal Pipe (Inches)	I.D. INCH	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9
18	16.88	697.52	1046.3	1395.0	1743.8	2093.0	2441.3	2790.1	3138.8	3488.0	3836.3	4185.0	4534.0	4883.0	5231.0	5580.0	5928.9	6277.7
20	18.81	866.14	1299.0	1732.0	2165.3	2598.4	3031.5	3464.6	3897.6	4330.7	4763.8	5196.8	5629.9	6063.0	6496.0	6929.1	7362.2	7795.3
24	22.63	1253.7	1880.0	2507.0	3134.1	3761.0	4387.8	5014.6	5641.5	6268.3	6895.1	7522.0	8148.8	8775.6	9402.4	10029	10656	11283
26	25.25	1560.7	2341.0	3121.0	3901.9	4682.2	5462.6	6243.0	7023.4	7803.7	8584.1	9364.5	10145	10925	11706	12486	13266	14047
28	27.25	1817.8	2727.0	3636.0	4544.5	5453.4	6362.3	7271.2	8180.0	9088.9	9997.8	10907	11816	12725	13633	14542	15451	16360
30	29.25	2094.4	3142.0	4189.0	5236.0	6283.2	7330.4	8377.6	9424.9	10472	11519	12566	13614	14661	15708	16755	17803	18850
32	31.25	2390.6	3586.0	4781.0	5976.5	7171.9	8367.2	9562.5	10758	11953	13148	14344	15539	16734	17930	19125	20320	21516
34	33.25	2706.4	4060.0	5413.0	6766.0	8119.2	9472.4	10826	12179	13532	14885	16238	17592	18945	20298	21651	23004	24358
36	35.25	3041.8	4563.0	6084.0	7604.5	9125.4	10646	12167	13688	15209	16730	18251	19772	21292	22813	24334	25855	27376
42	41.25	4165.4	6248.0	8331.0	10414	12496	14579	16662	18744	20827	22910	24992	27075	29158	31241	33323	35406	37489
48	47.99	5637.8	8457.0	11276	14095	16913	19732	22551	25370	28189	31008	33827	36646	39465	42284	45103	47922	50740
54	53.98	7133.1	10700	14266	17833	21399	24966	28532	32099	35665	39232	42798	46365	49931	53498	57065	60631	64198
60	60.09	8839.2	13259	17678	22098	26518	30937	35357	39777	44196	48616	53035	57455	61875	66294	70714	75134	79553
72	72.10	12726	19089	25451	31814	38177	44540	50903	57266	63628	69991	76354	82717	89080	95443	101805	108168	114531
84	84.10	17314	25971	34628	43285	51943	60600	69257	77914	86571	95228	103885	112542	121199	129856	138514	147171	155828

FPS TO GPM: GPM = $(\text{PIPE ID})^2$ X VELOCITY IN FPS X 2.45

GPM TO FPS: $\text{FPS} = \dfrac{\text{GPM}}{(\text{ID})^2 \times 2.45}$

FPS X .3048 = MPS

GPM X .0007 = GPD

GPM X 3.7878 = LPM

Limited Warranty and Disclaimer

Dynasonics, division of Racine Federated Inc. warrants to the end purchaser, for a period of one year from the date of shipment from the factory, that all new transmitters and transducers manufactured by it are free from defects in materials and workmanship. This warranty does not cover products that have been damaged due to misapplication, abuse, lack of maintenance, or improper installation. Dynasonics' obligation under this warranty is limited to the repair or replacement of a defective product, at no charge to the end purchaser, if the product is inspected by Dynasonics and found to be defective. Repair or replacement is at Dynasonics' discretion. An return goods authorization (RGA)number must be obtained from Dynasonics before any product may be returned for warranty repair or replacement. The product must be thoroughly cleaned and any process chemicals removed before it will be accepted for return.

The purchaser must determine the applicability of the product for its desired use and assumes all risks in connection therewith. Dynasonics assumes no responsibility or liability for any omissions or errors in connection with the use of its products. Dynasonics will under no circumstances be liable for any incidental, consequential, contingent or special damages or loss to any person or property arising out of the failure of any product, component or accessory.

All expressed or implied warranties, including **the implied warranty of merchantability and the implied warranty of fitness for a particular purpose or application are expressly disclaimed** and shall not apply to any products sold or services rendered by Dynasonics.

The above warranty supersedes and is in lieu of all other warranties, either expressed or implied and all other obligations or liabilities. No agent or representative has any authority to alter the terms of this warranty in any way.

GENERAL TERMS AND CONDITIONS OF SALES

1. PAYMENT – Terms of payment are effective from the actual date of invoice. If, in the Seller's opinion, the financial condition of the Buyer at any time – or any other circumstances – do not justify the incurrence of production costs of shipment on the terms of payment specified, the Seller may require partial or full payment in advance. Payment terms are net 30 days unless otherwise stated on invoice.

2. F.O.B. – All shipments are from Racine, Wisconsin, USA, unless otherwise other stated, and title transfers to the buyer upon leaving factory.

3. QUOTATION AND PRICES – Quoted prices are firm for 30 days unless stated in the quotation and are subject to change without notice after expiration of this period.

4. TAXES – Any applicable sales, use, revenue, excise or other taxes not specifically stated in the quotation are to be remitted by the Buyer directly to the appropriate regulatory agency.

5. WARRANTY – Seller's standard published warranty in effect at the time of shipment shall apply. This warranty is exclusive and is in lieu of all other warranties, express, implied, or statutory, including the warranty of merchantability.

6. DELIVERY – The Seller shall not be liable for loss or damage of any kind resulting from delay or inability to deliver on account of flood, fire, labor trouble, riots, civil disturbances, accidents, acts or orders or regulations of civil or military authorities, shortages of material, or any other causes beyond Seller's control.

7. PRODUCT CHANGES – In keeping with our continuing policy of product improvement, we reserve the right to make changes in our products at any time, without incurring an obligation to change, replace or upgrade equipment previously shipped.

8. CANCELLATIONS – An order placed by Buyer and accepted by Seller may be cancelled only with the Seller's consent and upon terms that will indemnify the Seller against loss.

9. RESTOCKING CHARGE – On standard equipment, the charge is 25%, provided the equipment is returned within 30 days in acceptable condition with a RGA number. Restocking charges for special equipment may vary from standard equipment, and will be handled on a case-by-case basis. No returns will be taken after one year.

RETURN OF EQUIPMENT/SALES INFORMATION

CONTACTS AND PROCEDURES

Customer Service/Application Engineer:

If you have a question regarding order status, placing an order, reviewing applications for future purchases, or wish to purchase a new flowmeter, please contact our new National Sales and Marketing Headquarters:

DYNASONICS
Division of Racine Federated Inc.
8635 Washington Avenue
Racine, WI 53406
PHONE: (800)535-3569 or
(262)639-6770
FAX: (262)639-2267

Service/Repair Department:

If you already purchased equipment and have an operation problem, require service, or need to schedule field service, please contact our Service Department:

DYNASONICS
Division of Racine Federated Inc.
8635 Washington Avenue
Racine, WI 53406
PHONE: (800)535-3569 or
(262)639-6770
FAX: (262)639-2267

Return Goods Authorization:

When returning equipment, it is necessary for you to contact our Service Department at (800)535-3569 or (262)639-6770 to obtain an RGA number for the authority and proper tracking of your material and its prompt inspection and return. The RGA number should be noted on the outside of the box. All returns of equipment go to the following address:

DYNASONICS
Division of Racine Federated Inc.
8635 Washington Avenue
Racine, WI 53406
Attn: RGA #

DYNASONICS™
Division of Racine Federated Inc.
8635 WASHINGTON AVENUE
RACINE, WI 53406-3738
TOLL-FREE IN NORTH AMERICA
TEL: 800-535-3569 FAX: 800-732-8354
TEL: 262-639-6770 FAX: 262-639-2267
www.dynasonics.com

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