

## **USER'S GUIDE**

Installation & Operation  
Instructions

Transit Time Flow Meter

Model TTFM 1.0

Manual Series A.3

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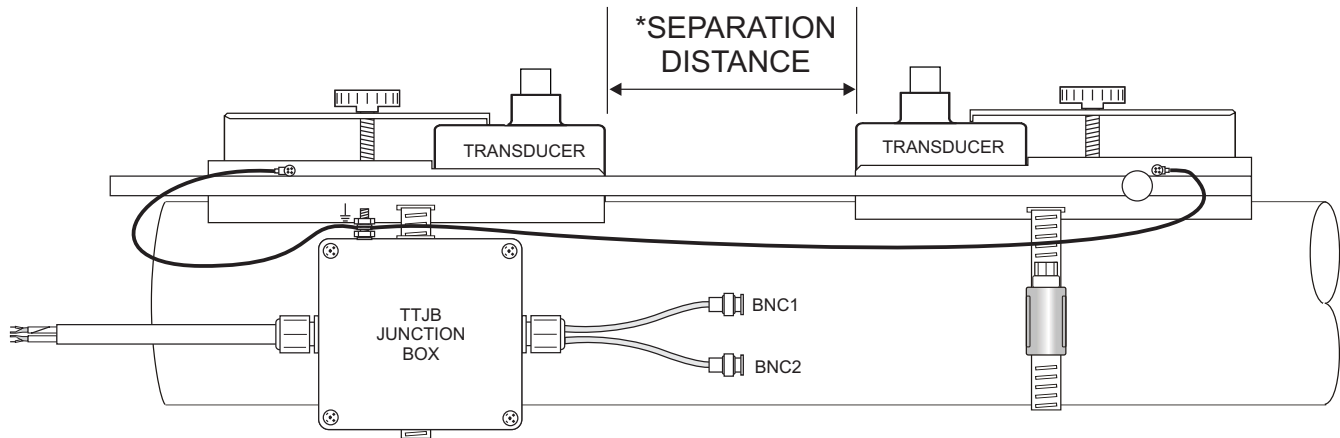
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*IMPORTANT NOTE: This instrument is manufactured and calibrated to meet product specifications. Please read this manual carefully before installation and operation. Any unauthorized repairs or modifications may result in a suspension of the warranty.*

*If this product is not used as specified by the manufacturer, protection may be impaired.*

*Available in Adobe Acrobat pdf format*

**TRANSDUCER INSTALLATION**



\* Shown in 'Message' display after pipe dimensions are entered.

**CONNECTIONS:**

POWER INPUT: The standard model requires AC power input between 100 to 240 VAC 50/60Hz . No adjustments are necessary for voltages within this range. Connect L (Live) N (Neutral) and AC Ground.

Optional DC input model requires 9-32 VDC/9 Watts. Connect to + and - terminals.

Optional Thermostat and Heater modules are available rated for 115 VAC or 230 VAC.

IMPORTANT NOTE: To comply with CSA/UL electrical safety standards, AC power input and relay connection wires must have conduit entry to the instrument enclosure. Installation requires a switch, overcurrent fuse or circuit breaker in the building (in close proximity to the equipment) that is marked as the disconnect switch.

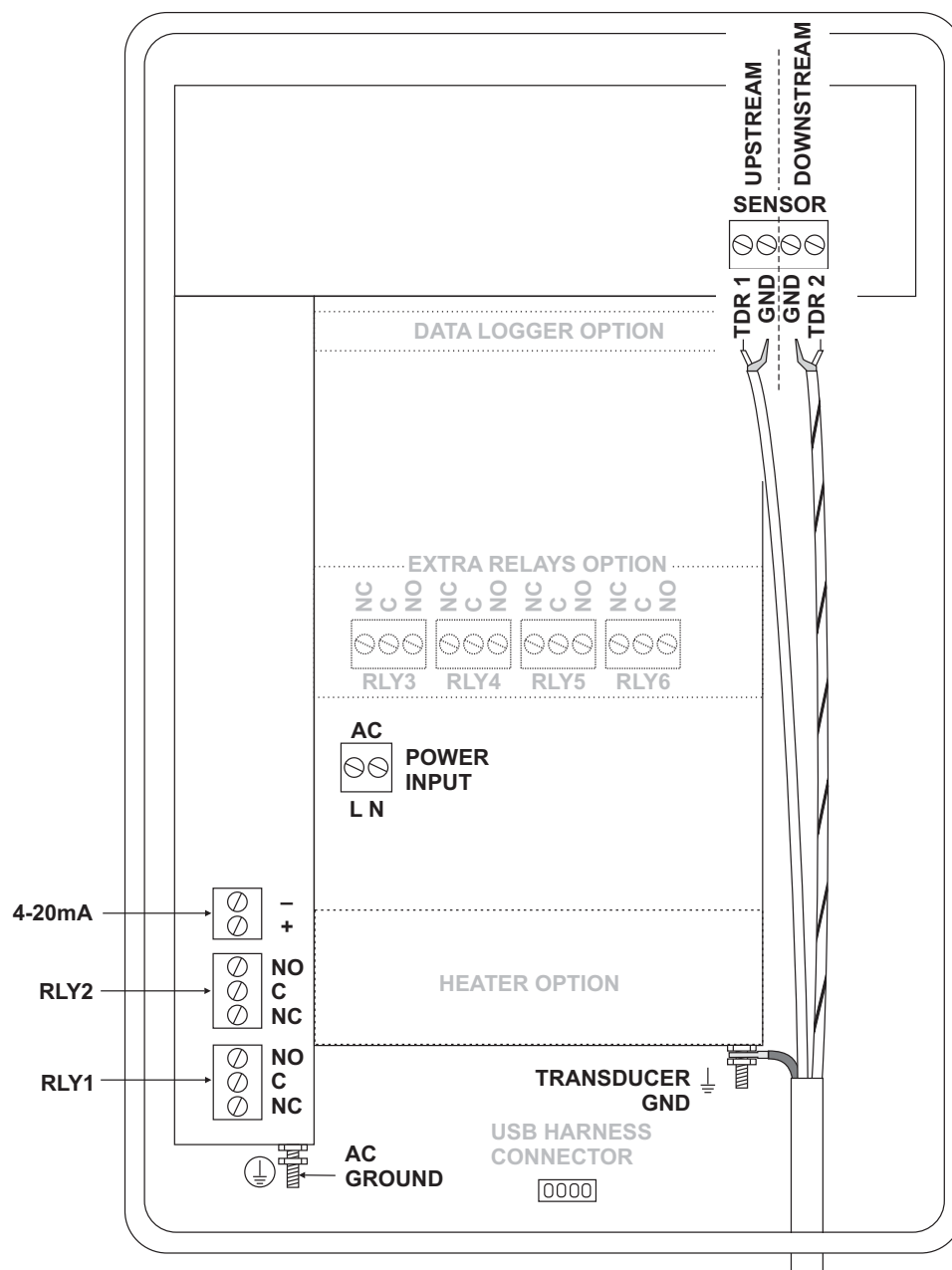


Risk of electric shock. Loosen cover screw to access connections. Only qualified personnel should access connections.

Note: Use of instrumentation over 40°C ambient requires special field wiring.

Note: User replaceable fuse is 2 Amp 250V (T2AL250V), located on the power supply.

## CONNECTIONS



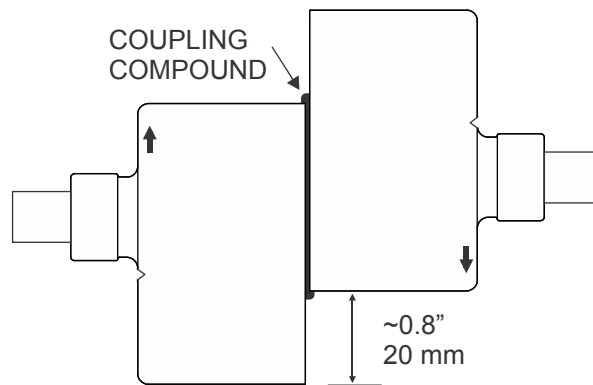
## **QUICK BENCH TEST:**

In the TTFM Calibration menu set parameters to perform a bench test:

- Set Pipe OD = 1.000 inch
- Set Pipe wall = 0.25 inch
- Set Pipe material to ABS
- Press ✓ twice to exit Calibration and return to main display.

From main display press ▼ to view Status menu. Apply coupling compound to the face of transducers and press together as indicated in the illustration below.

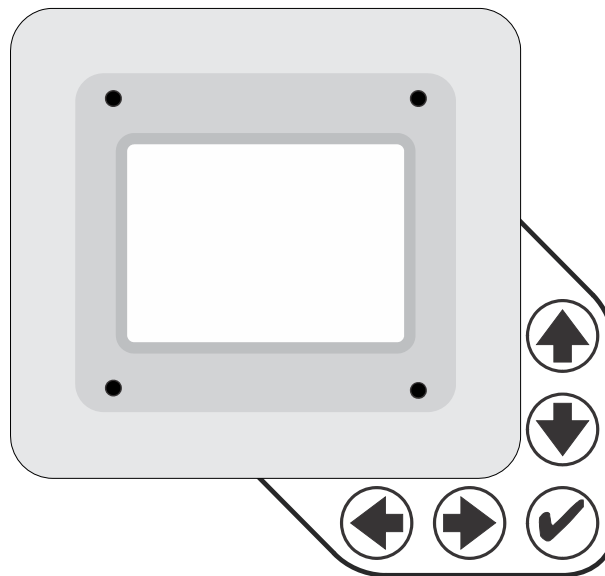
The Status menu should indicate Echo Confidence of 100% and a high Signal Strength (75-100% for TTFM with standard options).



**KEYPAD SYSTEM**

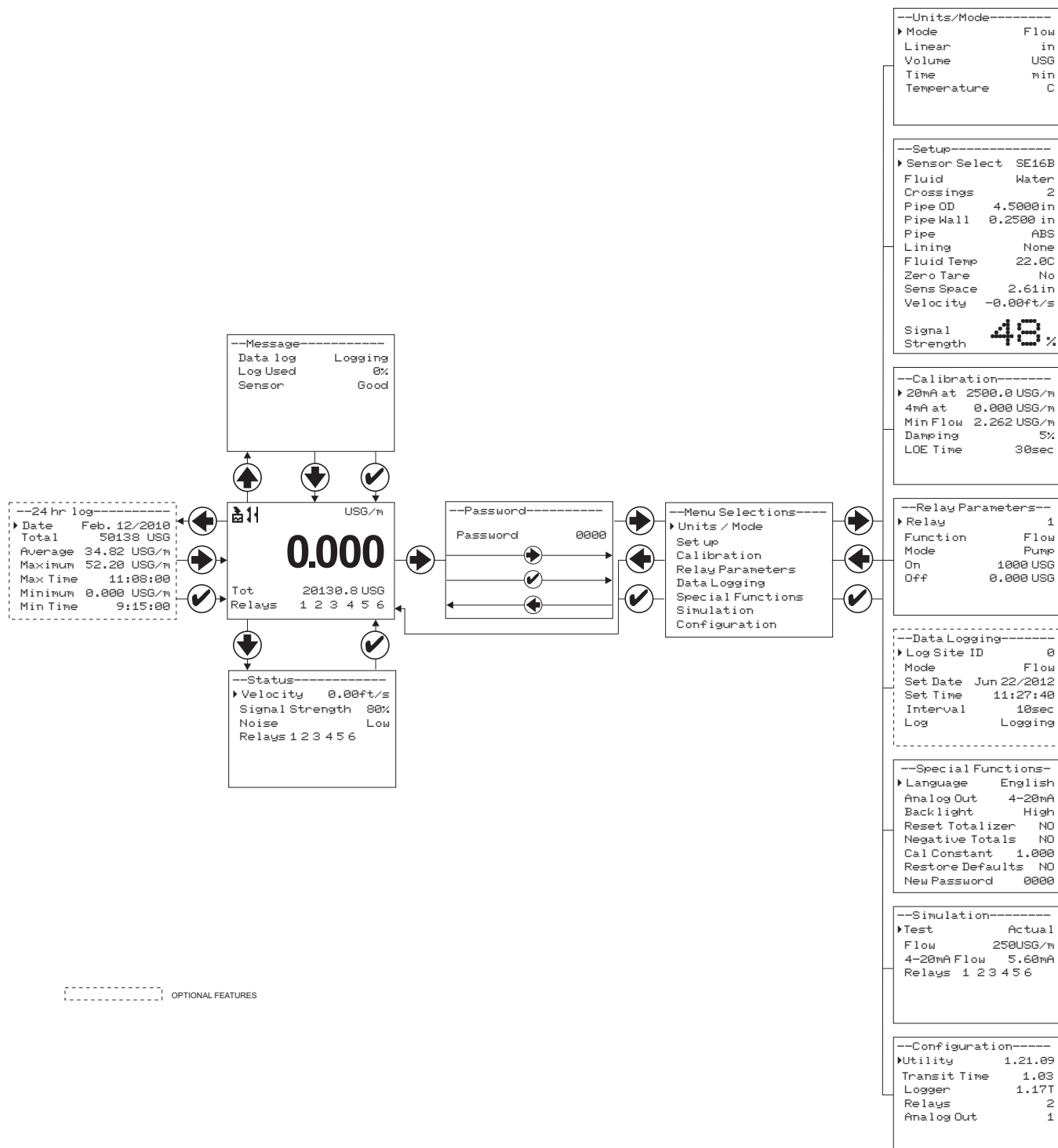
The diagram on page 9 shows the TTFM 1.0 menu system. Arrows show the four directions to leave a menu box. Pressing a corresponding keypad arrow will move to the next item in the direction shown. Move the cursor (underline) under numerals and increase or decrease numerals with the **▲** and **▼** keys.

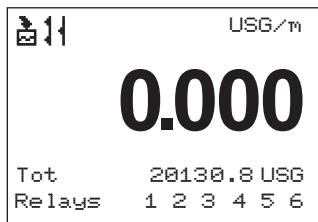
To store calibration values permanently (even through power interruptions), press the **✓**.





## CALIBRATION MENU





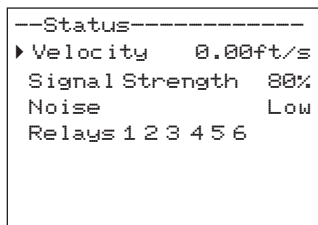
## RUN

The main display shows the units selected from the Units/Mode menu, Flow or Velocity rate being measured, TOTALIZER and RELAY states. The TTFM 1.0 will start-up with this display and will return to this screen after a timeout if keys are not pressed in other menus.



## MESSAGE

Press **↑** from the RUN display to view status of the data logger and error/warning messages provided by the instrument. The word Message will appear on the RUN display if error messages are being generated by the instrument. Refer to the manual section Error/Warning Messages for a description. Press **✓** to return to the main display.



## STATUS

Press **↓** from the RUN display to view instrument status.

**Velocity**                      Displayed in ft/sec or m/sec.

**Signal Strength**      Displays magnitude of signal being received by the ultrasonic transducer.

**Noise**                              Indicates whether noise is High or Low relative to the received signal.

**Relays**                              Energized relays will display as a white character on a black background.

```


--24 hr log-----
Date      Feb. 12/2010
Total      50138 USG
Average    34.82 USG/m
Maximum    52.20 USG/m
Max Time   11:08:00
Minimum    0.000 USG/m
Min Time   9:15:00
  
```

## 24 HR LOG (Data Logging option only)

Press **◀** from the RUN display to view a formatted flow report from instruments with a built-in data logger. Press **↓** to scroll down one day or repeatedly to scroll to a specific date. Up to 365 days can be stored. Newest date will overwrite the oldest. Press **✓** to return to the main display.

```

--Password-----
Password      0000
  
```



## PASSWORD

The password (a number from 0000 to 9999) prevents unauthorized access to the Calibration menu.

From the Run display press the **➡** key to get to **PaSswOrd**. Factory default password is 0000 and if it has not been changed press the **✓** to proceed to the Menu Selections screen.

If a password is required, press **➡** to place the cursor under the first digit and **↓** or **↑** to set the number, then **➡** to the second digit, etc. Press **➡** or **✓** to proceed to the Menu Selections screen.

A new password can be stored by going to **Special Functions/New Password**.

```
--Units/Mode-----
▶Mode                Flow
Linear              in
Volume             USG
Time               min
Temperature         C
```

## UNITS/MODE

From ▶**Mode** press the ➡ and then the ⬆ or ⬇ to select **Flow** or **Velocity**. Flow mode displays the flow rate in engineering units (e.g. gpm, litres/sec, etc.) Press the ✓ to store your selection then the ⬇ to the next menu item and ➡ to enter.

From ▶**Linear** press the ➡ key and then the ⬆ or ⬇ to select your units of measurement. Press the ✓ to store your selection.

```
--Units/Mode-----
Mode                Flow
▶Linear             in
                   ft
                   m
                   mm
```

Press the ⬇ key to move the ▶ symbol to each subsequent menu item and the ✓ to save your selections.

Note: the volume selection "bbl" denotes U.S. oil barrel.

Press ⬅ or ✓ to return to the Menu Selections screen.

```
--Units/Mode-----
▶Volume             USG
                   ft3
                   bbl
                   L
                   m3
                   IMG
                   IG
                   USMG
```

```
--Units/Mode-----
Mode                Flow
Linear              in
Volume             USG
▶Time              sec
                   day
                   hr
                   min
```

```

--Setup-----
▶ Sensor Select  SE16B
Fluid           Water
Crossings       2
Pipe OD         4.5000in
Pipe Wall       0.2500 in
Pipe            ABS
Lining          None
Fluid Temp      22.00C
Zero Tare       No
Sens Space      2.61in
Velocity        -0.00ft/s

Signal Strength  48 %
  
```

## SET UP

Sensor Select	Choose SE16B (standard) or SE16A (optional).
Fluid	Select fluid type. <del>Other</del> will require additional information:
Crossings	1 = Z mounting 2 = V mounting 4 = W mounting
Pipe OD	Place the cursor under the digits and then <b>↓</b> or <b>↑</b> to change the numbers and decimal point. <b>Pipe OD</b> should be entered as the exact outside diameter of the pipe where the transducer is mounted. Refer to the Pipe Charts Appendix in this manual for outside diameter of common pipe types and sizes.
Pipe Wall	Enter wall thickness. Refer to the Pipe Charts Appendix in this manual for thickness of common pipe materials and sizes.
Pipe	Select pipe material. <del>Other</del> – consult factory.
Lining	Enter thickness of bonded liner material. Zero represents no liner.
Fluid Temp	Enter average fluid temperature.
Zero Tare	To suppress readings or fluctuations at zero flow. Under no flow conditions select <b>Yes</b> to force readings to zero.
Sens Space	Displays the calculated sensor spacing
Velocity	Displays the measured velocity.
Signal Strength	Displays magnitude of signal being received by the ultrasonic transducer.

Press **✓** from the **Units/Mode** display to return to Menu Selections.

## NOTE:

Transducer separation distance is automatically calculated by the instrument and will be displayed from the main RUN display. From the RUN display press **↑** to view the **Message** screen and **Sens Space** will be displayed.

```

--Calibration-----
▶ 20mA at 2500.0 USG/m
 4mA at 0.000 USG/m
Min Flow 2.262 USG/m
Damping 5%
LOE Time 30sec
  
```

## CALIBRATION

Press **↓** to **▶Calibration** and **→** to enter. Use **↓** or **↑** to position **▶** before each menu item and **→** to enter. When settings are completed press **✓** to store and return to the Calibration menu.

**20mA at** Press **→** then **↓** or **↑** to change the numbers and decimal point. Use this menu to set the corresponding flow rate that will be represented by 20mA analog output. If maximum flow is unknown, enter an estimated flow rate and observe actual flow to determine the correct maximum value. Any velocity or flow rate up to +40 ft/sec (12.2 m/sec) may be selected.

**4mA at** Press **↓** or **↑** to set the flow rate corresponding to 4mA analog output. This setting may be left at zero flow (or velocity or can be raised to any value less than the 20mA setting, or lowered to any velocity or corresponding flow rate down to -40 ft/sec (-12.2 m/sec).

**Min Flow** Flow rates below this setting will be displayed as zero flow.

**Damping** Increase damping to stabilize readings under turbulent flow conditions. Decrease for fast response to small changes in flow. Damping is shown in percentage (maximum is 99%). Factory default is 20%.

**LOE Time** Loss of Echo alarm after XX seconds.

Press **✓** from the **Units/Mode** display to return to Menu Selections.

**NOTE:** Transducer separation distance is automatically calculated by the instrument and will be displayed from the main RUN display. From the RUN display press **↑** to view the **Message** screen and **Sens Space** will be displayed.

```
--Relay Parameters--
►Relay              1
Function            Flow
Mode                Pump
On                  1000 USG
Off                 0.000 USG
```

## **RELAY PARAMETERS**

**Relay** Press **➡** and **⬇** or **⬆** to select a corresponding relay number (2 relays are standard, 4 additional are optional).

**Function** Press **⬇** or **⬆** to select **Off**, **Pulse** or **Flow**.

**Flow** Mode Select **Pump**, **Low Alarm** or **Hi Alarm**.

**Pump** mode provides separate On/Off settings where the relay will energize at one flow rate and de-energize at another.

**On** Position the cursor under the numerals and press **⬇** or **⬆** to set digits to the required relay **On** set point.

**Off** set digits to the required **Off** set point.

**Low Alarm** mode relay will energize at a programmable flow rate and remain energized with flow below the set point. When flow rises above the set point, the relay will de-energize.

**Hi Alarm** mode relay will energize at a programmable flow rate and remain energized with flow above the set point. When flow falls below the set point, the relay will de-energize.

**Pulse** Press **⬇** and set digits to the flow volume increment required between relay pulses. Use this feature for remote samplers, chlorinators or totalizers. Minimum time between pulses is 2.25 seconds and pulse duration is 350 milliseconds.

Return to **Relay** and change settings for each relay number.

Press **✓** to return to **Menu Selections**.

## DATA LOGGING (OPTIONAL)

Refer to Options section of this manual.

```
--Special Functions--
▶ Language      English
Analog Out      4-20mA
Backlight       High
Reset Totalizer NO
Negative Totals NO
Cal Constant    1.000
Restore Defaults NO
New Password     0000
```

## SPECIAL FUNCTIONS

Language	Select English, French or Spanish
Analog Out	Select 4-20mA or 0-5V mode for the analogue output.
Backlight	Select High, Medium or Low for continuous backlight.  Select KeyHi/Lo for high backlight for 1 minute after a keypress and then Lo backlight until a key is pressed again.  Select KeyHigh, Med or Low for backlight for 1 minute after a keypress and then backlight off until a key is pressed again.
Reset Totalizer	Press ➡ and select Yes to erase and restart the totalizer at zero.
Negative Totals	Select Yes to have reverse flow readings deducted from the totalizer. Select No to totalize forward flow only and ignore reverse flow.
Cal Constant	Set to 1.000 for SE16B transducer.
Restore Defaults	Select Yes and press ✓ to erase all user settings and return the instrument to factory default settings.
New Password	Select any number from 0000 to 9999 and press ✓. Default setting of 0000 will allow direct access to the calibration menus. Setting of any password greater than 0000 will require the password to be entered to access the calibration menus.

Press ✓ to return to Menu Selections.



## **SIMULATION**

```
--Simulation-----  
▶Test           Actual  
Flow           250USG/m  
4-20mA Flow    5.60mA  
Relays 1 2 3 4 5 6
```

Exercises the 4-20mA output, digital display and control relays (does not affect the totalizer or optional data logger).

Simulate a **Flow/Velocity** reading. Press **➡** and then **⬇** or **⬆** to change the simulated output. Press **✓** to begin simulation. The 4-20mA output and relay states will be displayed on the screen below.

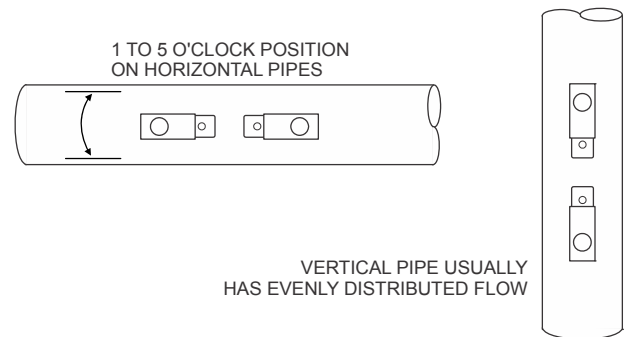
Press the **✓** to terminate simulation and return to the **Menu Selections** screen.

## **TRANSDUCER MOUNTING LOCATION**

The position of the transducer is one of the most important considerations for accurate Transit Time flow measurement. The same location guidelines apply to Transit Time as most other types of flow meters.

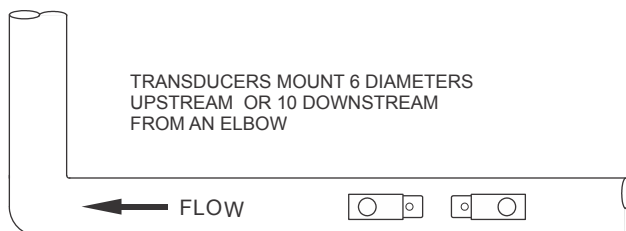
Before permanently mounting a Transit Time transducer onsite testing is recommended to determine optimum mounting position. Use the transducer coupling compound (supplied with each Greyline flow meter, or petroleum gel, acoustic compound or electrocardiograph gel). Take several readings around the axis of the pipe and then at several points upstream and downstream from the selected position, checking for consistent readings. Avoid high or low reading areas. Mount the transducers where consistent (average) readings were obtained or continue testing on another pipe section.

**VERTICAL OR HORIZONTAL PIPE** - Vertical pipe runs generally provide evenly distributed flow. On Horizontal pipes and liquids with high concentrations of gas or solids, the transducers should be mounted on the side (1 to 5 o'clock positions) to avoid concentrations of gas at the top of the pipe, or solids at the bottom.



**VELOCITY INCREASING DEVICES:** Generally the transducers must be mounted away from flow disturbances such as valves, pumps, orifice plates, venturis or pipe inlets and discharges which tend to increase flow velocity. Velocity increasing devices often cause cavitation, or rapid release of gas bubbles, and readings both up and downstream may be intermittent or inaccurate. As a guideline, mount the transducer at least 20 diameters upstream or 30 diameters downstream from velocity increasing devices.

Required distance from a velocity increasing device will vary in applications depending on the flow velocity and the characteristics of the liquid itself.



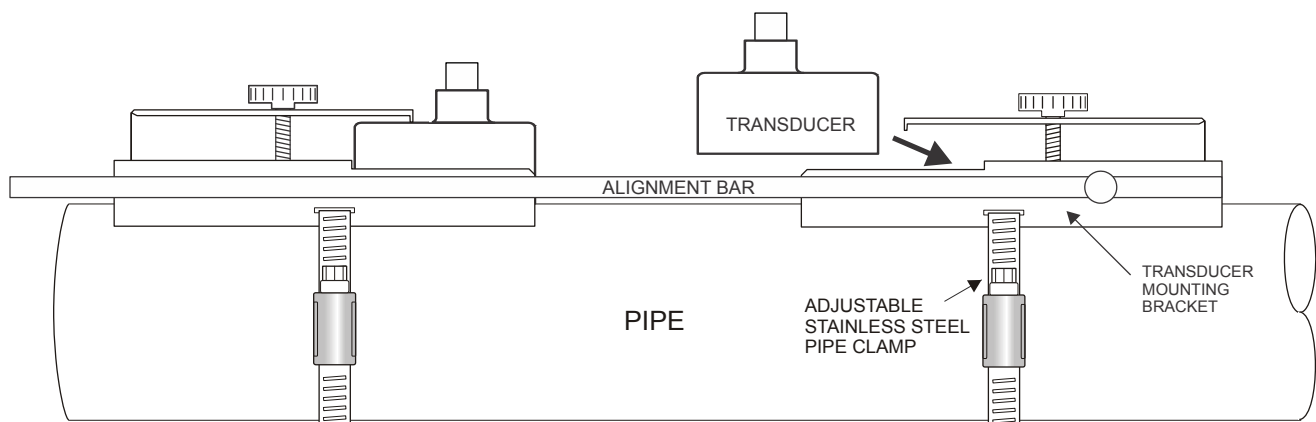
**TURBULENCE INCREASING DEVICES:** Elbows, flanged connections and tees tend to introduce desirable conditions of an evenly distributed flow profile. Transducer mounting 6 pipe diameters upstream and 10 diameters downstream from these disturbances is generally optimum.

The transducers are designed to mount longitudinally on a straight section of pipe. Do not attempt to mount it on bends, elbows or fittings.

## **TRANSDUCER MOUNTING**

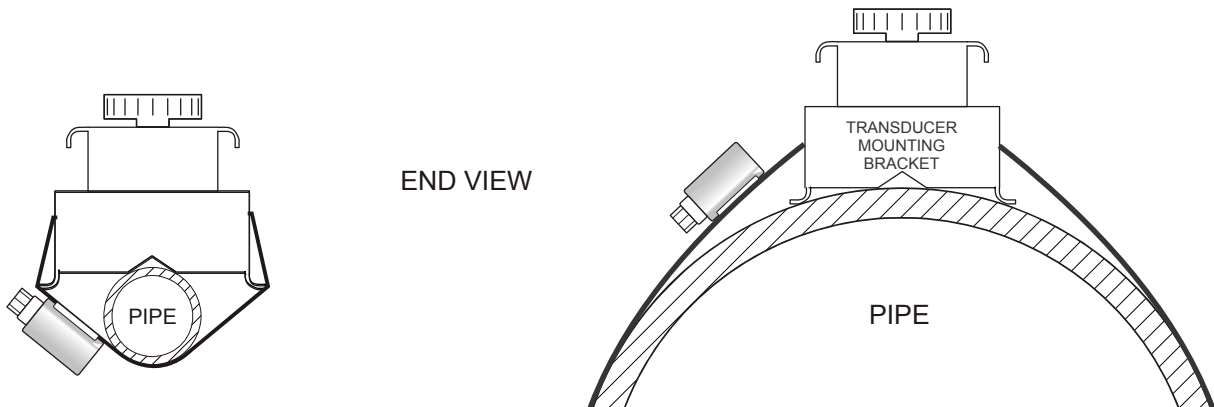
Prepare an area 2" wide by 4" long (50mm x 100mm) for transducer bonding by removing loose paint, scale and rust. The objective of site preparation is to eliminate any discontinuity between the transducer and the pipe wall, which would prevent acoustical coupling.

A TMK1 Transducer Mounting Kit is supplied with each Greyline flow meter. It includes recommended coupling compound in a plastic applicator and a stainless steel mounting bracket with adjustable pipe straps. Use the Alignment Bar (included) to align transducer brackets for V and W mode mounting.



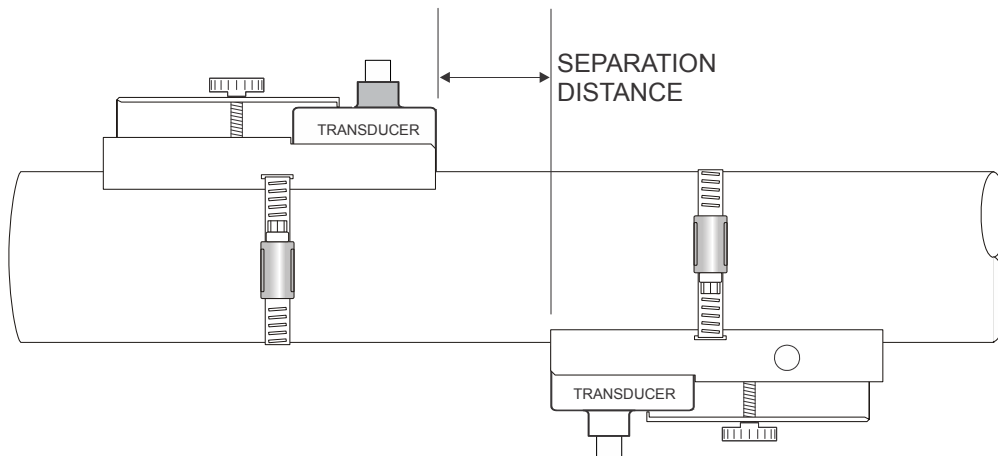
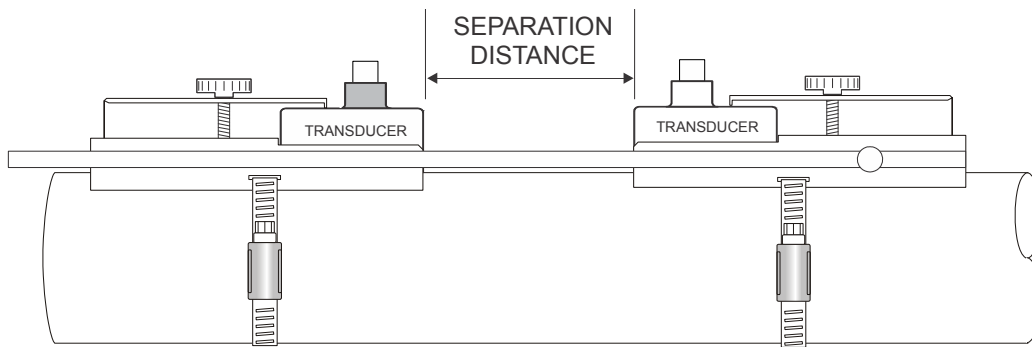
Mount the PC16 Mounting Bracket as illustrated on pipes 0.6" / 15 mm OD or larger. Stainless steel bands are included for mounting on pipes up to 30" / 750 mm OD.

Additional stainless steel bands (by customer) may be combined to mount on larger pipes.



## **SEPARATION DISTANCE**

Measure separation distance with a ruler or tape measure. Separation distance is automatically calculated by the TTFM 1.0 based on parameters entered in the **Calibration** menu. To view separation distance from the **RUN** display press **↑** to view the **Message** screen where **Sens Space** is displayed.

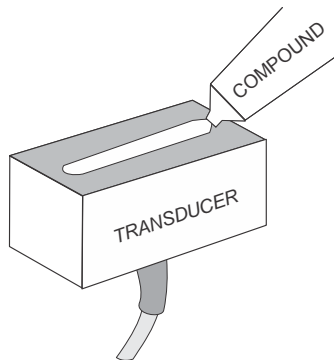


## **TRANSDUCER COUPLING**

For permanent or temporary bonding, the following are recommended:

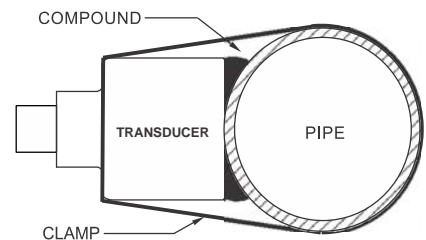
- a) Dow Corning silicon compound #4 (supplied)  
Additional supply: order Greyline Option CC
- b) Water-based sonic compound: Order Greyline Option CC30
- c) Electrocardiograph gel
- d) Petroleum gel (Vaseline)

The above are arranged in their order of preferred application.  
d & e are only good for temporary bonding at room temperature.  
**DO NOT USE:** Silicon RTV caulking compound (silicon rubber).



Use the pipe clamp and rail (supplied) as illustrated above or use a loop of electrical tape for temporary mounting. Apply silicon coupling compound #4 to the colored face of the transducer. A bead, similar to toothpaste on a toothbrush, is ideal. Do not overtighten (crush the transducer).

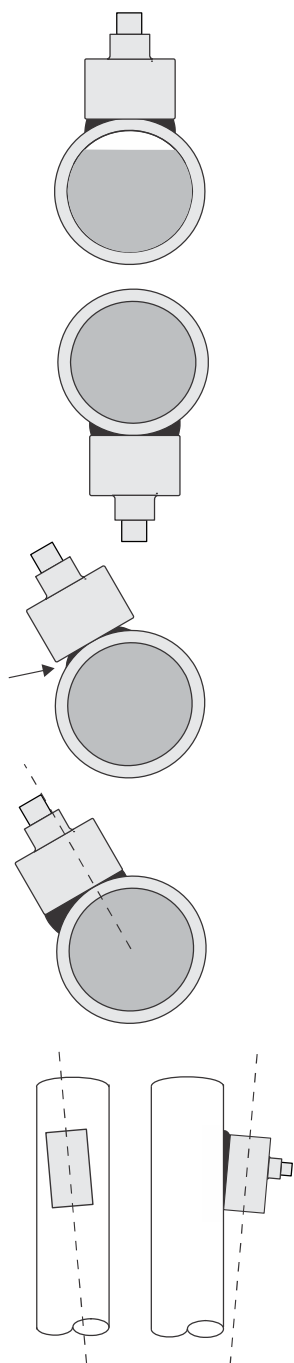
The transducer must be fixed securely to the pipe with coupling material between the transducer face and the pipe. Transducer installation with excessive coupling compound can result in gaps or voids in the coupling and cause errors or loss of signal. Insufficient coupling compound will create similar conditions.



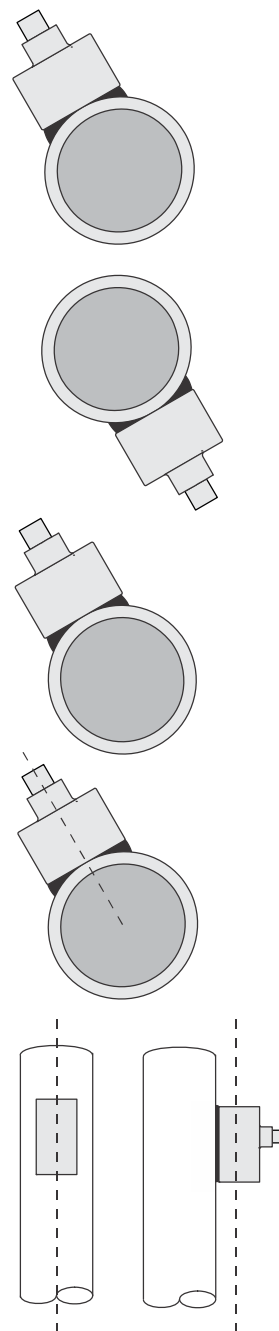
Over time temporary coupling compounds (e.g. Petroleum Gel) may gradually sag away from the transducer resulting in reduced signal strength and finally complete loss of signal. Warm temperatures, moisture and vibration will accelerate this process. Dow Corning Silicone Compound #4 as supplied with the TTFM 1.0 (and available from Greyline Instruments) is recommended for semi-permanent installations.

**TRANSDUCER MOUNTING/COUPLING RECOMMENDATIONS**

**BAD**



**GOOD**



## **ENCLOSURE INSTALLATION**

Locate the enclosure within 20 ft (6 m) of the transducer (500 ft -150 m optional). The enclosure can be wall mounted with the four mounting screws (included) or panel mounted with Option PM Panel Mount kit from Greyline Instruments.

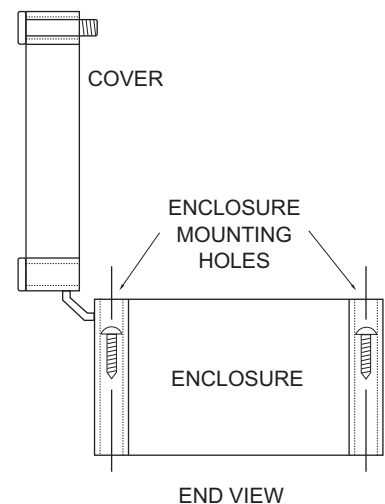
Avoid mounting the enclosure in direct sunlight to protect the electronics from damage due to overheating and condensate. In high humidity atmospheres, or where temperatures fall below freezing, Option TH Enclosure Heater and Thermostat is recommended. Seal conduit entries to prevent moisture from entering enclosure.

### **NEMA4X (IP66) WITH CLEAR COVER**

1. Open hinged enclosure cover.
2. Insert #8 screws (supplied) through the four enclosure mounting holes to secure the enclosure to the wall or mounting stand.

Additional conduit holes can be cut in the bottom of the enclosure when required. Use a hole saw or Greenlee-type hole cutter to cut the required holes.

**DO NOT** make conduit/wiring entries into the top of the enclosure.



Note: This non-metallic enclosure does not automatically provide grounding between conduit connections. Grounding must be provided as part of the installation. Ground in accordance with the requirements of the National Electrical Code. System grounding is provided by connecting grounding wires from all conduit entries to the steel mounting plate or another point which provides continuity.

## **CLEANING**

Cleaning is not required as a part of normal maintenance.

## FIELD TROUBLESHOOTING

Possible Causes:	Corrective Action:
<b>METER READING WHEN THERE IS NO FLOW?</b>	
Erratic measurement (set damping to 0% to check) due to electrical noise or poor signal quality.	<ul style="list-style-type: none"> <li>• Ensure all Flowmeter wiring is in METAL conduit and transducer shield is properly connected to Ground.</li> <li>• Ensure correct power input Ground connection (&lt;1 ohm resistance).</li> <li>• Ensure 4-20mA Shield connected to Instrument Ground stud.</li> <li>• Try adjusting transducer spacing (+/- 10%) and contact Greyline for further assistance.</li> </ul>
Variable Speed Drive interference	<ul style="list-style-type: none"> <li>• Follow Drive manufacturers wiring and Grounding instructions</li> <li>• Relocate Flowmeter electronics, Transducer and wiring away from VSD</li> </ul>
Transducer cable connections incorrect or loose	<ul style="list-style-type: none"> <li>• Refer to Connections diagram. Disconnect and reconnect transducer cables ensuring that cable is properly inserted into terminals and tightened.</li> </ul>
<b>METER READING LOWER THAN EXPECTED?</b>	
Calibration Error	Review calibration menu. Pipe dimensions and fluid selection/fluid velocity.
Lower flow rate than expected	Investigate pump/valves. Compare velocity with alternate instrument.
Erratic measurement (set damping to 0% to check) due to electrical noise or poor signal quality.	<ul style="list-style-type: none"> <li>• Ensure all Flowmeter wiring is in METAL conduit and transducer shield is properly grounded.</li> <li>• Ensure correct power input Ground connection (&lt;1 ohm resistance).</li> <li>• Ensure 4-20mA Shield connected to Instrument Ground stud.</li> <li>• Try adjusting transducer spacing (+/- 10%) and contact Greyline for further assistance.</li> </ul>

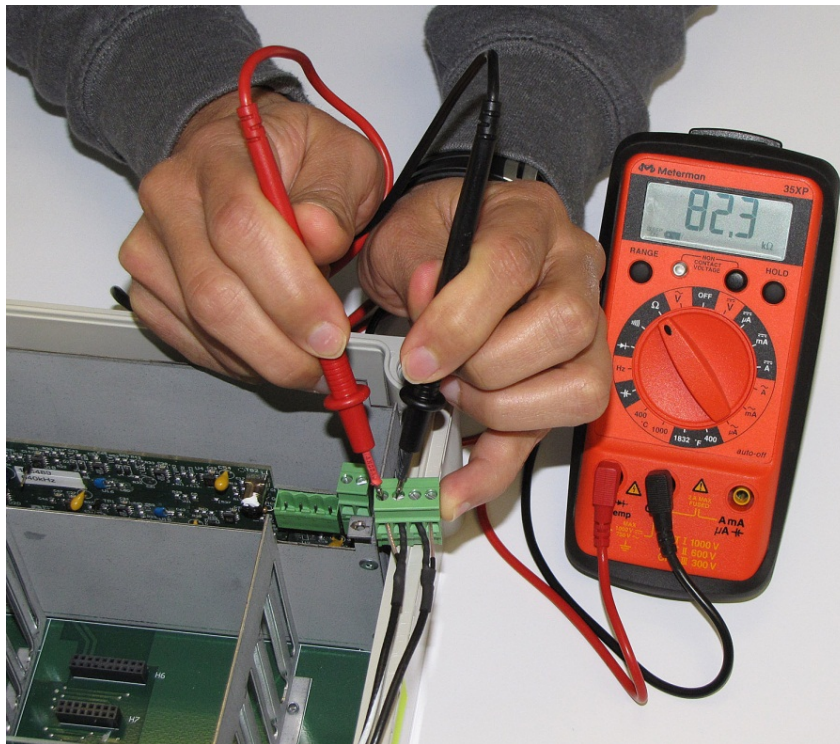


<i>NO ECHO INDICATION (EC = 0)?</i>	
Transducer Connections	<ul style="list-style-type: none"> <li>• Check transducer connections at TTFM and at transducer junction box.</li> <li>• Note: Refer to Transducer Cable Resistance Test to test final connections.</li> </ul>
Transducers not mounted to Pipe or mounted improperly	<ul style="list-style-type: none"> <li>• Apply coupling compound and mount transducers to pipe with proper transducer spacing.</li> </ul>
Empty pipe or partially filled	<ul style="list-style-type: none"> <li>• Pipe must be fluid filled and acoustically transparent in order to obtain echoes.</li> </ul>
Coupling compound washed out, or transducer loose on pipe.	<ul style="list-style-type: none"> <li>• Remount transducer</li> <li>• Use Dow Corning Silicone #4</li> </ul>
<i>METER READING HIGHER THAN EXPECTED?</i>	
Calibration Error	<ul style="list-style-type: none"> <li>• Review calibration menu. Pipe dimensions and fluid selection/fluid velocity.</li> </ul>
Higher flow rate than expected	<ul style="list-style-type: none"> <li>• Investigate pump/valves. Compare velocity with alternate instrument.</li> </ul>
Erratic measurement (set damping to 0% to check) due to electrical noise or poor signal quality.	<ul style="list-style-type: none"> <li>• Ensure all Flowmeter wiring is in METAL conduit and transducer shield is properly grounded.</li> <li>• Ensure correct power input Ground connection (&lt;1 ohm resistance).</li> <li>• Ensure 4-20mA Shield connected to Instrument Ground stud.</li> <li>• Try adjusting transducer spacing (+/- 10%) and contact Greyline for further assistance.</li> </ul>
Pipe not Full	<ul style="list-style-type: none"> <li>• Verify pipe is full by mounting transducers at top of pipe and check echo confidence. EC = 0 if pipe is not full.</li> </ul>
High viscosity fluid	<ul style="list-style-type: none"> <li>• Laminar flow profile due to high viscosity fluid requires an adjustment to Cal Const.</li> </ul>

## **TRANSDUCER CABLE RESISTANCE TEST**

Unplug the green transducer terminal from the Transit Time board and connect the transducer wires as shown. With a multimeter, perform resistance checks for each set of wires. One single loose terminal may cause false readings.

Test across shield and core of each wire: TMTR (black/white) and RCVR (black). Resistance should be around 10K ohms for any cable length. High readings indicate an open circuit and low readings indicate a short or partial short in the transducer cable connections.



**COMMON QUESTIONS AND ANSWERS**

*The pipe vibrates. Will it affect the flow meter?*

Common vibration frequencies are far lower than the sonic frequencies used by the Greyline flow meter, and will not normally affect accuracy or performance. However, applications where very weak Transit Time signal is present (when sensitivity is adjusted to maximum and signal strength is low), accuracy may be affected by pipe vibration, or the flow meter may show readings under no-flow conditions. Attempt to relocate the transducer on a pipe section where vibration is reduced, or arrange pipe mounting brackets to reduce vibration at the transducer mounting location.

*The flow meter must be installed in a high noise environment. Will this affect operation?*

Greyline flow meters are designed to discriminate between environmental noise and the Transit Time signal. High noise environments may affect the flow meter's performance where low signal strength and/or low flow velocities are being measured. Relocate the transducer in a more quiet environment if possible.

*Will pipe corrosion affect accuracy of the flow meter?*

Yes. Rust, loose paint etc. must be removed from the outside of the pipe to provide a clean mounting position when installing a Transit Time transducer. Severe corrosion/oxidation on the inside of the pipe may prevent the Transit Time signal from penetrating into the flow. If the pipe cannot be cleaned, a spool piece (PVC recommended) should be installed for transducer mounting.

*What effect do pipe liners have on the flow meter?*

The air gap between loose insertion liners and the pipe wall prevent the Transit Time signal from entering the flow. Better results can be expected with bonded liners such as cement, epoxy or tar, however an on site test is recommended to determine if the application is suitable for a Transit Time flow meter.

*Why is Transit Time recommended for clean liquids?*

The Transit Time transducer transmits sound across the flow stream in order to measure sound velocity and therefore requires a fluid medium that is relatively transparent to the acoustic signal. The Transit Time system will not function when there is high volume of solids or aeration. As a guideline, Greyline Transit Time flow meters are recommended for clean liquids with solids or bubbles content less than 2%. Most applications such as water, chemicals and oils will meet this minimum requirement.

*Can the transducer be submerged in water?*

Yes, for short periods of time or by accident, but it is not recommended for continuous operation. The transducer is constructed to withstand submersion to 10 psi (0.7 Bar) without damage.

*What is the purpose of the Signal Strength Display?*

The primary function of the signal strength display is to assist as a feedback when mounting transducers. Signal Strength can also be a useful diagnostics tool when troubleshooting problems with an installation. A low signal strength (< 20%) will cause the TTFM to be more susceptible to environmental noise and may indicate a problem with the installation or other qualitative issues.

*Can I change the length of the transducer cable?*

Yes. Technological advances in Greyline Transit Time design allow cable lengths up to 250 ft (75 m). Extended cable (Greyline Option DXC) should be installed in rigid or flexible conduit for mechanical protection. Use only Greyline shielded coaxial pair (RG174U) cable. BNC coaxial connectors (TV cable type) are not recommended for cable splices.

*Does the TTFM 1.0 require periodic recalibration?*

No. TTFM 1.0 calibration does not drift over time. The solid state transducer has no moving parts to wear and affect calibration. All Greyline timing/counting circuits use crystal-controlled frequency references to eliminate any drift in the processing circuitry.



*TTFM 1.0 Transit Time Flow Meter*

## **APPLICATIONS HOTLINE**

For applications assistance, advice or information on any Greyline Instrument contact your Sales Representative, write to Greyline or phone the Applications Hotline below:

United States:	Tel: 315-788-9500	Fax: 315-764-0419
Canada:	Tel: 613-938-8956	Fax: 613-938-4857
Toll Free:	888-473-9546	
Email:	info@greyline.com	
Web Site:	www.greyline.com	

Greyline Instruments Inc.

Canada  
16456 Sixsmith Drive  
Long Sault, Ont. K0C 1P0

USA:  
105 Water Street  
Massena, NY 13662

## **PRODUCT RETURN PROCEDURE**

Instruments may be returned to Greyline for service or warranty repair.

### **1 Obtain an RMA Number from Greyline -**

Before shipping a product to the factory please contact Greyline by telephone, fax or email to obtain an RMA number (Returned Merchandise Authorization). This ensures fast service and correct billing or credit.

When you contact Greyline please have the following information available:

1. Model number / Software Version
2. Serial number
3. Date of Purchase
4. Reason for return (description of fault or modification required)
5. Your name, company name, address and phone number

### **2 Clean the Transducer/Product -**

**Important: unclean products will not be serviced and will be returned to the sender at their expense.**

1. Rinse transducer and cable to remove debris.
2. If the transducer has been exposed to sewage, immerse both transducer and cable in a solution of 1 part household bleach (Javex, Clorox etc.) to 20 parts water for 5 minutes. Important: do not immerse open end of transducer cable.
3. Dry with paper towels and pack transducer and cable in a sealed plastic bag.
4. Wipe the outside of the enclosure to remove dirt or deposits.
5. Return to Greyline for service.

### **3 Ship to Greyline -**

After obtaining an RMA number please ship the product to the appropriate address below:

Canadian and International  
Customers:

Greyline Instruments Inc.  
16456 Sixsmith Drive  
Long Sault, Ont. K0C 1P0

RMA#

USA  
Customers:

Greyline Instruments Inc.  
204 150th Avenue  
Madeira Beach, FL 33708

RMA#

## FLOW METER DATA SHEET

<input type="checkbox"/> 16456 Sixsmith Drive, Long Sault, ON K0C 1P0 Tel: 613-938-8956 / Fax: 613-938-4857 <input type="checkbox"/> 105 Water Street, Massena, NY 13662 Tel: 315-788-9500 / Fax: 315-764-0419		<b><i>Please complete and return this form to Greyline. It is important. We use this information to check our database for performance of Greyline flow meters in similar applications, and to provide advice and recommendations to you. Thank you for your cooperation.</i></b>	
Contact Information	Contact		
	Title/Dept		
	Company		
	Address		
	Address		
	Tel		
	Fax		
	Email		
	Mobile		
Service Conditions	Pipe Run	<input type="checkbox"/> Vertical	<input type="checkbox"/> Horizontal
	Pipe Full	<input type="checkbox"/> Yes	<input type="checkbox"/> No
	Fluid Type		
	% of Solids		
	Nominal Pipe Size and Schedule		
	Pipe Outside Diameter		
	Wall Thickness		
	Pipe Material		
	Liner Material		
	Liner Thickness		
	Normal Flow		
	Maximum Flow		
	Minimum Flow		
	Maximum Temperature		
	Maximum Pressure		
	Vibration	<input type="checkbox"/> Yes	<input type="checkbox"/> No
	Hazardous Rating		
Notes / Additional Comments / Pipe Run Diagram:			

## LIMITED WARRANTY

---

Greyline Instruments warrants, to the original purchaser, its products to be free from defects in material and workmanship for a period of one year from date of invoice. Greyline will replace or repair, free of charge, any Greyline product if it has been proven to be defective within the warranty period. This warranty does not cover any expenses incurred in the removal and re-installation of the product.

If a product manufactured by Greyline should prove defective within the first year, return it freight prepaid to Greyline Instruments along with a copy of your invoice.

This warranty does not cover damages due to improper installation or handling, acts of nature, or unauthorized service. Modifications to or tampering with any part shall void this warranty. This warranty does not cover any equipment used in connection with the product or consequential damages due to a defect in the product.

All implied warranties are limited to the duration of this warranty. This is the complete warranty by Greyline and no other warranty is valid against Greyline. Some states do not allow limitations on how long an implied warranty lasts or limitation of incidental or consequential damages, so the above limitations or exclusions may not apply to you.

This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

Greyline Instruments Inc.

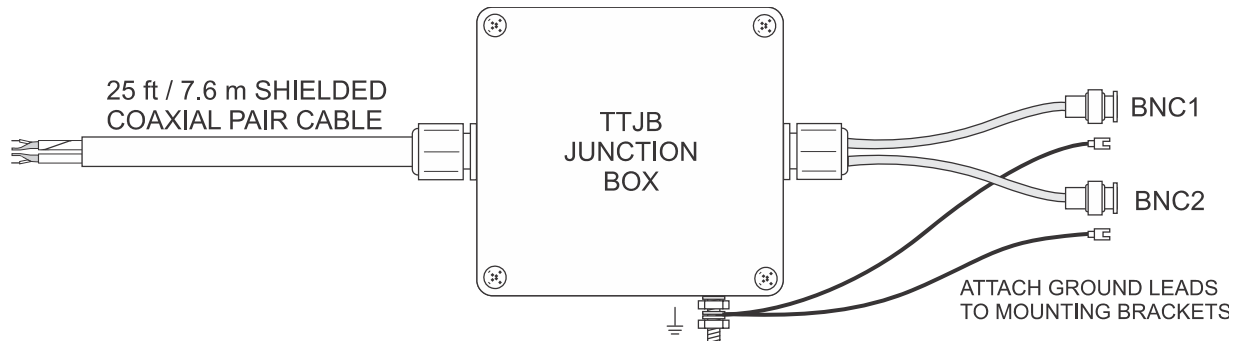


## **APPENDIX A – OPTIONS**

### **EXTRA TRANSDUCER CABLE (OPTION DXC)**

Each Greyline flow meter includes 25 ft / 7.6m (or 50 ft / 15 m optional) continuous shielded coaxial pair cable. Additional cable may be ordered with the Flow Meter, or the cable may be spliced and extended up to 250 ft (75 m) as required during installation. No adjustment is required when the transducer cable is extended or shortened. Use only Greyline shielded coaxial pair (RG174U) cable.

Extended transducer cable should be installed in conduit for mechanical protection. Recommended installation with a NEMA4X junction box is illustrated below:



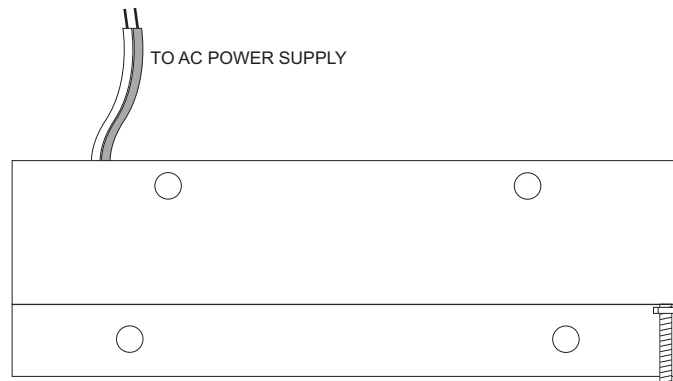
### **COAXIAL CABLE PREPARATION**

DXC Transit Time transducer cable can be cut and spliced up to a maximum length of 250 ft (75 m). Cable ends must be prepared as illustrated below.



## **ENCLOSURE HEATER AND THERMOSTAT - Option TH**

Instruments can be factory-equipped with an Enclosure Heater and Thermostat or the module can be customer-installed. The Thermostat is factory set to turn ON at 40°F (4.5°C) and OFF at 60°F (15.5°C). Power consumption is 15 Watts.



## **ENCLOSURE SUNSCREEN - Option SCR**

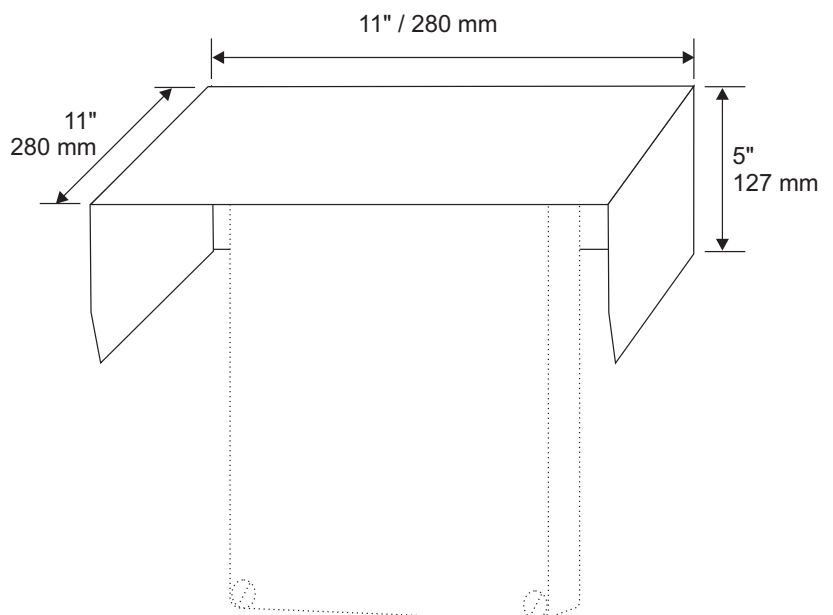
Do not mount instrument electronics in direct sunlight. Overheating will reduce the life of electronic components and condensate may form during the heat/cool cycles and cause electrical shorts.

### Note:

Exposure to direct sunlight can cause overheating and moisture condensation which will reduce the operating life of electronics.

Protect Instruments from direct sunlight with this iridite finished aluminum sun screen (Greyline Option SCR).

Seal conduit entries with caulking compound to further reduce moisture condensation.

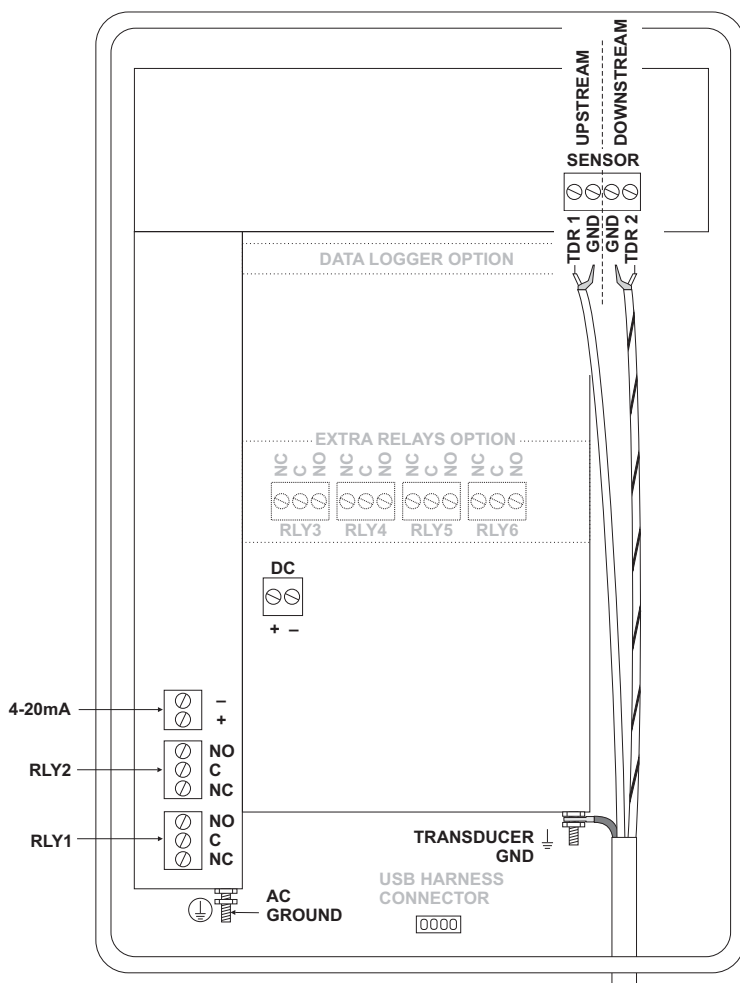


## POWER INPUT OPTION 9-32VDC

TTFM 1.0 Flow Meters may be ordered factory-configured for 9-32VDC power input.

### CONNECTIONS:

**POWER INPUT:** Connect 9-32VDC to the + and - terminals. The Power Input GND terminal must be connected to the nearest Ground pole. A 1 amp fuse in line is recommended.



```

--Data Logging-----
▶Log Site ID      00
                  99
Mode              Level
                  Range
                  Flow
                  HRT
                  Volume
Set Date   Feb 18/2008
           Mar 19/2009
Set Time   11:27:40
           12:28:41
Interval   10sec
           60min
           30min
           15min
           10min
           5min
           2min
           1min
           30sec
Log         Start
           Stop
           Delete
  
```

## DATA LOGGING (Optional)

### Setup

Select **Data Logging** from Menu Selections.

**Log Site ID** Enter a number from **00** to **99**. The site ID will become part of the downloaded file name to help distinguish downloads from different instruments. Press **✓** to store the setting.

**Mode** Select Velocity (e.g. ft/sec or m/sec). **Flow** (e.g. USGPM or l/sec). Press **✓** to store the setting.

**Set Date** Press **↑** or **↓** to scroll and select Month, Day and Year. Press **✓** to store the setting.

**Set Time** Press **↑** or **↓** to select the current time in Hours, Minutes and Seconds. Press **✓** to store the setting.

**Interval** Press **↑** or **↓** to select the logging interval. Flow rate reading will be stored at each time interval. Press **✓** to store the setting.  
Note: Press **↓** to **Log** **➡** and **↑** or **↓** to **Delete** and **✓** to delete the log file. Press **➡** and **↑** or **↓** to **Start** and **✓** to restart the logger.

**Log** **Stop**, **Start** or **Delete** the log file. Delete old file and start a new log to apply any changes that have been made to the **Log Site ID**, **Mode** or **Interval**.

## RETRIEVE LOG FILE

Plug a USB Flash Memory Drive (not supplied by Greyline) into the USB output cable from the instrument. The instrument display will show the message **Downloading** until the log file is transferred to the memory card and then display **Completed**. The USB flash drive may be removed.

Download file names will appear in this format:

```

TTFM_ _00A.LOG
  ↑      ↑  ↑
MODEL TAG DOWNLOAD
  
```

Tag is set according to the **Log Site ID** entered in the instrument **Data Logging** menu.

Download letter will be A for the first download from an instrument. B for the second, then C etc. At the letter Z a - character will appear indicating that the maximum number of downloads for that instrument are on the USB flash drive. Older files can be erased or moved from the flash memory drive or a new memory drive can be used.

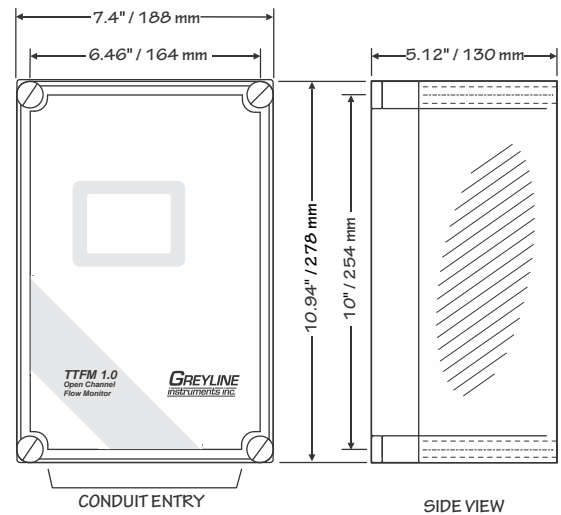
### ***OPENING LOG FILES***

Install Greyline Logger on your PC or laptop. Refer to the Help menu in the program for detailed instructions.

Select File/Open/Instrument Log (.log) to open the log file from your USB flash drive.

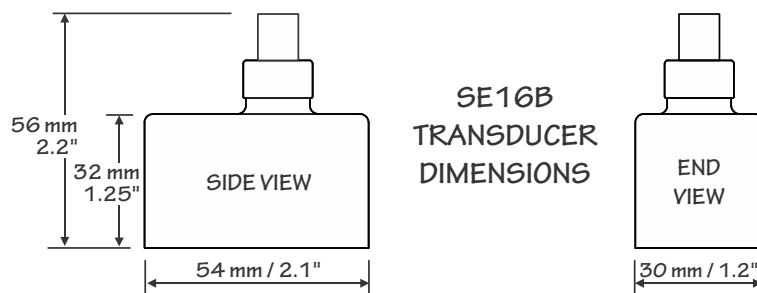
### SPECIFICATIONS

<b>Flow Rate Range:</b>	±0.07 to 39 ft/sec (±0.02 to 12 m/sec) typical
<b>Pipe Size:</b>	½" to 24" (12 to 610 mm)
<b>Accuracy:</b>	±1% of flow rate, Repeatability and Linearity: ±0.25%
<b>Displays:</b>	White, backlit matrix - displays flow rate, totalizer, relay states, operating mode and calibration menu
<b>Calibration:</b>	built-in 5-key calibrator with English, French or Spanish language selection
<b>Power Input:</b>	100-240VAC, 50/60Hz, 30 Watts or 9-32VDC, 9 Watts max
<b>Output:</b>	Isolated 4-20mA (1000 ohm load max.)
<b>Control Relays:</b>	Qty 2, rated 5 amp 240Vac SPDT, programmable flow alarm and/or proportional pulse
<b>Enclosure:</b>	watertight, dust tight NEMA4X (IP 66) polycarbonate with a clear shatter-proof face
<b>Environmental Conditions:</b>	Relative humidity up to 80%, -23 to 60°C ambient temperature, maximum 5000 m altitude, pollution degree 4, Installation Category II.
<b>Electrical Surge Protection:</b>	Transducer, 4-20mA output and AC power input
<b>Approximate Shipping Weight:</b>	12 lbs (5.5 kg)



### SE16 Transit Time Transducer

<b>Pipe Diameter:</b>	½" to 24" (12 mm to 610 mm)
<b>Operating Temperature:</b>	-40° to 300°F (-40° to 150°C)
<b>Operating Frequency:</b>	1.28 MHz
<b>Transducer Cable:</b>	25 ft (7.6 m) with Junction Box, BNC connectors and seal jackets Optional 50 ft (15 m) continuous
<b>Submersion Rating:</b>	Withstands accidental submersion pressure up to 10 psi (0.7 Bar)



**APPENDIX B - CONVERSION TABLE**

CONVERSION GUIDE		
FROM	TO	MULTIPLY BY
US GALLONS	CUBIC FEET	0.1337
US GALLONS	IMPERIAL GALS	0.8327
US GALLONS	LITRES	3.785
US GALLONS	CUBIC METERS	0.003785
LITRES/SEC	GPM	15.85
LITRES	CUBIC METERS	0.001
BARRELS	US GALLONS	42
BARRELS	IMPERIAL GALS	34.9726
BARRELS	LITRES	158.9886
INCHES	MM	25.4
DEGREES F	DEGREES C	$(^{\circ}\text{F}-32) \times 0.556$
POUNDS	KILOGRAMS	0.453
PSI	BAR	0.0676
FOOT <sup>2</sup>	METER <sup>2</sup>	0.0929

Note: BARRELS are U.S. oil barrels.

## PIPE CHARTS

### Carbon Steel & PVC Pipe

Pipe Size	Pipe O.D.	Standard		Extra Heavy		Dbl. Extra Heavy		Schedule 10		Schedule 20		Schedule 30		Schedule 40	
		I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL
½	.840	.622	.109	.546	.147	.252	.294							.622	.109
¾	1.050	.824	.113	.742	.154	.434	.308							.824	.113
1	1.315	1.049	.133	.957	.179	.599	.358							1.049	.133
1¼	1.660	1.380	.140	1.278	.191	.896	.382							1.380	.140
1½	1.900	1.610	.145	1.500	.200	1.100	.400							1.610	.145
2	2.375	2.067	.154	1.939	.218	1.503	.436							2.067	.154
2½	2.875	2.469	.203	2.323	.276	1.771	.552							2.469	.203
3	3.500	3.068	.216	2.900	.300	2.300	.600							3.068	.216
3½	4.000	3.548	.226	3.364	.318	2.728	.636							3.548	.226
4	4.500	4.026	.237	3.826	.337	3.152	.674							4.026	.237
5	5.563	5.047	.258	4.813	.375	4.063	.750							5.047	.258
6	6.625	6.065	.280	5.761	.432	4.897	.864							6.065	.280
8	8.625	7.981	.322	7.625	.500	6.875	.875			8.125	.250	8.071	.277	7.981	.322
10	10.750	10.020	.365	9.750	.500	8.750	1.000			10.250	.250	10.136	.307	10.020	.365
12	12.750	12.000	.375	11.750	.500	10.750	1.000			12.250	.250	12.090	.330	11.938	.406
14	14.000	13.250	.375	13.000	.500			13.500	.250	13.376	.312	13.250	.375	13.124	.438
16	16.000	15.250	.375	15.000	.500			15.500	.250	15.376	.312	15.250	.375	15.000	.500
18	18.000	17.250	.375	17.000	.500			17.500	.250	17.376	.312	17.124	.438	16.876	.562
20	20.000	19.250	.375	19.000	.500			19.500	.250	19.250	.375	19.000	.500	18.814	.593
22	22.000	21.250	.375	21.000	.500			21.500	.250	21.250	.375	21.000	.500		
24	24.000	23.250	.375	23.000	.500			23.500	.250	23.250	.375	22.876	.562	22.626	.687
26	26.000	25.250	.375	25.000	.500			25.376	.312	25.000	.500				
28	28.000	27.250	.375	27.000	.500			27.376	.312	27.000	.500	26.750	.625		
30	30.000	29.250	.375	29.000	.500			29.376	.312	29.000	.500	28.750	.625		
32	32.000	31.250	.375	31.000	.500			31.376	.312	31.000	.500	30.750	.625		
34	34.000	33.250	.375	33.000	.500			33.376	.312	33.000	.500	32.750	.625		
36	36.000	35.250	.375	35.000	.500			35.376	.312	35.000	.500	34.750	.625		
42	42.000	41.250	.375	41.000	.500					41.000	.500	40.750	.625		

### Ductile Iron Pipe - Standard Classes

Size NCH	OUTSIDE DIA. INCH	Class 50		Class 51		Class 52		Class 53		Class 54		Class 55		Class 56		CEMENT LINING	
		WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.	**STD THICKNESS	**DOUBLE THICKNESS
3	3.96			0.25	3.46	0.28	3.40	0.31	3.34	0.34	3.28	0.37	3.22	0.41	3.14	.125	.250
4	4.80			0.26	4.28	0.29	4.22	0.32	4.16	0.35	4.10	0.38	4.04	0.44	3.93		
6	6.90	0.25	6.40	0.28	6.34	0.31	6.28	0.34	6.22	0.37	6.16	0.40	6.10	0.43	6.04		
8	9.05	0.27	8.51	0.30	8.45	0.33	8.39	0.36	8.33	0.39	8.27	0.42	8.21	0.45	8.15		
10	11.10	0.39	10.32	0.32	10.46	0.35	10.40	0.38	10.34	0.41	10.28	0.44	10.22	0.47	10.16		
12	13.20	0.31	12.58	0.34	12.52	0.37	12.46	0.40	12.40	0.43	12.34	0.46	12.28	0.49	12.22	.1875	.375
14	15.30	0.33	14.64	0.36	14.58	0.39	14.52	0.42	14.46	0.45	14.40	0.48	14.34	0.51	14.28		
16	17.40	0.34	16.72	0.37	16.66	0.40	16.60	0.43	16.54	0.46	16.48	0.49	16.42	0.52	16.36		
18	19.50	0.35	18.80	0.38	18.74	0.41	18.68	0.44	18.62	0.47	18.56	0.50	18.50	0.53	18.44		
20	21.60	0.36	20.88	0.39	20.82	0.42	20.76	0.45	20.70	0.48	20.64	0.51	20.58	0.54	20.52		
24	25.80	0.38	25.04	0.41	24.98	0.44	24.92	0.47	24.86	0.50	24.80	0.53	24.74	0.56	24.68	.250	.500
30	32.00	0.39	31.22	0.43	31.14	0.47	31.06	0.51	30.98	0.55	30.90	0.59	30.82	0.63	30.74		
36	38.30	0.43	37.44	0.48	37.34	0.62	37.06	0.58	37.14	0.63	37.04	0.68	36.94	0.73	36.84		
42	44.50	0.47	43.56	0.53	43.44	0.59	43.32	0.65	43.20	0.71	43.08	0.77	42.96	0.83	42.84		
48	50.80	0.51	49.78	0.58	49.64	0.65	49.50	0.72	49.36	0.79	49.22	0.86	49.08	0.93	48.94		
54	57.10	0.57	55.96	0.65	55.80	0.73	55.64	0.81	55.48	0.89	55.32	0.97	55.16	1.05	55.00		

\*\*REDUCE I.D. BY DIMENSION SHOWN



## Stainless Steel, Hastelloy "C" & Titanium Pipe

Pipe Size	Pipe O.D.	Schedule 5 S (a)		Schedule 10 S (a)		Schedule 40 S		Schedule 80 S	
		I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL
½	.840	.710	.065	.674	.083	.622	.109	.546	.147
¾	1.050	.920	.065	.884	.083	.824	.113	.742	.154
1	1.315	1.185	.065	1.097	.109	1.049	.133	.957	.179
1¼	1.660	1.530	.065	1.442	.109	1.380	.140	1.278	.191
1½	1.900	1.770	.065	1.682	.109	1.610	.145	1.500	.200
2	2.375	2.245	.065	2.157	.109	2.067	.154	1.939	.218
2½	2.875	2.709	.083	2.635	.120	2.469	.203	2.323	.276
3	3.500	3.334	.083	3.260	.120	3.068	.216	2.900	.300
3½	4.000	3.834	.083	3.760	.120	3.548	.226	3.364	.318
4	4.500	4.334	.083	4.260	.120	4.026	.237	3.826	.337
5	5.563	5.345	.109	5.295	.134	5.047	.258	4.813	.375
6	6.625	6.407	.109	6.357	.134	6.065	.280	5.761	.432
8	8.625	8.407	.109	8.329	.148	7.981	.322	7.625	.500
10	10.750	10.482	.134	10.420	.165	10.020	.365	9.750	.500
12	12.750	12.438	.156	12.390	.180	12.000	.375	11.750	.500
14	14.000	13.688	.156	13.624	.188				
16	16.000	15.670	.165	15.624	.188				
18	18.000	17.670	.165	17.624	.188				
20	20.000	19.634	.188	19.564	.218				
22	22.000	21.624	.188	21.564	.218				
24	24.000	23.563	.218	23.500	.250				

Pipe Size	Pipe O.D.	Schedule 60		Schedule 80		Schedule 100		Schedule 120		Schedule 140		Schedule 160	
		I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL
½	.840			.546	.147							.466	.187
¾	1.050			.742	.154							.614	.218
1	1.315			.957	.179							.815	.250
1¼	1.660			1.278	.191							1.160	.250
1½	1.900			1.500	.200							1.338	.281
2	2.375			1.939	.218							1.689	.343
2½	2.875			2.323	.276							2.125	.375
3	3.500			2.900	.300							2.624	.438
3½	4.000			3.364	.318								
4	4.500			3.826	.337			3.624	.438			3.438	.531
5	5.563			4.813	.375			4.563	.500			4.313	.625
6	6.625			5.761	.432			5.501	.562			5.189	.718
8	8.625	7.813	.406	7.625	.500	7.439	.593	7.189	.718	7.001	.812	6.813	.906
10	10.750	9.750	.500	9.564	.593	9.314	.718	9.064	.843	8.750	1.000	8.500	1.125
12	12.750	11.626	.562	11.376	.687	11.064	.843	10.750	1.000	10.500	1.125	10.126	1.312
14	14.000	12.814	.593	12.500	.750	12.126	.937	11.814	1.093	11.500	1.250	11.188	1.406
16	16.000	14.688	.656	14.314	.843	13.938	1.031	13.564	1.218	13.124	1.438	12.814	1.593
18	18.000	16.500	.750	16.126	.937	15.688	1.156	15.250	1.375	14.876	1.562	14.438	1.781
20	20.000	18.376	.812	17.938	1.031	17.438	1.281	17.000	1.500	16.500	1.750	16.064	1.968
22	22.000	20.250	.875	19.750	1.125	19.250	1.375	18.750	1.625	18.250	1.875	17.750	2.125
24	24.000	22.064	.968	21.564	1.218	20.938	1.531	20.376	1.812	19.876	2.062	19.314	2.343

## Cast Iron Pipe - ASA Standard

Pipe Size	Pipe O.D.	Class 50		Class 100		Class 150		Class 200		Class 250		Class 300		Class 350	
		WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.
3	3.96	0.32	3.32	0.32	3.32	0.32	3.32	0.32	3.32	0.32	3.32	0.32	3.32	0.32	3.32
4	4.80	0.35	4.10	0.35	4.10	0.35	4.10	0.35	4.10	0.35	4.10	0.35	4.10	0.35	4.10
6	6.90	0.38	6.14	0.38	6.14	0.38	6.14	0.38	6.14	0.38	6.14	0.38	6.14	0.38	6.14
8	9.05	0.41	8.23	0.41	8.23	0.41	8.23	0.41	8.23	0.41	8.23	0.41	8.23	0.41	8.23
10	11.10	0.44	10.22	0.44	10.22	0.44	10.22	0.44	10.22	0.44	10.22	0.48	10.14	0.52	10.06
12	13.20	0.48	12.24	0.48	12.24	0.48	12.24	0.48	12.24	0.52	12.16	0.52	12.16	0.56	12.08
14	15.30	0.48	14.34	0.51	14.28	0.51	14.28	0.55	14.20	0.59	14.12	0.59	14.12	0.64	14.02
16	17.40	0.54	16.32	0.54	16.32	0.54	16.32	0.58	16.24	0.63	16.14	0.68	16.04	0.68	16.04
18	19.50	0.54	18.42	0.58	18.34	0.58	18.34	0.63	18.24	0.68	18.14	0.73	18.04	0.79	17.92
20	21.60	0.57	20.46	0.62	20.36	0.62	20.36	0.67	20.26	0.72	20.16	0.78	20.04	0.84	19.92
24	25.80	0.63	24.54	0.68	24.44	0.73	24.34	0.79	24.22	0.79	24.22	0.85	24.10	0.92	23.96

## Cast Iron Pipe - AWWA Standard

Pipe Size	Class A 100 Ft. 43 PSIG			Class B 200 Ft. 86 PSIG			Class C 300 Ft. 130 PSIG			Class D 400 Ft. 173 PSIG		
	O.D.	WALL	I.D.	O.D.	WALL	I.D.	O.D.	WALL	I.D.	O.D.	WALL	I.D.
3	3.80	0.39	3.02	3.96	0.42	3.12	3.96	0.45	3.06	3.96	0.48	3.00
4	4.80	0.42	3.96	5.00	0.45	4.10	5.00	0.48	4.04	5.00	0.52	3.96
6	6.90	0.44	6.02	7.10	0.48	6.14	7.10	0.51	6.08	7.10	0.55	6.00
8	9.05	0.46	8.13	9.05	0.51	8.03	9.30	0.56	8.18	9.30	0.60	8.10
10	11.10	0.50	10.10	11.10	0.57	9.96	11.40	0.62	10.16	11.40	0.68	10.04
12	13.20	0.54	12.12	13.20	0.62	11.96	13.50	0.68	12.14	13.50	0.75	12.00
14	15.30	0.57	14.16	15.30	0.66	13.98	15.65	0.74	14.17	15.65	0.82	14.01
16	17.40	0.60	16.20	17.40	0.70	16.00	17.80	0.80	16.20	17.80	0.89	16.02
18	19.50	0.64	18.22	19.50	0.75	18.00	19.92	0.87	18.18	19.92	0.96	18.00
20	21.60	0.67	20.26	21.60	0.80	20.00	22.06	0.92	20.22	22.06	1.03	20.00
24	25.80	0.76	24.28	25.80	0.89	24.02	26.32	1.04	24.22	26.32	1.16	24.00
30	31.74	0.88	29.98	32.00	1.03	29.94	32.40	1.20	30.00	32.74	1.37	30.00
36	37.96	0.99	35.98	38.30	1.15	36.00	38.70	1.36	39.98	39.16	1.58	36.00
42	44.20	1.10	42.00	44.50	1.28	41.94	45.10	1.54	42.02	45.58	1.78	42.02
48	50.50	1.26	47.98	50.80	1.42	47.96	51.40	1.71	47.98	51.98	1.96	48.06
54	56.66	1.35	53.96	57.10	1.55	54.00	57.80	1.90	54.00	58.40	2.23	53.94
60	62.80	1.39	60.02	63.40	1.67	60.06	64.20	2.00	60.20	64.82	2.38	60.06
72	75.34	1.62	72.10	76.00	1.95	72.10	76.88	2.39	72.10			
84	87.54	1.72	84.10	88.54	2.22	84.10						

Pipe Size	Class E 500 Ft. 217 PSIG			Class F 600 Ft. 260 PSIG			Class G 700 Ft. 304 PSIG			Class H 800 Ft. 347 PSIG		
	O.D.	WALL	I.D.	O.D.	WALL	I.D.	O.D.	WALL	I.D.	O.D.	WALL	I.D.
6	7.22	0.58	6.06	7.22	0.61	6.00	7.38	0.65	6.08	7.38	0.69	6.00
8	9.42	0.66	8.10	9.42	0.71	8.00	9.60	0.75	8.10	9.60	0.80	8.00
10	11.60	0.74	10.12	11.60	0.80	10.00	11.84	0.86	10.12	11.84	0.92	10.00
12	13.78	0.82	12.14	13.78	0.89	12.00	14.08	0.97	12.14	14.08	1.04	12.00
14	15.98	0.90	14.18	15.98	0.99	14.00	16.32	1.07	14.18	16.32	1.16	14.00
16	18.16	0.98	16.20	18.16	1.08	16.00	18.54	1.18	16.18	18.54	1.27	16.00
18	20.34	1.07	18.20	20.34	1.17	18.00	20.78	1.28	18.22	20.78	1.39	18.00
20	22.54	1.15	20.24	22.54	1.27	20.00	23.02	1.39	20.24	23.02	1.51	20.00
24	26.90	1.31	24.28	26.90	1.45	24.00	27.76	1.75	24.26	27.76	1.88	24.00
30	33.10	1.55	30.00	33.46	1.73	30.00						
36	39.60	1.80	36.00	40.04	2.02	36.00						

## Copper Tubing

Pipe	K			L			M			Copper & Brass Pipe			Aluminum		
Size	O.D.	I.D.	WALL	O.D.	I.D.	WALL	O.D.	I.D.	WALL	O.D.	I.D.	WALL	O.D.	I.D.	WALL
½"	0.625	0.527	0.049	0.625	0.545	0.040	0.625	0.569	0.028	0.840	0.625	0.108			
⅝"	0.750	0.652	0.049	0.750	0.666	0.042	0.750	0.690	0.030						
¾"	0.875	0.745	0.065	0.875	0.785	0.045	0.875	0.811	0.032	1.050	0.822	0.114			
1"	1.125	0.995	0.065	1.125	1.025	0.050	1.125	1.055	0.035	1.315	1.062	0.127			
1 ¼"	1.375	1.245	0.065	1.375	1.265	0.055	1.375	1.291	0.042	1.660	1.368	0.146			
1 ½"	1.625	1.481	0.072	1.625	1.505	0.060	1.625	1.527	0.049	1.900	1.600	0.150			
2"	2.125	1.959	0.083	2.125	1.985	0.070	2.125	2.009	0.058	2.375	2.062	0.157			
2 ½"	2.625	2.435	0.095	2.625	2.465	0.080	2.625	2.495	0.065	2.875	2.500	0.188	2.500	2.400	0.050
3"	3.125	2.907	0.109	3.125	2.945	0.090	3.125	2.981	0.072	3.500	3.062	0.219	3.000	2.900	0.050
3 ½"	3.625	3.385	0.120	3.625	3.425	0.100	3.625	3.459	0.083	4.000	3.500	0.250			
4"	4.125	3.857	0.134	4.125	3.905	0.110	4.125	3.935	0.095	4.500	3.935	0.095	4.000	4.000	0.250
4 ½"													5.000	4.500	0.250
5"	5.125	4.805	0.160	5.125	4.875	0.125	5.125	4.907	0.109	5.563	5.063	0.250	5.000	4.874	0.063
6"	6.125	5.741	0.192	6.125	5.845	0.140	6.125	5.881	0.122	6.625	6.125	0.250	6.000	5.874	0.063
7"										7.625	7.062	0.282	7.000	6.844	0.078
8"	8.125	7.583	0.271	8.125	7.725	0.200	8.125	7.785	0.170	8.625	8.000	0.313	8.000	7.812	0.094
10"	10.125	9.449	0.338	10.125	9.625	0.250	10.125	9.701	0.212	10.000	9.812	0.094			
12"	12.125	11.315	0.405	12.125	11.565	0.280	12.125	11.617	0.254						

**APPENDIX C – Liquid Speed of Sound**

FLUID	FORMULA	SOUND SPEED m/s
Acetic Acid	$(\text{CH}_3\text{CO})_2\text{O}$	1180
Acetone	$\text{C}_3\text{H}_6\text{O}$	1174
Ammonia	$\text{NH}_3$	1729
Benzene	$\text{C}_6\text{H}_6$	1306
Bromine	$\text{Br}_2$	889
Carbon dioxide	$\text{CO}_2$	839
Carbon tetrachloride	$\text{CCl}_4$	926
Chloro-benzene	$\text{C}_6\text{H}_5\text{Cl}$	1273
Chloroform	$\text{CHCl}_3$	979
Ethanol	$\text{C}_2\text{H}_6\text{O}$	1207
Ethylene glycol 100%	$\text{C}_2\text{H}_6\text{O}_2$	1658
Ethylene glycol 50/50		1578
Freon R12		774
Glycerin	$\text{C}_3\text{H}_8\text{O}_3$	1904
Kerosene		1324
Methanol	$\text{CH}_4\text{O}$	1076
Methylene chloride	$\text{CH}_2\text{Cl}_2$	1070
Milk		1548
Nitromethane	$\text{CH}_3\text{NO}_2$	1300
Diesel Oil		1250 Fuel
Lube Oil		1530 Lube
Sulphuric Acid	$\text{H}_2\text{SO}_4$	1257.6
Toluene	$\text{C}_7\text{H}_8$	1328
Turpentine		1255
Water Distilled	$\text{H}_2\text{O}$	1498
Water Sea		1531