DCT6088

Dedicated Transit Time Flowmeter
User Guide
P/N 1-0561-006

Revision J

Part of Thermo Fisher Scientific

Thermo SCIENTIFIC

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Revision History

Revision Level	Date	Comments
B	05-2003	Revised per ECO 3912.
C	03-2005	Revised per ECO 4760.
D	02-2006	Revised per ECO 5077.
E	05-2007	Revised per ECO 5601.
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G	11-2007	Revised per ECO 6016.
H	06-2011	Revised per ECO 7752.
J	07-2017	Revised per ECO 9242.

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Contents

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Safety Information & Guidelines

This section contains information that must be read and understood by all persons installing, using, or maintaining this equipment.

Safety Considerations

Failure to follow appropriate safety procedures or inappropriate use of the equipment described in this manual can lead to equipment damage or injury to personnel.

Any person working with or on the equipment described in this manual is required to evaluate all functions and operations for potential safety hazards before commencing work. Appropriate precautions must be taken as necessary to prevent potential damage to equipment or injury to personnel.

The information in this manual is designed to aid personnel to correctly and safely install, operate, and/or maintain the system described; however, personnel are still responsible for considering all actions and procedures for potential hazards or conditions that may not have been anticipated in the written procedures. **If a procedure cannot be performed safely, it must not be performed until appropriate actions can be taken to ensure the safety of the equipment and personnel.** The procedures in this manual are not designed to replace or supersede required or common sense safety practices. All safety warnings listed in any documentation applicable to equipment and parts used in or with the system described in this manual must be read and understood prior to working on or with any part of the system.

Failure to correctly perform the instructions and procedures in this manual or other documents pertaining to this system can result in equipment malfunction, equipment damage, and/or injury to personnel.

Warnings, Cautions, & Notes

The following admonitions are used throughout this manual to alert users to potential hazards or important information. **Failure to heed the warnings and cautions in this manual can lead to injury or equipment damage.**

Warning Warnings notify users of procedures, practices, conditions, etc. which may result in injury or death if not carefully observed or followed. ▲

Caution Cautions notify users of operating procedures, practices, conditions, etc. which may result in equipment damage if not carefully observed or followed. ▲

Note Notes emphasize important or essential information or a statement of company policy regarding an operating procedure, practice, condition, etc. ▲

Chapter 1
Product Overview

Introduction

The Thermo Scientific DCT6088 dedicated transit time flowmeter is a microprocessor-based instrument that measures the flow of clean, homogeneous liquids (liquids without large concentrations of suspended particles or gasses such as air bubbles). The flowmeter is non-invasive, which means that it measures flow from outside the pipe. The transducers can be mounted to a pipe within a matter of minutes, and flow measurements may be made without interrupting the flow or modifying pipe work. The instrument can be configured using an integral keypad for entering variables such as pipe size, pipe material, wall thickness, and fluid type.

Theory of Operation

Sound waves travel in fluids at a specific velocity depending on the type of fluid. If the fluid is moving, the sound wave travels at a velocity equal to the sum of the speed of sound in the fluid and the velocity of the fluid itself relative to the transducer. A sound wave traveling in the same direction as the fluid flow (downstream) will arrive sooner than a sound wave traveling against the flow (upstream). A transit time flowmeter operates by measuring both the absolute travel time of each sound wave and the difference in time required for the waves to travel between externally mounted downstream and upstream transducers (refer to Figure 1–1). Based on the transit time of the two sound waves, the flowmeter calculates the average fluid velocity.

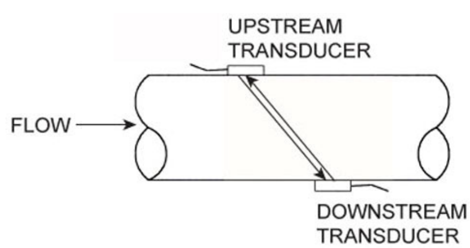


Figure 1–1. Typical transit time system

Once the differential transit time is calculated, several additional variables must be taken into consideration. The overall velocity of the fluid is comprised of many individual local velocities that vary according to their distance from the pipe wall. The velocities in the center of the pipe are higher than the velocities near the pipe wall. The combination of these individual velocities for a specific type of fluid within a specific pipe yield a velocity distribution known as the flow profile, which is a function of the Reynolds number (see Figure 1–2). By properly configuring the flowmeter, the effects of the flow profile are taken into consideration when calculating the mean fluid velocity. The flowmeter then multiplies this velocity by the pipe's cross-sectional area to obtain volumetric flow.

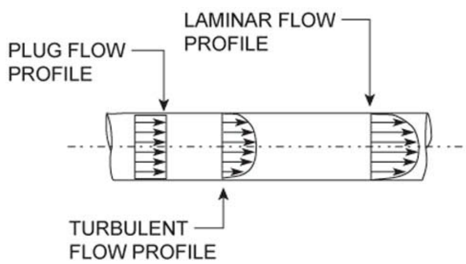


Figure 1–2. Flow profiles

Transit Time Accuracy

Non-invasive ultrasonic measurements are subject to a variety of effects that can influence measurement accuracy. All ultrasonic instruments are velocity measuring devices and only infer volumetric flow from the operator-entered parameter of pipe inside diameter (ID). When this value is squared to get cross-sectional area, a 1% error yields a 2% error in volumetric flow. In practice, commercially fabricated pipe seldom has ID consistency much tighter than 1%, and unless the pipe to be measured has been accurately measured, this uncertainty is not reducible through instrument calibration.

The more sophisticated transit time flowmeters incorporate flow profile corrections to compensate for the pipe's cross-sectional velocity profile with a changing Reynolds number. However, this requires the operator to know the inside roughness of the pipe to be measured. The instrument may infer a roughness if none is entered by the operator, but that is only an estimate based on the characteristics of new pipe. Pipes can accumulate deposits that may reduce the ID and affect the roughness as well. Errors on the order of 2% as a result of this phenomenon are not uncommon.

While other factors may influence instrument accuracy to a lesser extent, the issues described above are the major elements of pipe dependency upon absolute instrument accuracy. While calibration on a reference flow loop under known conditions is a useful exercise to determine the accuracy potential of an instrument, it is not a guarantee of absolute accuracy on different pipes under field conditions.

Ordering Information

The table below provides ordering information for the flowmeter.

Table 1–1.

Code	Model
DCT6088	Thermo Scientific DCT6088 dedicated digital correlation transit time flowmeter
Code	**Power Supply**
1	90 to 132 Vac, 50/60 Hz
2	190 to 250 Vac, 50/60 Hz
3	12 to 24 Vdc nominal
Code	**Output**
1	For non-hazardous area use only: One relay, 5 amp, SPDT fully programmable
2	For non-hazardous area use only: Two relays, 5 amp, SPDT fully programmable
3	For non-hazardous area use only: Three relays, 5 amp, SPDT fully programmable
4	For non-hazardous area use only: Four relays, 5 amp, SPDT fully programmable
5	For hazardous area use: One relay, 5 amp, SPDT fully programmable
6	For hazardous area use: Two relays, 5 amp, SPDT fully programmable
7	For hazardous area use: Three relays, 5 amp, SPDT fully programmable
8	For hazardous area use: Four relays, 5 amp, SPDT fully programmable
Code	**Transmitter Enclosure**
1	NEMA 4X
2	NEMA 7
Code	**Transducer Type (set of two)**
S	Standard cable (100°C/212°F maximum)
H	High temperature cable (200°C/392°F maximum)
Code	**Transducer Cable (set of two)**
030	30 ft (9 m) cable length
XXX	Optional standard cable lengths: 50 ft, 75 ft, 100 ft, 150 ft, 200 ft, 300 ft
XXX	Optional high temperature cable lengths: 50 ft, 100 ft, 150 ft, 200 ft
Code	**Transducer Hazardous Area Certification**
A	Non-hazardous
B	CSA: Class I, Div. 2 Groups A, B, C, D or Class II, Div. 2 Groups E, F, G (available with standard transducer configuration only)
C	Barriers to use transducer in CSA Class I, Div. 1 Groups C, D or Class II, Div 1 Groups E, F, G (available with standard transducer configuration only)

Specifications

Results may vary under different operating conditions.

Table 1–2. Performance specifications

Velocity range	±0 m/s to 15 m/s (±0 ft/s to 50 ft/s)*
Accuracy	±0.5% of velocity or ±0.05 ft/s, typical
Fluids	Potable water, ultrapure liquids, deionized water, petroleum products
Pipe size	25.4 mm to 5 m (1 in to 200 in)* Contact factory for line sizes smaller than 1 inch.

*Large pieps and high velocities cannot be measured simultaneously.

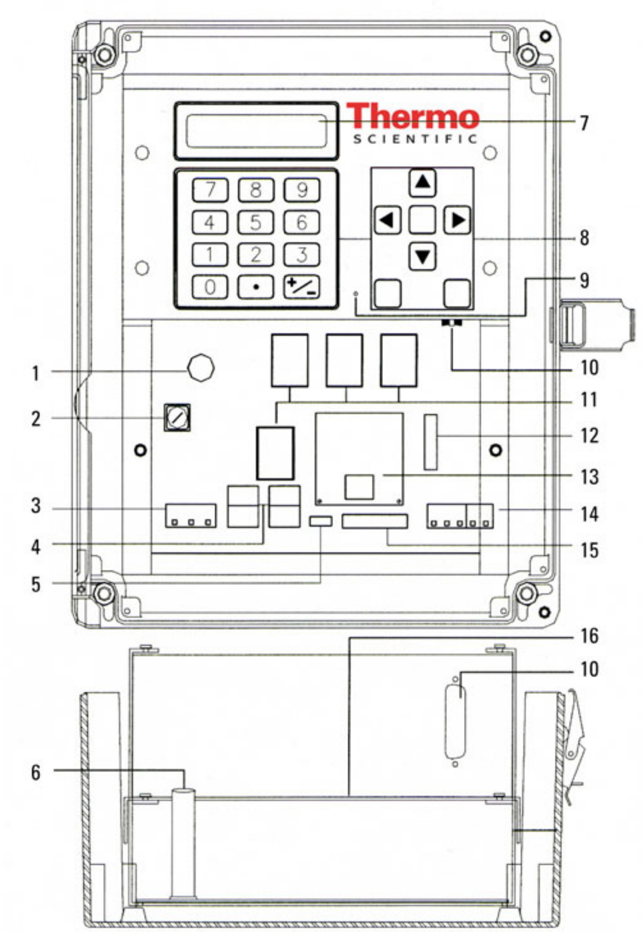
Table 1–3. Physical specifications

Transmitter	IP65, flame retardant, fiberglass reinforced polyester
Transducers	Two encapsulated transducers suitable for submersion or underground service; 9 m (30 ft) standard cable length
Weight	Approximately 5.4 kg (12 lb)

Table 1–4. Functional specifications

Outputs	4–20 mA (into 1 to 5 kohms), 12-bit, 5 kV, opto-isolated, loop or self-powered RS232 serial interface
Power supply	90 to 132 Vac or 190 to 250 Vac, 50/60 Hz (switch selectable) 12 to 24 Vdc
Temperature range	Transducers Surface: -40°C to 100°C (-40°F to 212°F) Ambient: -28°C to 80°C (-20°F to 176°F) Transmitters: -40°C to 60°C (-40°F to 140°F) Contact factory for higher temperature range requirements.
Keypad	19-key with tactile action
Display	2-line x 40-character, alphanumeric, backlit LCD
Data logger	30,000 point data logger, programmable in 1-second intervals

External Features



#	Description
1	Input voltage selection switch: For selecting 120 or 240 Vac operation
2	Fuse
3	AC input terminal
4	Relay terminal blocks
5	MUX interface connector
6	Fuse access hole
7	LCD: For displaying configuration selections, flow rate, totalized flow, etc.
8	Keypad: For selecting display screen and configuring the instrument
9	Power indicator
10	DB25 connector for RS232 communications
11	Location of option relays (1 standard)
12	COM terminal block
13	4-20 mA current loop module
14	Transducer terminal block
15	AUX terminal block
16	Sheet metal access cover: Provides access to wiring terminals and other components

Figure 1–3. External features of the DCT6088

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Chapter 2
System Installation

Enclosure Mounting

The enclosure should be mounted to a sturdy vertical surface such as a wall. The enclosure can be directly mounted with screws or indirectly mounted with mounting ears. The flowmeter has 5/16” metal threaded inserts located in the corners of the enclosure. The inserts are located in mounting wells that are sealed from the interior of the enclosure when the door is closed, preventing moisture from entering the instrument through the mounting holes.

Direct Mount Method

The enclosure can be directly mounted to a wall by inserting four 1/4" screws into the mounting wells from the front of the enclosure. The screws act as “through bolts” for securing the unit to the wall.

Mounting Ears Method

The enclosure can be mounted to a flat, vertical surface using the optional mounting ears. The mounting ears can be oriented vertically or horizontally as follows.

1. Screw the four mounting ears to the metal threaded inserts on the back of the enclosure using the 5/16” screws provided in the mounting ears kit.

2. Attach the ears to the wall with standard mounting screws.

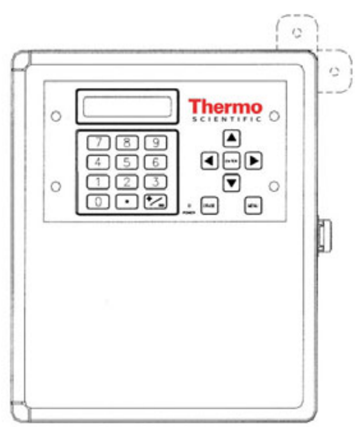


Figure 2–1. Mounting ears method

Transducer Installation

Site Selection & Preparation

Prior to installing the transducers, a proper site must be selected to ensure accurate measurement. Examples of site recommendations are illustrated below.

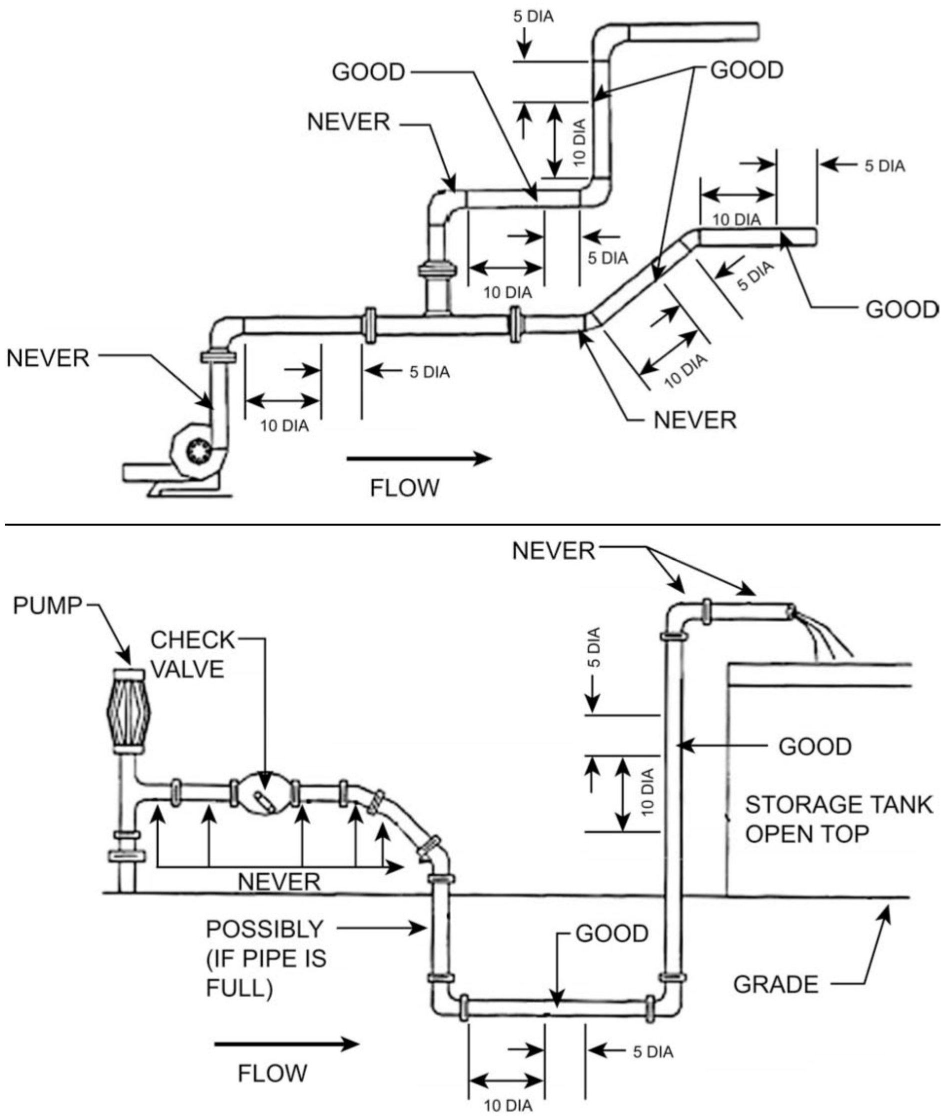


Figure 2–2. Site recommendations

Use the following guidelines when selecting the transducer site:

- Choose a section of pipe that is always full of liquid, such as a vertical pipe with up flow or a full horizontal pipe.
- The site should have a straight run equivalent to at least 10 pipe diameters upstream and 5 pipe diameters downstream from any elbows, tees, throttling valves, orifices, reduced sections, or other flow disturbances.
- Up to 30 diameters of straight run may be required upstream from the flowmeter after a pump, control valve, or double piping bend for greater accuracy. A distance of 5 diameters downstream is usually sufficient under all circumstances.
- Always mount the transducers on the sides of the pipe in the 3 o'clock or 9 o'clock position on horizontal pipes. Positioning the transducers in this manner prevents signal loss that can be caused by sediment along the bottom of the pipe or gas bubbles and air pockets along the top of the pipe.
- Ensure that the pipe skin temperature is within the transducer temperature rating. The transducers are rated for -40°F to +212°F (-40°C to +100°C). Temperature ratings up to 392°F (200°C) are available with optional high temperature transducers.
- Pipes with excessive corrosion or scaling create conditions that can make accurate measurement difficult or impossible. If possible, avoid selecting these sections of pipe as mounting locations.
- Remove any dirt, grease, rust, loose paint, or scale from the pipe surface prior to mounting the transducers. To obtain best results on aging and rough pipes, a file or grinder may be required to clean the pipe down to bare metal.

If your application cannot follow these guidelines completely, meaningful flow measurements (with some loss in accuracy and stability) may still be obtained, depending on signal quality.

Spacing & Mounting the Transducers

Once you have selected a proper transducer site, you must ensure proper transducer spacing and mounting in order to maximize signal strength and accuracy. Do this by following the steps below.

1. Determine the mounting method that is appropriate for your application: V, W, Z, WW, WV.

2. Refer to Chapter 4 to configure the flowmeter via the keypad or to the UltraScan manual to configure with the UltraScan software. Note the value required for the transducer spacing (value calculated by and displayed on flowmeter LCD or in UltraScan).

3. Clean the area of the pipe designated as the mounting location. Remove any rust, scale, or loose paint. Well-bonded paint does not need to be removed.

   Note On horizontal pipes, the transducers should be mounted in the 3 o'clock and9 o'clock positions in order to avoid situations that can cause signal loss, such as sediment along the bottom of the pipe or gas bubbles or air pockets along the top of the pipe. ▲

4. Apply a wide bead of sonic coupling compound lengthwise down the center of the face of each transducer.

   Note The coupling compound should squeeze out from around the edges of the transducer when placed against the pipe. There should be no air gaps between the transducer and the pipe. Refer to "Replacing Sonic Coupling Compound" (Chapter 7) for instructions on how to apply sonic coupling compound and for information on using other sonic coupling compounds for high temperature, underground, or submerged installations. ▲

5. Attach the transducers to the pipe using the stainless steel clamps and referring to one of the following sections to mount the transducers according to the selected mounting method: V method, W method, Z method, or WV and WW methods.

   Note The transducers should be mounted on the pipe in relation to the direction of flow, as shown in the following figure. Reversing the position of the upstream and downstream transducers or reversing the transducer cable connections to the instrument will result in negative flow readings. ▲

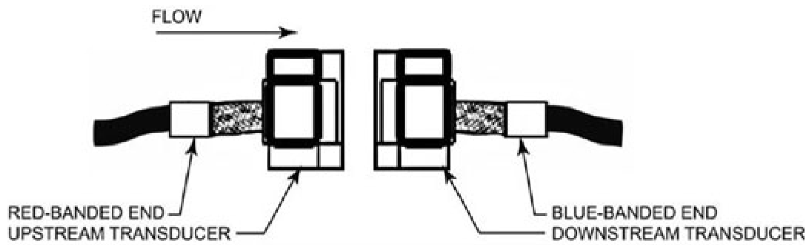


Figure 2–3.

6. Tighten both straps securely. Ensure the transducer face is aligned normal to the pipe. The transducer face alignment is particularly critical on small pipes due to pipe curvature. In the figure below, notice that the properly installed transducer contacts the pipe at the pipe's centerline and that the gaps on either side of the centerline are equal. Follow these steps for the easiest method of aligning transducers on small pipes:
   a. Secure both transducers to the pipe with pipe clamps, and tighten the clamps until the transducers fit snugly.
   b. Adjust the transducers until the gaps on both sides are equal.
   c. While holding the transducers in place, tighten the clamps sufficiently to prevent the transducers from slipping and to allow proper flowmeter operation.

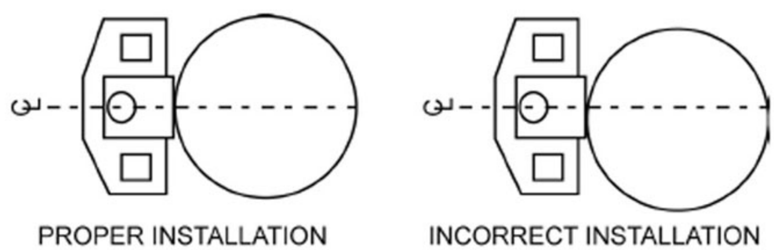


Figure 2–4.

7. The transducer cables connect to the terminal block labeled TRANSDUCERS.

   Note The upstream transducer cable has red-banded ends, and the downstream transducer cable has blue-banded ends. ▲

   Note Refer to Chapter 8 for information on connecting the transducer cables in hazardous area applications. ▲

   Connect the transducer cables to the flowmeter as follows:

   a. Connect the center wire of downstream transducer cable to the XMT (DN) terminal.
   b. Connect the braided shield wire of downstream transducer cable to the XMT GND terminal.
   c. Connect the center wire of upstream transducer cable to the RCV (UP) terminal.
   d. Connect the braided shield wire of upstream transducer cable to the RCV GND terminal.

8. If maximum accuracy at low flow rates is important, calibrate the flowmeter according to "The Calibration Menu" (Chapter 5).

The flowmeter is now capable of accurately measuring velocity and flow.

Transducer Mounting Methods

There are several methods of mounting the transducers. The best method is determined by the specific application. Complete steps 1–5 in previous section, and then refer to the following sections for instructions on how to properly mount the transducers using one of the available mounting methods.

V Method

The V method is considered the standard method for pipes with diameters of 4 to 16 inches (101.6 to 406.4 mm). This method typically yields a more accurate reading than the Z method since it utilizes a longer measurement path. When configuring the flowmeter, ensure V is the selected mounting method.

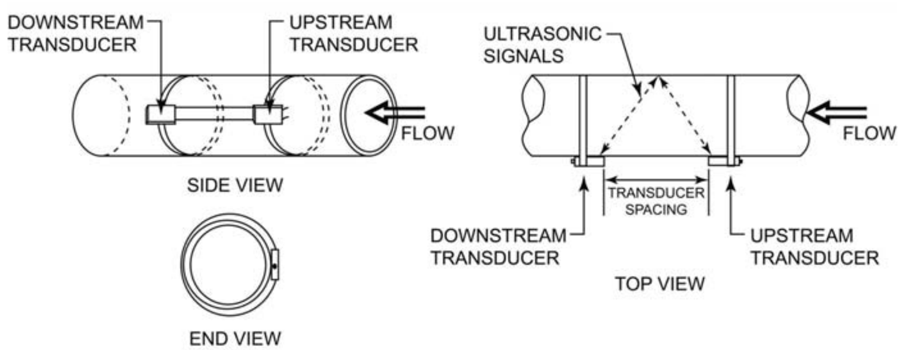


Figure 2–5. V mounting method

W Method

In many instances, flowmeter performance on small metallic pipes with outer diameters of 4 inches (100 mm) or less can be improved by using the W mounting method. With the W method, the sound wave traverses the fluid four times and bounces off the pipe walls three times. Like the V method, both transducers are mounted on the same side of the pipe. When configuring the flowmeter, ensure W is the selected mounting method.

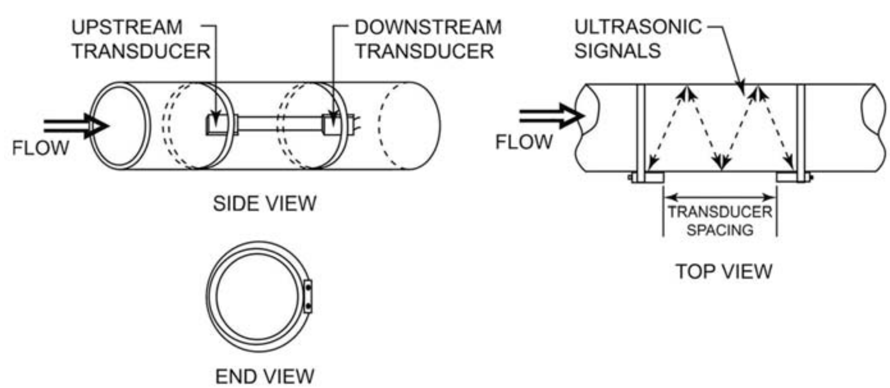


Figure 2–6. W mounting method

Z Method

The signal transmitted in a Z method installation has less attenuation than a signal transmitted with the V method. This is because the Z method utilizes a directly transmitted (rather than reflected) signal that transverses the liquid only once. The Z method is used primarily in applications where the V method cannot work due to signal attenuation from excessive air or solids in the liquid, thick scale, poorly bonded linings, or very large pipes. In addition, the Z method generally works better on larger diameter pipes where less pipe length is required for mounting.

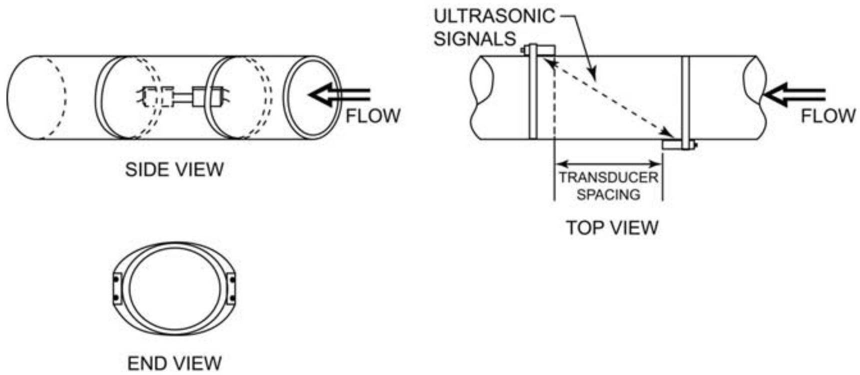


Figure 2–7. Z mounting method

To mount the transducers using the Z mounting method, follow the steps below.

1. Establish a reference at the 3 o'clock and 9o'clock positions on the pipe.

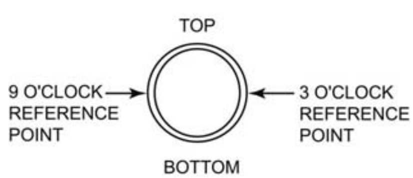


Figure 2–8. Z mounting method, step 1

2. Place a transducer at the 3 o'clock position.

3. Trace the shape of the 3 o'clock transducer along its inside edge (opposite the cable connection). Draw a horizontal line at its center. Remove the transducer.

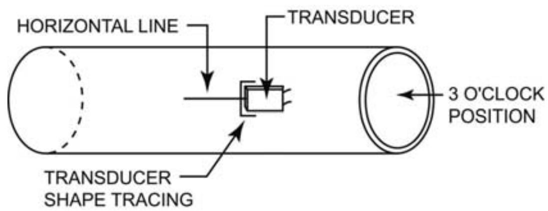


Figure 2–9. Z mounting method, steps 2–3

4. Obtain a continuous sheet of paper longer than the circumference of the pipe. Calculator paper tape or thermal printer paper works well for this.

5. Fold one end of the paper across the pipe's width to produce a clean, straight edge.

6. Line the fold of the paper up with the horizontal centerline of the 3 o'clock transducer.

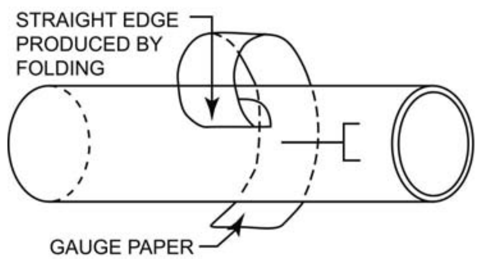


Figure 2–10. Z mounting method, steps 4–6

7. Wrap the paper firmly around the pipe, and mark the intersection point where the fold comes in contact with the rest of the paper.

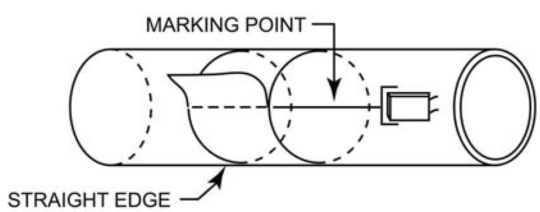


Figure 2–11. Z mounting method, step 7

8. Remove the paper from the pipe. Place the fold and intersection mark together again, and fold the paper exactly in half.

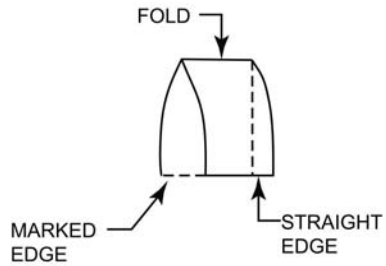


Figure 2–12. Z mounting method, step 8

9. Mark along the new fold.

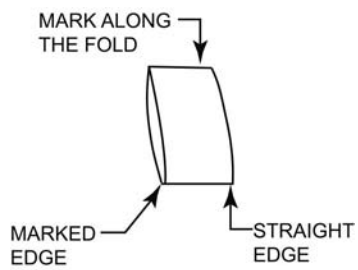


Figure 2–13. Z mounting method, step 9

10. Draw a horizontal line along the pipe from the centerline of the 3 o'clock transducer position. Use a level to ensure that the line is level with the top of the pipe. The line should be at least 3 inches (76 mm) longer than the transducer spacing calculated by the UltraScan software or via menu 25.

    For example, if the software calculates the spacing as 14 inches (356 mm), draw a line 17 inches (432 mm) long.

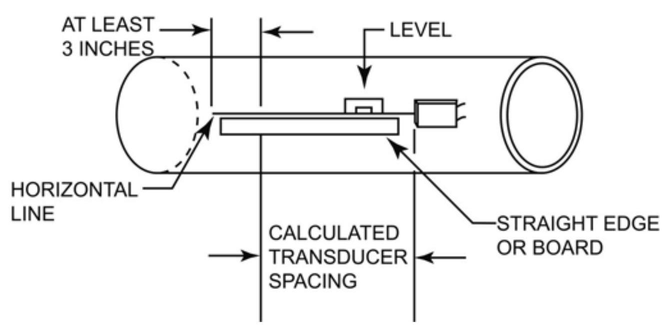


Figure 2–14. Z mounting method, step 10

11. Measure the spacing from the inside edge of the 3 o'clock transducer, and mark this on the pipe.

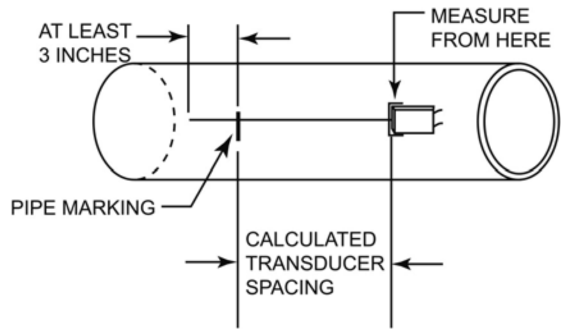


Figure 2–15. Z mounting method, step 11

12. Wrap the paper firmly back on the pipe. Have the point where the ends of the paper come together line up with the horizontal line on the 3 o'clock side of the pipe. Ensure that the inside corner of the straight edge of the paper is aligned with the mark made for the transducer spacing. Tape the paper down, or have someone hold the paper in place.

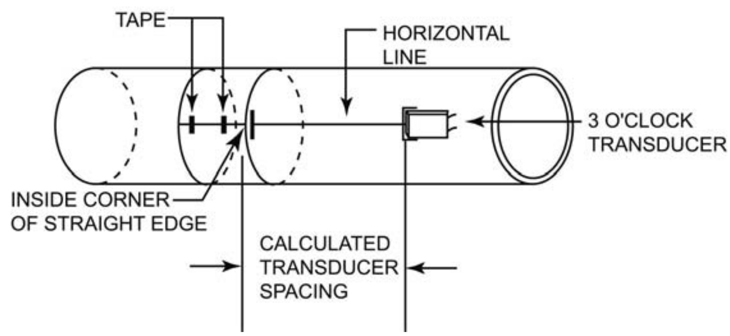


Figure 2–16. Z mounting method, step 12

13. Go to the other side of the pipe (9 o'clock position), and mark the pipe at the point where the marked fold and the inside edge of the paper length intersect.

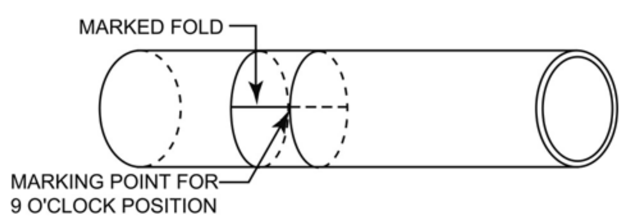


Figure 2–17. Z mounting method, step 13

14. Remove the paper from the pipe and trace the shape of the 9 o'clock transducer in the same manner you did for the 3 o'clock transducer. Ensure that the inside edge of the transducer (opposite the cable connection) is even with the point just marked on the 9o'clock side of the pipe.

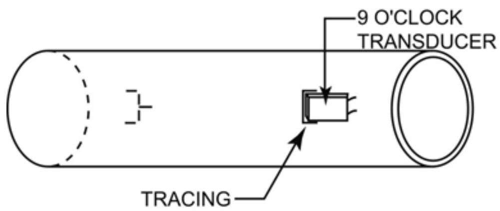


Figure 2–18. Z mounting method, step 14

15. Mount the transducers with pipe straps by following steps 5-6 in "Spacing & Mounting the Transducers" earlier in this chapter.

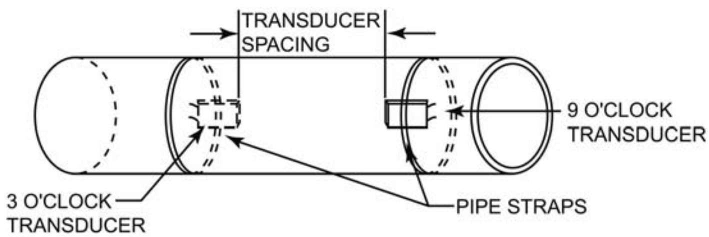


Figure 2–19. Z mounting method, step 15

The figure below illustrates the final Z method installation.

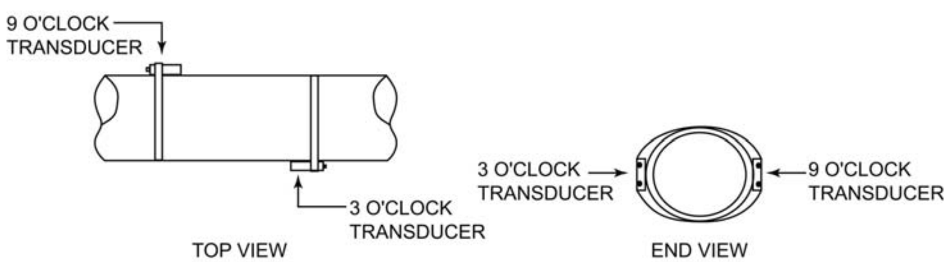


Figure 2–20.

WV and WW Methods

For applications with pipe diameters smaller than 2 inches (50 mm), the WV and WW methods are options that allow higher accuracy and stability to be achieved when reasonable signal strength can be obtained (10% or higher).

Small Pipe Applications

In this section, small pipe applications refer to the following pipe sizes:

- Stainless steel or brass: 1.0 to 3.5 inches (25.4 to 88.9 mm)
- PVC, carbon steel, or other: 1.0 to 2.5 inches (25.4 to 63.5 mm)

If signal strength is greater than 10%, we recommend the W mounting method for pipe sizes 3.5 inches (63.5mm) or smaller and the WW mounting method for pipe sizes 2.0 inches (50.8 mm) or smaller.

The pipe curve effect on small pipe applications can cause multipath signals and measurement uncertainty. Removing extra compound along the transducer sides can eliminate the side wave paths as seen in Figure 2–21 below.

To eliminate these side wave paths, apply coupling compound as usual on to the coupling surfaces, and clamp the transducers onto the pipe. Use a pen-sized, standard screwdriver to remove the extra grease between the transducers and the pipe.

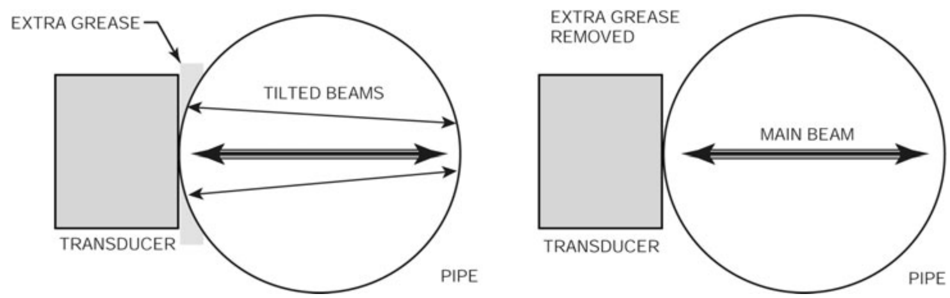


Figure 2–21. Effect of extra compound on small pipes

For high temperature or outdoor small pipe applications, use the foam tape strips shipped with the flowmeter to block the side wave paths. Other tape materials generally do not satisfy performance or safety specifications. Please contact Thermo Fisher when more tape strips are needed.

Apply the foam tape strips according to the steps below.

1. Wipe grease off the coupling surfaces of both transducers. Clean the surfaces with detergent and let dry.

2. Draw two lines on each transducer surface with a pencil so that the band defined by the lines is in the middle of the surface. The spacing between the two lines should be as shown in the following table.

Table 2–5.

Pipe Sizes	Spacing
3.0 to 3.5 inches (76.2 to 88.9 mm)	0.50 inches (12.7 mm)
2.5 to 3.0 inches (63.5 to 76.2 mm)	0.44 inches (11.2 mm)
2.0 to 2.5 inches (50.8 to 63.5 mm)	0.38 inches (9.7 mm)
1.5 to 2.0 inches (38.1 to 50.8 mm)	0.32 inches (8.13 mm)
1.5 inches (38.1 mm) and smaller	0.25 inch (6.35 mm)

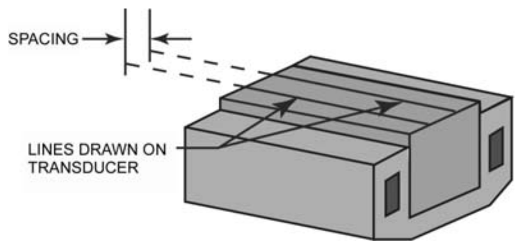


Figure 2–22.

3. Remove the adhesive protection paper to expose the tape strips. Place a strip on each side of the surface along the line. Press the strips down to ensure good adhesion.

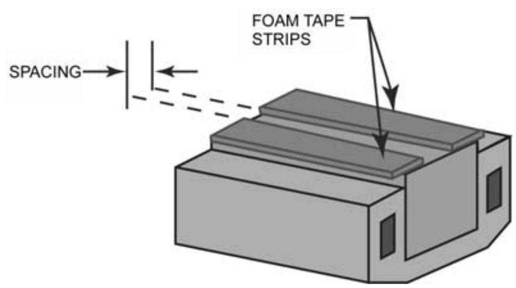


Figure 2–23.

4. Apply coupling compound to the space between the tape strips. The optimum height of the compound layer is approximately half the height of the tape strips.

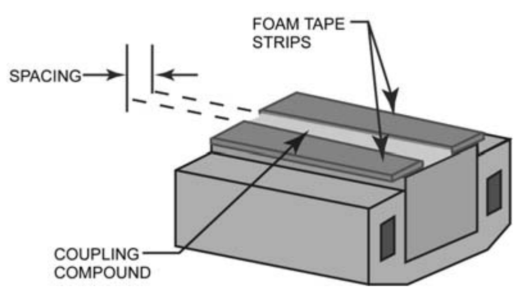


Figure 2–24.

Chapter 3
Wiring

Cable Routing

Warning Avoid potential injury or damage to equipment. Ensure the flowmeter is grounded at ALL times. ▲

Warning Minimize the possibility of explosion in hazardous areas. Do not disconnect power until the area is known to be non-hazardous. ▲

Warning Prevent the possibility of electrical shock or damage to the instrument. Disconnect power prior to removing the sheet metal access cover. Replace the cover before reconnecting power to the unit. ▲

Warning All wiring should be routed through conduit or cable glands to seal the enclosure. Refer to Figure 3–1 for the recommended cable routing. Bonding between conduit connections is not automatic and must be provided as part of the installation. ▲

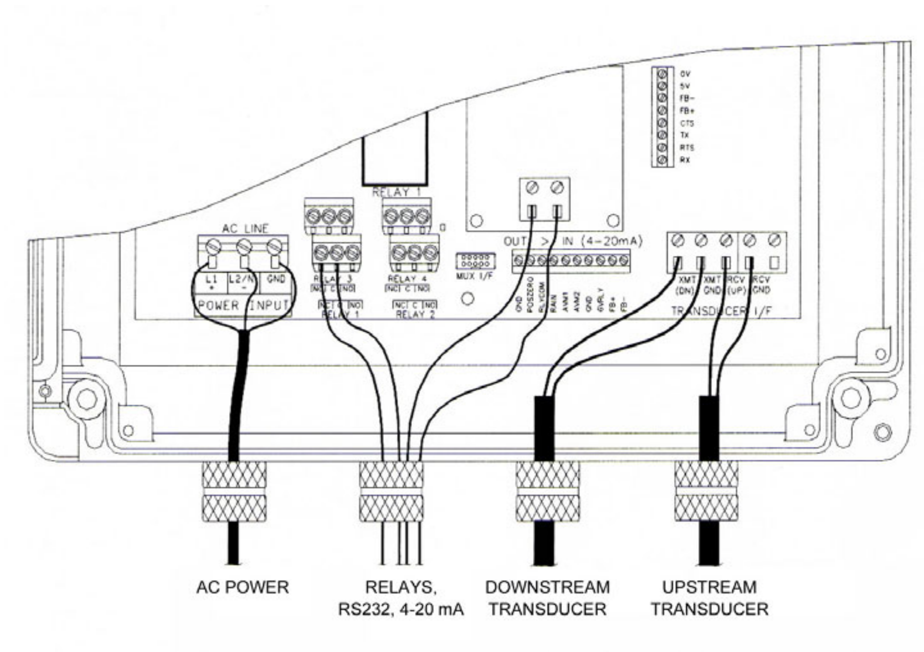


Figure 3–1. Recommended cable routing

Power Connections

Warning To prevent damage to the instrument, verify that the voltage to be connected matches the voltage rating of the flowmeter. The voltage rating is indicated beneath the power input terminals. ▲

Warning Power connections must be made in accordance with local standards or codes of practice. ▲

The power input terminals shown in Figure 3–1 can be connected to one of the following voltages:

- 120 Vac, 50/60 Hz (setting should be on 110)
- 240 Vac, 50/60 Hz (setting should be on 220)
- 12 to 24 Vdc (setting should be on 110)

To connect power, remove the sheet metal access cover. Locate the individual power input terminals. They are marked directly on the main board or on a sticker attached to the main board. Connect the power according to one of the following sections.

120 Vac Operation

To connect the power for 120 Vac operation:

1. Connect the **hot wire to the L1**(+) terminal.
2. Connect the **neutral wire to the L2/N**(-) terminal.
3. Connect the **ground wire to the GND** terminal.

Single Phase 240 Vac Operation

To connect the power for single phase 240 Vac operation:

1. Connect the **live wire to the L1**(+) terminal.
2. Connect the **neutral wire to the L2/N**(-) terminal.
3. Connect the **ground wire to the GND** terminal.

Double Phase 240 Vac Operation

To connect the power for double phase 240 Vac operation:

1. Connect the **one hot wire to the L1**(+) terminal.
2. Connect the **other hot wire to the L2/N**(-) terminal.
3. Connect the **ground wire to the GND** terminal.

12 to 24 Vdc Operation

Note For DC operation, set the 4 –20 mA current loop function to loop powered mode to prevent ground loops. ▲

To connect the power for 12 to 24 Vdc operation:

4. Connect the **positive wire to the L1**(+) terminal.
5. Connect the **negative wire to the L2/N**(-) terminal.

The Current Loop

The 4–20 mA current loop module has an input terminal and an output terminal, which are indicated on a label on the inside of the flowmeter door. The current loop output is rated for a loop resistance of up to 1 kohm and is isolated for up to 5 kV when loop-powered.

The 4–20 mA module is shipped in the self-powered configuration. Switch to loop power by moving a jumper on the module. Current loop modules that are loop powered must be driven from an external power supply. In this case the flowmeter acts as a passive two-wire transmitter.

Warning Prevent the possibility of electrical shock or damage to the instrument. Disconnect power prior to making connections or changing the loop configuration. ▲

To connect the current loop:

1. Ensure the loop powering option is correct. Locate the jumpers on the upper right corner of the module. Refer to the figure below to change the jumper settings.

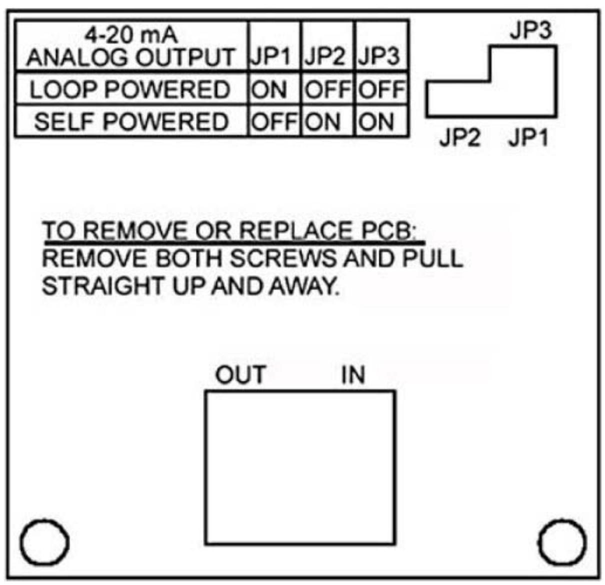


Figure 3–2. Jumper settings for current loop configurations

2. Refer to the self-powered or loop powered configuration figure below for wiring.

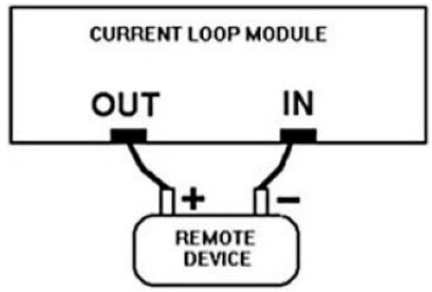


Figure 3–3. Self-powered current loop configuration

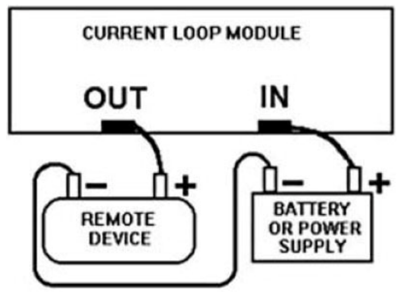


Figure 3–4. Loop powered current loop configuration

Relay Terminals

Up to four relays may be installed in the instrument. The relays are rated at 5 A, 250 Vac. Each relay contains a normally open and normally closed dry contact accessible at the terminal blocks. The terminals for the relay are labeled on the module as NO (normally open), C (common), and NC (normally closed). When the relay is energized, the C terminal is shorted to the NO terminal (refer to Figure 3–5). When the relay is at rest, the C terminal is shorted to the NC terminal.

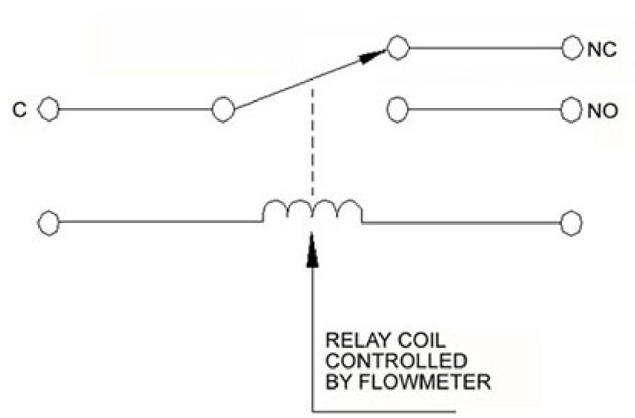


Figure 3–5. Relay schematic

The terminal blocks for the relays are labeled on the board as RELAY 1 through RELAY 4. The relay terminal blocks should be wired for either NO or NC circuits. Figure 3–6 shows RELAY 1 is wired for a NC circuit.

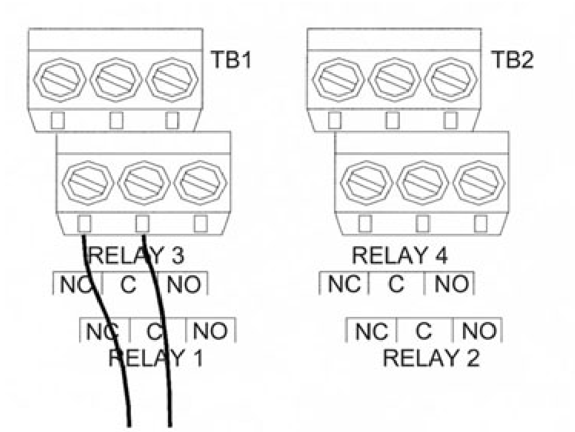


Figure 3–6. Relay terminal block

Note The auxiliary terminal block is for future development. ▲

Communications Terminal Block

The communications terminal block is for future development.

Transducer Wiring

The transducer terminals and cables are arranged in pairs and are labeled DN STREAM and UPSTREAM. The downstream transducer cable has blue-banded ends, and the upstream transducer has red-banded ends.

Refer to the figure below. The symbol is on both pairs of terminals and indicates which terminals should connect to the center wire conductors and which should connect to the coaxial shields.

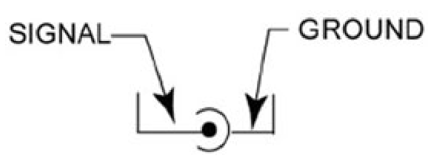


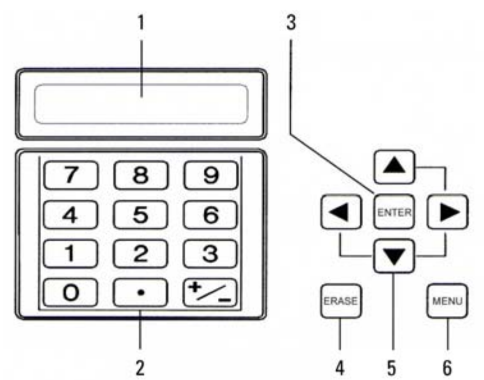
Figure 3–7.

Chapter 4

Operating & Configuring the Flowmeter

The Keypad & Display

Interface with the instrument is via the keypad. During operation, the LCD indicates flow rate and totalizer values. The display is also backlit for ease of viewing in low-light conditions and has a variable contrast setting.



#	Description
1	LCD
2	Numeric keys: **0** through **9** and **decimal (.)**.
3	**ENTER** key: Operates like the Enter (Return) key on a computer.
4	**ERASE** key: Deletes the last value entered. When in most setup and diagnostic menus, press to access the Main menu. Press twice to access Menu 00 (flow rate and net totalizer display).
5	Arrow keys: For scrolling up, down, left, right.
6	**MENU** key: Provides access to setup and diagnostic menus.

Figure 4–1. Keypad & display

Adjusting the Contrast

You may need to adjust the contrast on the display as ambient temperature changes. Follow the steps below to do so.

1. Press **MENU** followed by the **+/-** (plus/minus) key.

2. LCD CONTRAST appears on the display with a bar the indicating current contrast setting.

3. Press the **left** or **right arrows** to adjust the contrast.

4. Press **ENTER** when complete.

Flowmeter Configuration

Flowmeter configuration is accomplished using the setup menus. Some setup menus allow a numeric value to be entered, and others offer non-numeric selections. In non-numeric setup menus, an asterisk is displayed to the left of the selected currently entered in the flowmeter, as shown in the figure below.

Figure 4–2.

There are two ways to access the setup menus: via direct access or through the menu structure.

Direct Menu Access

The unique two-digit address for each setup and diagnostic menu enables the user to directly access the desired menu. The menu addresses are listed in Table 4–1. To use them, follow the two steps below.

1. Press **MENU**, and the letter M appears in the lower right corner of the display.

2. Enter the desired two-digit address.

   Note The address must be entered while the M is displayed (within approximately 4 seconds). If the M is no longer displayed, press **MENU** again followed by the two-digit address. ▲

3. If the setup menu requires a numeric entry, use the numeric keys to enter the value and press **ENTER** to accept the value. If you need to change the entry, press **ERASE**. If the setup menu offers a non-numeric selection, press **ENTER**, and the asterisk changes to a flashing cursor. Use the arrow keys to scroll through the available selections. When the cursor is to the left of the desired selection, press **ENTER**.

4. Complete the process by accessing a Primary display (menus 00 through 04).

   Note The flowmeter will not use the new parameters until you access a Primary display. ▲

Table 4–1. Menu addresses

Menu Type	Display	Address
Primary	Flow/Net Totalizer	00
	Flow/Velocity	01
	Flow/Positive Totalizer	02
	Flow/Negative Totalizer	03
	Signal Strength/Low Signal Cutoff	04
Pipe	Pipe OD	10
	Pipe Wall Thickness	11
	Pipe ID	12
	Pipe Material	13
	Pipe Sound Speed	14
	Pipe Inside Roughness	15
Liner	Liner Material	16
	Liner Thickness	17
	Liner Sound Speed	18
	Liner Inside Roughness	19
Fluid	Fluid Type	20
	Fluid Sound Speed	21
	Fluid Viscosity	22
Transducer	Transducer Type	23
	Transducer Mounting	24
	Transducer Spacing	25
Flow	Flow Units	30
	Max Flow Range	31
	Min Flow Range	32
	Damping	33
	Low Flow Cutoff	34
	Low Signal Cutoff	35
Totalizer	Totalizer Units	36
	Totalizer Multiplier	37
	Net Totalizer	38
	Positive Totalizer	39
	Negative Totalizer	40

Menu Type	Display	Address
	Totalizer Reset	41
Options	Measurement Units	42
	Site Parameters	43
	RS232 Configuration	46
	Change System Password	47
	Change Scale Factor Password	48
	Unit ID	49
Calibration		50
	Zero Set	51
	Scale Factor	52
	Sound Speed Compensation	53
	Date and Time	54
Current Loop		56
	Current Loop Span	57
	Current Loop Calibration	58
	Current Loop Test	59
Relays		70
	Program Relays	71
	View Relays	72
	Test Relays	73
Datalog		80
	Datalog Interval	81
Diagnostics	Signal Strength/Margin	90
	Delta Time/Fluid Sound Speed	91
	Reynolds#/Profile Factor	92
	Current Loop Output	93
	Software/Firmware Rev. Level	94

Using the Arrow Keys to Access Menus

The other method of accessing the flowmeter menus is to use the **left** and **right arrows** to scroll through the menu structure. Menus are organized into three basic levels:

- Main menu
- Submenus
- Primary displays, setup menus, diagnostic menus.

The Main menu displays various submenus that contain individual setup and diagnostic menus. Following is an example of how to use the arrow keys to access the Main menu from any screen.

1. Press **MENU** twice. The Main menu is displayed with the Pipe and Line submenu options.

Figure 4–3. The Main menu

2. To view the remaining submenus, press the **down arrow**.

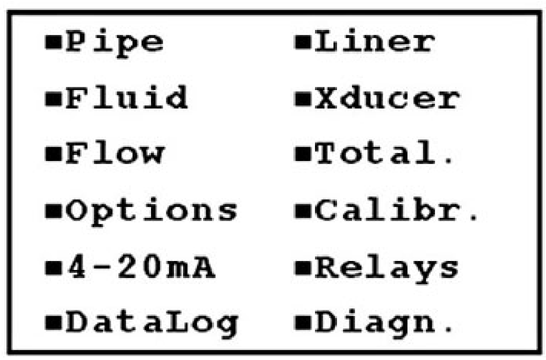


Figure 4–4. Remaining submenus of the Main menu

3. When the desired submenu is highlighted, press **ENTER** to display the first menu of the selected submenu. The figure below shows what is displayed if the Flow submenu is selected.

Figure 4–5.

4. If the setup menu requires a numeric entry, use the numeric keys to enter the value and press **ENTER** to accept the value. If you need to change the entry, press **ERASE**. If the setup menu offers a non-numeric selection, press **ENTER**, and the asterisk changes to a flashing cursor. Use the arrow keys to scroll through the available selections. When the cursor is to the left of the desired selection, press **ENTER**.

5. Complete the process by accessing a Primary display (menus 00 through 04).

   Note The flowmeter will not use the new parameters until you access a Primary display. ▲

Quick Setup Configuration

The quick setup procedure contains the minimal steps required for flowmeter configuration. These steps enable the flowmeter to calculate transducer spacing, acquire ultrasonic signal, and measure flow. The number in parentheses after the required menu is the two-digit address to directly access that menu.

1. Select a proper transducer site according to "Site Selection & Preparation" in Chapter 2.

2. Access the Pipe submenu. This submenu contains setup menus related to the pipe parameters such as pipe inside diameter (ID) and pipe outside diameter (OD).

   Note Pipe Wall Thickness is an additional setup menu within the Pipe submenu. If values for two of the following setup menus are entered, the flowmeter will calculate the remaining parameter automatically: Pipe OD (10), Pipe Wall Thickness (11), Pipe ID (12). ▲

   Note Accuracy is directly affected by the square of an error in pipe dimensions. Actual measurements (not nominal) must be entered. ▲

   a. Select the **PIPE OD** menu (10). The screen shown in Figure 4–6 is displayed. Enter the value for the pipe OD and press **ENTER**. Press the **down arrow**, and select **Actual**.

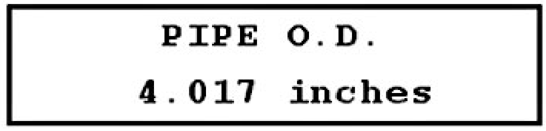


Figure 4–6. Pipe OD menu

If you know the pipe circumference but not the OD, enter the circumference value instead and press **ENTER** and the **down arrow.** The screen shown in Figure 4–7 is displayed. Select **Circum**. The flowmeter will calculate the pipe OD automatically.

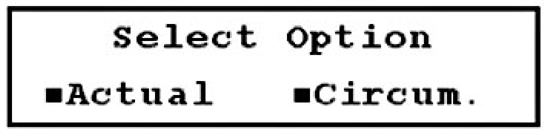


Figure 4–7. Pipe OD type options

b. Select the Pipe ID setup menu (12), and enter the pipe ID. Press **Enter**.

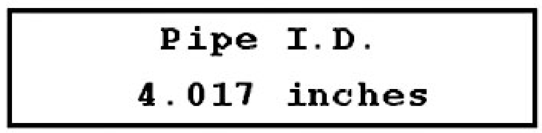


Figure 4–8. Pipe ID setup menu

c. Select the Pipe Material setup menu (13). Press the **up** or **down arrow** to scroll through the available options.

Note Select **OTHER** if the material is not listed. You must then enter the pipe sound speed (14) and pipe inside roughness (15). ▲

Figure 4–9. Pipe Material setup menu

Note Refer to "The Pipe Menu" (Chapter 5) for additional items not addressed in the quick setup procedure. ▲

3. If there is a liner, continue with this step. Otherwise, skip to step 4.

   a. Access the Liner Material setup menu (16). The screen shown in Figure 4–10 is shown. Select one of the available options.

Note Select **OTHER** if the material is not listed. You must then enter the liner sound speed (18) and liner inside roughness (19). ▲

```
Liner Material
*POLYETHYLENE
```

Figure 4–10. Liner Material setup menu

b. Access the Liner Thickness setup menu (17), and enter the thickness.

```
Liner Thickness
  0.100 inches
```

Figure 4–11. Liner Thickness setup menu

Note Refer to "The Liner Menu" (Chapter 5) for additional items not addressed in the quick setup procedure. ▲

4. Access the Fluid Type setup menu (20), and select one of the available options.

Note Select **OTHER** if the fluid type is not listed. You must then enter the fluid sound speed (21) and fluid viscosity (22). ▲

```
    Fluid Type
*WATER
```

Figure 4–12. Fluid Type setup menu

Note Refer to "The Fluid Menu" (Chapter 5) for additional items not addressed in the quick setup procedure. ▲

5. Enter the Transducer submenu.

   a. Access the Transducer Type setup menu (23). Currently, the only selection available is **Standard**. **Standard** must be selected for all applications using clamp-on transducers, including high temperature transducers.

```
 Transducer Type
*Standard
```

   Figure 4–13. Transducer Type setup menu

   b. Access the Transducer Mounting setup menu (24), and select the desired mounting method.

```
 Transducer Mount
*V    Z    W    WV    WW
```

   Figure 4–14. Transducer Mounting setup menu

6. Access the Transducer Spacing view-only menu (25). Note the required spacing between transducers.

```
 Transducer Spacing
3.30 inches
```

Figure 4–15. Transducer Spacing menu

7. Enter the **Flow** submenu, and access the Flow Units setup menu (30). Select the flow rate units.

   a. Select one of the available volumetric units.

```
    Flow Units
    *Gallons
```

   Figure 4–16. Flow Units setup menu

b. Press the **down arrow** and the Flow Units Per options are displayed. Select the desired option.

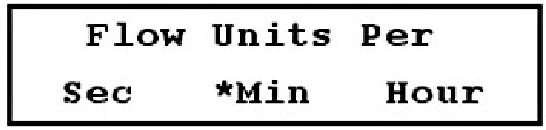


Figure 4–17. Flow Units Per setup menu

Note Refer to "The Flow Menu" (Chapter 5) for additional items not addressed in the quick setup procedure. ▲

8. Install the transducers on the pipe using the spacing provided by the flowmeter, and connect the transducer cables to the flowmeter.

9. Access a Primary Display (00 through 04) to complete the configuration process.

If the flowmeter and transducers are properly installed and a steady flow is present, the flow and signal strength readings should be relatively stable.

Note If any of the above setup parameters are changed, the flowmeter stops measuring flow until the new value is entered and a Primary Display is accessed to accept the new value. ▲

Chapter 5
Primary Displays & Menus

Primary Displays

The primary displays are for viewing only and cannot be configured. Primary displays are menus 00 through 04 and display values for flow rate, totalizers, velocity, signal strength, or low signal cutoff.

Flow/Net Totalizer

The Flow/Net Totalizer primary display (00) is the standard display used under normal operating conditions. It displays the flow rate and net totalizer value. If the net totalizer is not currently enabled, the last net totalized value is displayed.

```
Flow=      0.00 GPM
Net        0    x1Gal
```

Figure 5–1. Flow/Net Totalizer primary display

Flow/Velocity

The Flow/Velocity primary display (01) indicates the flow rate and fluid velocity. Velocity is displayed in feet per second (FPS) if English is selected as the measurement unit (menu 42) and in meters per second (MPS) if Metric is selected.

```
Flow=      0.00 GPM
Vel =      0.00 FPS
```

Figure 5–2. Flow/Velocity primary display

Flow/Positive Totalizer

The Flow/Positive Totalizer primary display (02) indicates the flow rate and the totalized flow in the positive flow direction. If the positive totalizer is not currently enabled, the last net totalized value is displayed.

```
Flow=      0.00 GPM
Pos        0    x1Gal
```

Figure 5–3. Flow/Positive Totalizer primary display

Flow/Negative Totalizer

The Flow/Negative Totalizer primary display (03) indicates the flow rate and the totalized flow in the negative flow direction. If the negative totalizer is not currently enabled, the last net totalized value is displayed.

```
Flow=      0.00  GPM
Neg        0     x1Gal
```

Figure 5–4. Flow/Negative Totalizer primary display

Signal Strength/Low Signal Cutoff

The Signal Strength/Low Signal Cutoff primary display (04) indicates the values for signal strength and low signal cutoff.

```
SigStr =       100%
Cutoff =       2.0%
```

Figure 5–5. Signal Strength/Low Signal Cutoff primary display

The Pipe Menu

The Pipe menu contains additional items that are not included in the quick setup procedure described in Chapter 4. These items are listed below.

- Pipe Wall Thickness setup menu (11)

```
Pipe Wall Thickness
    0.249 inches
```

Figure 5–6. Pipe Wall Thickness setup menu

- Pipe Sound Speed setup menu (14)

  This menu can only be configured if **OTHER** was selected as the pipe material (13). Enter the pipe sound speed. If **OTHER** was not selected as the pipe material, this menu is available by the direct access method only and functions as a view-only display to indicate the pipe sound speed as programmed in the instrument's database.

```
 Pipe Sound Speed
  10597.13  FPS
```

Figure 5–7. Pipe Sound Speed setup menu

- Pipe Inside Roughness setup menu (15)

  This menu can only be configured if **OTHER** was selected as the pipe material (13). Data on this parameter are available from the *Cameron Hydraulic Data Book* published by Ingersoll-Rand. Enter the inside roughness of the pipe. If **OTHER** was not selected as the pipe material, this menu is available by the direct access method only and functions as a view-only display to indicate the pipe inside roughness as programmed in the instrument's database.

Figure 5–8. Pipe Inside Roughness setup menu

The Liner Menu

The Liner menu contains additional items that are not included in the quick setup procedure described in Chapter 4. These items are listed below.

- Liner Sound Speed setup menu (18)

  This menu can only be configured if **OTHER** was selected as the liner material (16). Enter the liner sound speed. If **OTHER** was not selected as the liner material, this menu is available by the direct access method only and functions as a view-only display to indicate the liner's sound speed as programmed in the instrument's database.

Figure 5–9. Liner Sound Speed setup menu

- Liner Inside Roughness setup menu (19)

  This menu can only be configured if **OTHER** was selected as the liner material (16). Enter the liner inside roughness. If **OTHER** was not selected as the liner material, this menu is available by the direct access method only and functions as a view-only display to indicate the inside roughness of the liner as programmed in the instrument's database.

Figure 5–10. Liner Inside Roughness setup menu

The Fluid Menu

The Fluid menu contains additional items that are not included in the quick setup procedure described in Chapter 4. These items are listed below.

- Fluid Sound Speed setup menu (21)

  This menu can only be configured if **OTHER** was selected as the fluid type (20). Enter the fluid sound speed. If **OTHER** was not selected as the fluid type, this menu is available by the direct access method only and functions as a view-only display to indicate the fluid sound speed as programmed in the instrument's database.

Figure 5–11. Fluid Sound Speed setup menu

- Fluid Viscosity setup menu (22)

  This menu can only be configured if **OTHER** was selected as the fluid type (20). Enter the fluid viscosity. If **OTHER** was not selected as the fluid type, this menu is available by the direct access method only and functions as a view-only display to indicate the fluid viscosity as programmed in the instrument's database.

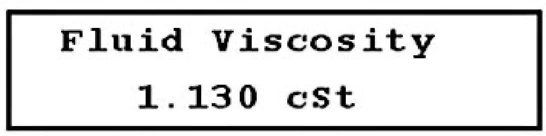


Figure 5–12. Fluid Viscosity setup menu

The Flow Menu

The Flow menu contains additional items that are not included in the quick setup procedure described in Chapter 4. These items are listed below.

- Max Flow Range (31) and Min Flow Range (32) setup menus

  Use these menus to enter the minimum and maximum flow values for setting the volumetric flow range. Setting the optimum flow range generally improves response time.

Figure 5–13. Max Flow Range setup menu

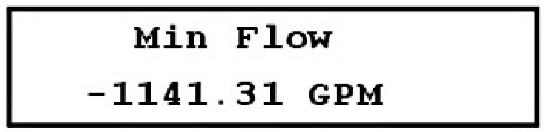


Figure 5–14. Min Flow Range setup menu

Note Whenever the pipe ID is changed, the flowmeter returns the volumetric flow range to default settings. The default settings are the maximum and minimum flows for the new pipe ID that occur at +32 and -32 ft/s (+9.76 and -9.76 m/s). ▲

- Damping setup menu (33)

  Use this menu to enter the value for the damping coefficient, which suppresses short-term fluctuations in the indicated flow rate. The displayed flow rate and the 4–20 mA current loop output is a moving average of the last n seconds where n is the damping value. Increasing the coefficient increases the response time to changes. The coefficient is adjustable from 1 to 99 seconds in1-second increments. Damping should be kept at a minimum unless the flow rate fluctuates wildly. If this is the case, increase the damping coefficient just enough to reduce the fluctuation to an acceptable degree.

Figure 5–15. Damping setup menu

- Low Flow Cutoff setup menu (34)

  When a zero flow condition occurs (for example, as the result of a pump being shut off), internal sloshing, check valve leakage, and other fluid movement can prevent the flowmeter from reading total zero. This phenomenon can result in totalizer errors. Minimize these errors by entering a low flow cutoff, which drives the flowmeter to zero for flow rates at or below the specified value. If the flow rate falls below the low flow cutoff value, the indicated flow rate is driven to zero and the totalizers stop incrementing. This is the case regardless of flow direction.

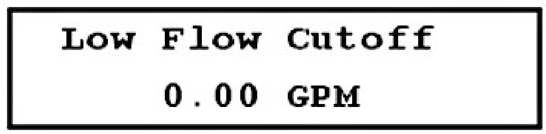


Figure 5–16. Low Flow Cutoff setup menu

For example, if you enter a low flow cutoff of 0.1 ft/s (0.03 m/s), the flowmeter will be driven to zero for flow rates less than 0.1 ft/s in the positive direction and greater than -0.1 ft/s in the negative direction.

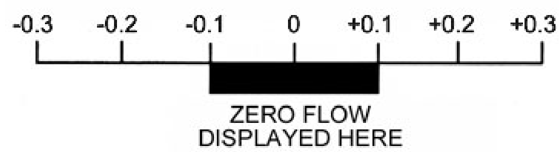


Figure 5–17.

- Low Signal Cutoff setup menu (35)

  Empty pipes or solids, bubbles, or voids in the flow stream may cause temporary drops in signal strength and erroneous readings. Minimize the effect of these dropouts by setting a low signal cutoff, which drives the flowmeter to the loss-of-signal (LOS)condition. The low signal cutoff should be set at the minimum acceptable signal amplitude.

  To set the low signal cutoff, access the Low Signal Cutoff setup menu (35). Enter the low signal cutoff and press **ENTER**.

Figure 5–18. Low Signal Cutoff setup menu

Note The value for the low signal cutoff should usually be set at approximately half of the value of the signal strength present under flow conditions. Typically, signal strength is not significantly affected by flow rate. ▲

From the Low Signal Action setup menu, select one of the following:

- Zero: The flowmeter drops the reading to zero during LOS condition.
- Hold: The flowmeter holds the last valid reading during LOS condition for about three seconds.

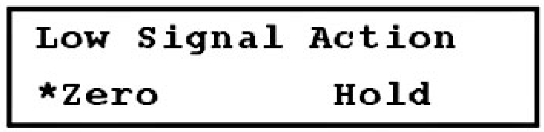


Figure 5–19. Low Signal Action setup menu

The Total Menu

Access the Total menu to configure the totalizer parameters.

- Totalizer Units setup menu (36)

  The flow units elected for the totalizer display may be different from the flow unit selected for the flow rate display.

Figure 5–20. Totalizer Units setup menu

- Totalizer Multiplier setup menu (37)

  The totalizer value can be displayed with one of several multiplier values. For example, 700 liters can be displayed as '700' if the selected multiplier value is X1, or it can be displayed as '7' if the selected multiplier value is X100.

Figure 5–21. Totalizer Multiplier setup menu

- Net Totalizer setup menu (38)

  Use this menu to enable or disable the net totalizer. The net totalizer provides the difference between the positive and negative flow values. For example, if there are 1,000 gallons of flow in the negative direction and 3,000 gallons of flow in the positive direction, the net totalizer indicates 2,000 gallons of net flow.

Figure 5–22. Net Totalizer setup menu

- Positive Totalizer setup menu (39)

  Use this menu to enable or disable the positive totalizer. The positive totalizer tracks the flow that moves in the positive direction, from upstream transducer to downstream transducer. It is not affected by flow in the opposite direction.

Figure 5–23. Positive Totalizer setup menu

- Negative Totalizer setup menu (40)

  Use this menu to enable or disable the negative totalizer. The negative totalizer tracks the flow that moves in the negative direction, from downstream transducer to upstream transducer. It is not affected by flow in the opposite direction.

Figure 5–24. Negative Totalizer setup menu

- Totalizer Reset menu (41)

  Use this menu to reset one or all of the totalizers.

Figure 5–25. Totalizer Reset menu

Options Menu

The Options submenu contains setup menus for several miscellaneous functions.

- Measurement Units setup menu (42)

  Use this menu to select **English** (feet per second, FPS) or **Metric** (meters per second, MPS) measurement units.

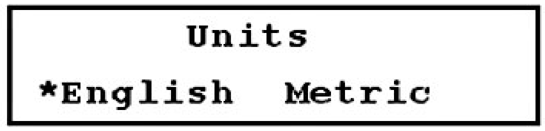


Figure 5–26. Measurement Units setup menu

- Site Parameters setup menu (43)

  This menu saves the parameters for the pipe, liner, fluid, transducer, and flow setup menus, allowing them to be recalled later for a specific measurement site. Several sites are available and are numbered. The site number is displayed in the lower left corner of the screen and is followed by a colon. An example of a site numbered 1 is shown below.

Figure 5–27. Site Parameters setup menu

As the setup parameters are entered during normal configuration, they are saved simultaneously in the Site Parameters setup menu for whichever site has the asterisk displayed. Access a different site to automatically enter that site's stored parameters into the flowmeter for measuring flow. To access a different site, press **Enter**, scroll to the desired site, and press **Enter** again.

Note To avoid overwriting stored parameters and losing old data, ensure that the desired site is active prior to entering the new set of parameters. ▲

- RS232 Configuration setup menu (46)

  Use this menu to configure the RS232 port that allows the flowmeter to connect to a PC. Communication is established using the Thermo Scientific UltraScan configuration software (refer to the UltraScan user guide) or the Thermo Scientific D-Link interface utility (refer to Appendix C).

  To configure the RS232 port, access the RS232 Configuration setup menu and select **ULTRASCAN** or **D-Link**.

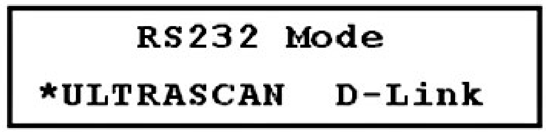


Figure 5–28. RS232 Mode setup menu

Press the **down arrow** to display the baud rate selections. The baud rate is the only RS232 configuration parameter that can be modified. The remaining parameters (parity, character size, stop bits) are preset.

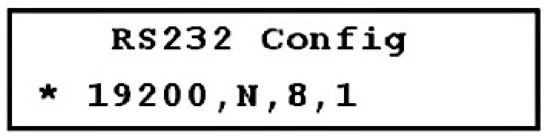


Figure 5–29. RS232 Configuration setup menu

Access a Primary display to cause the flowmeter to use the new settings.

- Change System Password setup menu (47)

  The flowmeter is shipped from the factory with the system password disabled. If a password is enabled, the flowmeter requests the password when a user attempts to enter any configuration data. Entering the correct password temporarily unlocks the system, allowing the user to make configuration changes.

  To change or disable the system password, access the Change System Password setup menu.

Figure 5–30. Change System Password setup menu

Enter the new system password and press **Enter**.

Note Disable the system password function by entering **0** (zero) as the system password. Enable the function by changing the password back to anon-zero number. ▲

Enter the old system password and press **Enter**. If the old system password is correctly entered, the software will display that the password is accepted (Figure 5–31). If the password is incorrectly entered, it will display that the entry is rejected (Figure 5–32).

Figure 5–31.

Figure 5–32.

Note After the system password is accepted or rejected, the Change Scale Factor Password setup menu is displayed, which allows you to change the scale factor password. ▲

Access menu 00 to lock the system with the new password.

- Change Scale Factor Password setup menu (48)

Use this menu to change the scale factor password which is designed to protect the scale factor from unauthorized or accidental changes. The flowmeter ships from the factory with the scale factor password disabled. If the scale factor password is enabled, the flowmeter requests the password whenever a user attempts to change the scale factor.

To change or disable the scale factor password, access the Change Scale Factor Password setup menu. Enter the new scale factor password and press **Enter**.

Figure 5–33. Change Scale Factor Password setup menu

Note The system password function must be disabled to allow the scale factor to be changed without entering a password. ▲

Enter the old scale factor password and press **Enter**. If entered correctly, the software will display that the password is accepted (Figure 5–34). If the password is incorrectly entered, it will display that the entry is rejected (Figure 5–35).

Figure 5–34.

Figure 5–35.

- Unit ID (identification) Number setup menu (49)

  This number is set by the operator to identify the specific instrument or site. Any whole number between 1 and 60,000 may be entered.

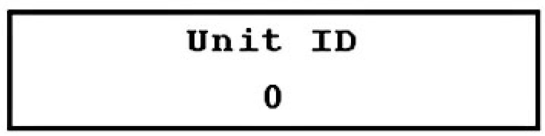


Figure 5–36. Unit ID setup menu

The Calibration Menu

Within the Calibration menu is the Calibration Group menu (50). This menu contains four setup menus: Zero Set, Scale, SS Comp, and Date (menus 51 through 54).

```
    Calibration
■Zero Set ■Scale
```

Figure 5–37. Calibr menu

Zero Set Calibration

An important step in assuring accurate flow measurement is the proper calibration of the instrument and the installation. The calibration methods must be performed for the particular pipe that is to be metered. The following table provides guidelines for selecting a calibration method.

Table 5–2. Calibration methods

Calibration Method	Function	Application
Zero flow set (zero set calibration)	Zeroes the instrument for an actual no flow condition.	Installations where flow can be stopped.
Manual zero set (zero set calibration)	Applies a manually entered offset to all flow readings.	Where an offset is required.
Scale Factor	Compensates for manufacturing variations in the transducers.	Set by the factory to the value imprinted on the transducers.

After installing the meter, you may find that a small adjustment to the zero point (zero set calibration) is required. Zero set calibration enables the meter to read very close to zero under zero flow conditions. There are two zero set calibration methods: the zero flow set method and the manual zero set method. View the zero point used by the flowmeter in either of these methods by selecting **Manual** in menu 51.

After the instrument is properly zeroed, it should display a stable reading well below 0.05 ft/s (0.015 m/s) under zero flow conditions with the low flow cutoff disabled.

Prior to performing a zero set calibration, verify the following:

- Transducers are connected to the pipe.
- Instrument is reading flow.
- Low flow cutoff is disabled to allow verification of calibration.

Zero Flow Set Method

The best method of zeroing the instrument is to stop the flow and perform a zero flow set on the pipe. The purpose of the zero flow set is to zero the instrument for the individual application. This method is used only when flow in the pipe can be stopped. The flow rate displayed in the Flow/Velocity primary display (01) must be between -0.25 and+0.25 ft/s (-0.076 and +0.076 m/s).

1. Ensure there is no flow in the pipe.

2. Access the Zero Set menu (51).

```
      Set  Zero
■No Flow   ■Manual
```

Figure 5–38.

3. Select **No Flow**. If the zero flow set calibration is successful, Figure 5–39 is displayed. If the flow rate is too high to perform a zero flow set calibration, Figure 5–40 is displayed. In this case, continue to step 4.

```
   Zero Cal Ok
 Flow = 0.00 GPM
```

Figure 5–39. Zero set calibration successful

```
   Zero Failed
  V = X.XX FPS
```

Figure 5–40. Zero set calibration failed

4. If Figure 5–40 is displayed, press any key and repeat steps 1 through 3 when the flow rate is within required limits.

Manual Zero Set

Use this method infrequently. Manual zero set applies a constant offset entered by the user to all readings. For example, if the flow reads 250 gal/min and a 10 gal/min offset is applied, the new reading becomes 240 gal/min. To zero the instrument using the manual zero set method, follow these steps.

1. Ensure that the minimum flow range setting in Min Flow Range setup menu (32) is the negative equivalent of the maximum flow rate setting in the Max Flow Range setup menu (31).

2. Enter ‘0.00’ as the manual zero setting in the Zero Set menu (51), then access the Flow/Net Totalizer primary display (00).

3. Minimize flow in the pipe.

4. Set the damping so that the flowmeter reads a steady flow.

5. Allow the flowmeter to settle for 10 minutes.

6. Take 10 separate flow readings and average. This average is designated as P for positive in the formula seen in step 10.

7. Disconnect the transducer wires, and reverse the upstream and downstream wires. The flowmeter displays a negative flow reading.

8. Allow the meter to settle for 10 minutes.

9. Take another 10 readings and average. This value is designated as N for negative in the formula instep 10.

10. Determine the manual zero point (Zp) by performing the following calculation:

$$Zp = \frac{(P + N)}{2}.$$

11. Access the Zero Set menu (51) and select **Manual**.

12. Enter the zero point. If necessary, you can apply a negative offset by pressing +/- (plus/minus key).

13. Press **Enter**, and access the Flow/Net Totalizer primary display (00). Reconnect the transducer wires according to their original orientation.

14. Restore the minimum and maximum flow range values (menus 31 and 32) if they were changed.

15. Allow the flowmeter readings to settle for 10 minutes.

Scale Factor Calibration

After setting and verifying the instrument's zero point, you can set a scale factor to adjust the measured flow. The measured flow is multiplied by this scale factor. For example, if the displayed flow is twice the actual flow, you can enter a scale factor of 0.5 to divide the displayed flow by 2. The primary reason for setting the scale factor is to compensate for manufacturing variations in the transducers. The scale factor printed on the transducer set should be entered in the Scale Factor setup menu (52).

Observe the following precautions when setting the scale factor:

- Always determine the scale factor at the highest possible flow rate achievable in order to maximize accuracy of the scale factor.
- Use only the factory preset scale factor as marked on the transducers in the following situations:
  - The flow cannot be stopped to verify or set the zero point.
  - A reasonably high flow rate cannot be achieved.
  - An accurate secondary flow standard is not available.

If an additional scale factor is required, the additional scale factor should be multiplied by the factory scale factor and the result should be entered. To enter a new scale factor, follow the steps below.

1. Access the Scale Factor setup menu (52).

Figure 5–41.

2. Enter the new scale factor and press **Enter**.

3. Enter the valid password and press **Enter**.

Figure 5–42.

4. The new scale factor is displayed in the Scale Factor setup menu (52). To maximize security, enter a new scale factor password immediately.

Sound Speed Compensation

The Sound Speed Compensation setup menu (53) allows you to enable or disable the instrument's sound speed compensation. Temperature variations in the fluid and other factors may cause variations in the fluid's sound speed. Typically, the flowmeter can determine sound speed more accurately when this feature is enabled.

Figure 5–43. Sound Speed Compensation setup menu

Date and Time

Access the Date and Time setup menu (54) to set the date and time in the flowmeter's internal clock. The time is expressed in military time (24-hour format), and the date is in the month-day-year format.

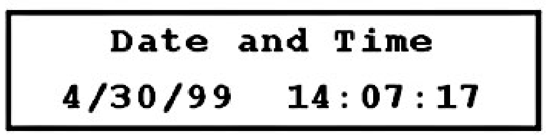


Figure 5–44. Date and Time setup menu

If you are not using UltraScan, set the time and date as follows:

1. Perform a master erase on the flowmeter as described in Chapter 6.

2. Reconfigure the flowmeter, and access the Date and Time setup menu (54).

   Note Performing a Master Erase and reconfiguring the flowmeter prior to changing the date or time prevents possible data corruption. ▲

3. Press **Enter**, and a prompt to enter the month will be displayed. Press **Enter** after making the entry. Prompts to enter the day, year hour, minute, and second will be displayed. Press **Enter** after each entry.

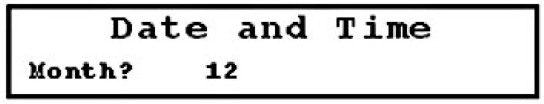


Figure 5–45.

4. To keep the current values displayed in any screen, scroll to the next screen with the **down arrow** instead of pressing **Enter**.

5. Once all parameters are entered, the new programmed date and time will be displayed.

The 4 –20 mA Menu

Under the 4–20 mA submenu is the Current Loop Group menu (56), which contains three setup menus: Span, Cal., and Test (menus 57 through 59).

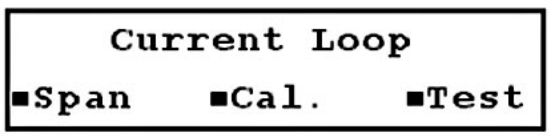


Figure 5–46. Current Loop Group menu

The 4–20 mA current loop is factory calibrated and should not require field calibration prior to use. If calibration and testing should become necessary, complete the following procedure that follows.

1. Connect a milliammeter to the input (IN) and output (OUT) terminals of the current loop module.

2. Access the Current Loop Calibration menu (58).

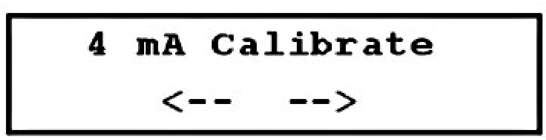


Figure 5–47. 4 mA Calibrate screen

3. Press the **right** and **left arrows** to adjust the 4 mA set point until the value reads exactly 4.00 mA on the milliammeter. Two presses of the arrow key will adjust the calibration approximately .01 mA.

4. Press **Enter**.

5. Access the Current Loop Calibration menu (58) again.

6. Press the **down arrow** to scroll to the 20 mA Calibrate screen.

Figure 5–48. 20 mA Calibrate screen

7. Press the **right** and **left arrows** to adjust the 20 mA set point until the value reads exactly 20.00 mA on the milliammeter. Every two presses of the arrow key adjusts the calibration approximately .01 mA

8. Access the Flow/Net Totalizer primary display (00).

9. Test the current loop calibration by accessing the Current Loop Test menu (59).

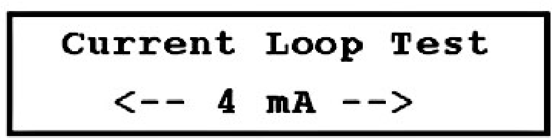


Figure 5–49. Current Loop Test menu

10. Change the current loop output in 1 mA increments using the **right** and **left arrows**. The output indicated on the screen should be the same as the output on the milliammeter. If the values do not match, repeat steps 2 through 10.

11. Set the current loop span by accessing the Current Loop Span menu (57). The current loop span is the span of flow versus current.

12. Enter a flow rate which equals the 4 mA (minimum anticipated) reading, and press **Enter**.

```
Span? (4 mA)
0.00 GPM
```

Figure 5–50. 4 mA Span screen

13. Press the **down arrow**, and enter a flow rate that equals the 20 mA (maximum anticipated) reading. Press **Enter**.

```
Span? 20 mA
0.00 GPM
```

Figure 5–51. 20 mA Span screen

14. Access the Flow/Net Totalizer primary display (00) to complete the current loop calibration process.

Note The current loop output freezes for approximately 30 seconds after calibrating or testing. ▲

The Relays Menus

The RELAYS menu contains the setup menus for programming, viewing, and testing the instrument's relay parameters. The relays may be used for functions such as alarm, pump control, etc. Up to four relays may be independently programmed for a variety of on/off conditions. Alternatively, the relay can send a pulse to a remote device (for example, a totalizer, sampler, or chlorinator) whenever the internal totalizer advances by one unit.

Programming

To program a relay, follow the steps below.

1. Access the Program Relays menu (71).

```
Prog Relay #
■1   ■2   ■3   ■4
```

Figure 5–52. Program Relays menu

2. Each relay is independently programmed. Select the relay you want to program. The Relay On Condition screen is displayed.

```
 Relay 1 On  Cond.
*Flow >
```

Figure 5–53. Relay On Condition screen

3. Select one of the following relay ON conditions:
   - NOT PROGRAMMED (OFF)
   - FLOW > : Relay actuates when the flow rate is greater than the ON condition value.
   - FLOW < : Relay actuates when the flow rate is less than the ON condition value.
   - SIGNAL > : Relay actuates when the signal strength value is greater than the ON condition value.
   - SIGNAL < : Relay actuates when the signal strength value is less than the ON condition value.
   - NET TOT > : Relay actuates when the net totalizer value is greater than the ON condition value.
   - NET TOT < : Relay actuates when the net totalizer value is less than the ON condition value.
   - POS TOT > : Relay actuates when the positive totalizer value is greater than the ON condition value.
   - POS TOT < : Relay actuates when the positive totalizer value is less than the ON condition value.
   - NEG TOT > : Relay actuates when the negative totalizer value is greater than the ON condition value.
   - NEG TOT < : Relay actuates when the negative totalizer value is less than the ON condition value.
   - NET TOTAL PULSE : Relay cycles once each time the net totalizer increments.
   - POS TOTAL PULSE : Relay cycles once each time the positive totalizer increments.
   - NEG TOTAL PULSE : Relay cycles once each time the negative totalizer increments.

Note The output for the PULSE selections is limited to one cycle per second. The pulse duration (relay ON time) is approximately 500 milliseconds. If the totalizer increments more than once per second, the flowmeter tracks how far behind the relay pulses are. The flowmeter then “catches up” when a flow condition occurs where the totalizer increments at a rate of less than once per second. To prevent the relay pulse output from falling behind, the Totalizer Multiplier menu (37) should be selected so that at the maximum anticipated flow rate, the totalizer increments once per second or less. For example, if the totalizer unit is gallons and the maximum anticipated flow is 600 gallons per minute (10 gallons per second), a multiplier of 10 should be selected. ▲

Note The net totalizer can either increment or decrement depending upon the direction of the flow. Since the external totalizer (driven by the net totalizer pulse) can only increment, the flowmeter stops transmitting pulses whenever negative flow is being measured. The flowmeter tracks the negative flow and does not start sending pulses to the external totalizer until the measured negative flow is canceled out by positive flow. If an application has negative flow for extended periods of time, separate external totalizers should be used, driven by the positive and negative totalizers. The net flow total can then be determined by subtracting the value for the negative external totalizer from the value for the positive external totalizer. ▲

4. Press the **down arrow**, and the Relay On Condition Value screen is displayed. Enter the value for the relay ON condition. Press **Enter**.

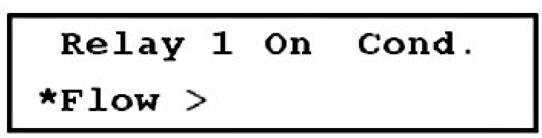


Figure 5–54. Relay On Condition screen

Note The flow units used for the relays are the same as the flow units selected for measuring flow in the Flow Units menu (30). ▲

5. Press the **down arrow**, and the Relay Off Condition screen is displayed. Select a relay OFF condition. The selections available for the OFF condition are the same as those for the ON condition. If the ON condition is one of PULSE selections, an OFF condition is not applicable.

   The OFF condition value should be entered in conjunction with the ON condition value to establish a “dead band”. This prevents the relay from continuously cycling on and off when the flow is close to the ON or OFF value. For example, if the ON condition is FLOW > 250 gallons per minute, the OFF condition may be set at FLOW < 240 gallons per minute. At these settings, the relay turns on when the flow exceeds 250gallons per minute and does not turn off until the flow falls below 240 gallons per minute.

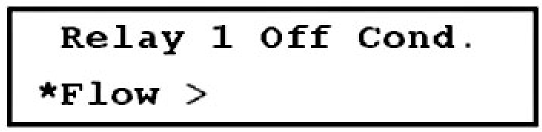


Figure 5–55. Relay Off Condition screen

6. Press the **down arrow**, and the Relay Off Condition Value screen is displayed. Enter the value for the relay OFF condition. Press **Enter**.

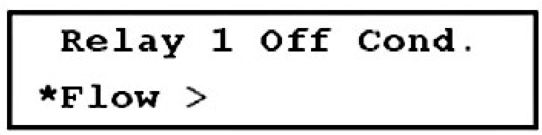


Figure 5–56. Relay Off Condition Value screen

7. Repeat this procedure for each relay you want to program.

Viewing Relays

You can view the current ON and OFF conditions of the relays through the View Relays menu (72) and selecting the desired relay. The ON and OFF conditions for the selected relay will be displayed.

Figure 5–57. Show Relays menu

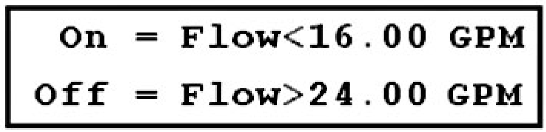


Figure 5–58. Example of ON/OFF conditions for selected relay

Testing Relays

Relays are tested by manually turning them on and off. This is accomplished using the Test Relays menu (73). Test a relay as follows:

1. Access the Test Relays menu (73). The ON/OFF status of each relay will be displayed. This display shows that relays 1 and 2 are off, and relays 3 and 4 are on.

Figure 5–59. Test Relays menu

2. Select the relay and press **Enter**. The relay's ON or OFF indication on the display changes to indicate the new status. The relay should audibly click as it opens or closes, and the LED should light up when the relay is on.

3. Repeat steps 1 through 2 for each relay you want to test.

4. Once you have completed testing the desired relays, exit the relay test function by pressing **Erase** or by directly accessing another menu.

The Data Log Menu

The Data Log menu contains the Log Menu (80) and the Log Interval menu (81). The data logger provides the ability of continuously recording flow data at a preset interval. The flowmeter has a single data log file with approximately 30,000 data points available. This allows considerable data to be collected. For instance, if collecting data at a 60-second interval, the flowmeter could store data for approximately 20 days. The data logger is always enabled (always recording data). When all 30,000 points are recorded, the data logger records over the previous data points one at a time in a continuous loop, starting with the oldest data points first.

The log file can be transferred in ASCII format to a PC for record keeping or analysis. In addition, the data log file can be deleted by resetting the data point values to zero. Log files are transferred using the D-Link flowmeter data link utility (refer to Appendix D).

- Data Log setup menu (80)

  The only option available in this menu is **Interval**. Select this to enter the next menu.

Figure 5–60. Data Log setup menu

- Data Log Interval menu (81)

  Data log intervals must be entered in whole seconds, with a minimum interval of 1 second.

Figure 5–61. Data Log Interval menu

Caution The data logger automatically deletes data whenever the log interval, data, time, flow units, pipe dimensions, or liner dimensions are changed. ▲

Any power interruptions cause zeroes to be written in the data log stream. This feature is useful to determine if an interruption in the time sequence has occurred or if the instrument has been moved or tampered with while logging data.

The Diagnostics Menu

The Diagnostics menu contains various view-only menus which display important diagnostic parameters that are currently used or calculated by the flowmeter. These parameters are helpful when troubleshooting the flowmeter.

- Signal Strength/Margin display (90)

  This screen displays the signal strength in percentage and the margin. The signal strength value displayed is the average of the signal strengths for the upstream and downstream transducers. Margin is an indicator of signal quality and is generally greater than 50%. Signal strength is generally greater than 3% under good measurement conditions.

```
SigStr =        95%
Margin =        82%
```

Figure 5–62. Signal Strength/Margin display

- Delta Time/Fluid Sound Speed display (91)

  Displays the value for DeltaT and the fluid sound speed as measured by the flowmeter. DeltaT is the difference between the upstream and downstream travel times, expressed in nanoseconds (ns).

```
DeltaT =     0.00 ns
SSpeed = 4863.33 FPS
```

Figure 5–63. Delta Time/Fluid Sound Speed display

- Reynolds Number/Profile Factor display (92)

  Displays the Reynolds number and flow profile factor currently being used by the flowmeter. The flow profile factor is calculated by the flowmeter and used to determine the effect of the flow profile on mean measured fluid velocity.

```
Reynolds=         0
Factor  =0.750000
```

Figure 5–64. Reynolds Number/Profile Factor display

- Current Loop Output display (93)

  Displays values of the current in mA that the flowmeter is presently providing to the current loop output.

```
Current Loop
4-20mA =   4.00 mA
```

Figure 5–65. Current Loop Output display

- Software/Firmware Revision Level display (94)

  Displays the software (SOFT VERS.) and firmware (FPGA VERS.) versions installed in the flowmeter.

```
Soft Vers. = 3.25
FPGA Vers. = A0
```

Figure 5–66. Software/Firmware Revision Level display

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Chapter 6
Emergency Override & Master Erase

Since the two procedures described below allow critical data to be accessed and changed, this chapter may be removed from the manual to prevent unauthorized use of these features.

Emergency Overrides

If a user-entered password is forgotten, the following emergency override passwords maybe used: 42 for the system password and 43 for the scale factor password. These override passwords may not be changed or disabled.

Performing a Master Erase

Caution The master erase function erases all user-entered data and data in the data logger. Note all configuration settings and download the data log file if a record is desired prior to performing a master erase. ▲

To perform a master erase:

1. Turn the flowmeter off and back on.

2. When the message INITIALIZING... is displayed, press **ERASE** within three seconds.

3. The Master Erase screen is displayed. To continue, press the **5** key within three seconds.

Figure 6–1.

4. At the prompt, press the **.** (decimal) key within three seconds to continue.

Figure 6–2.

5. If the master erase function is completed, the message shown below is displayed.

Figure 6–3.

6. Enter all configuration data.

Chapter 7
Maintenance & Troubleshooting

Replacing the Fuse

Warning Prevent possible electrical shock and / or damage to the meter. Disconnect power to the meter prior to performing this procedure. ▲

The flowmeter has a single fuse that is mounted to the main board. The sheet metal access cover does not need to be removed since there is a fuse access hole. To replace the fuse:

1. Disconnect power from the flowmeter.

2. Determine the cause of the fuse failure and correct if known.

3. Open the door of the flowmeter.

4. Using a small, flat-bladed screwdriver, remove the fuse and replace it with another fuse of the same rating.

5. Reconnect power to the flowmeter and verify that the unit is operating properly, e.g. the replacement fuse does not blow.

Replacing the Current Loop Module

Warning Prevent possible electrical shock and / or damage to the meter. Disconnect power to the meter prior to performing this procedure. ▲

1. Disconnect power from the flowmeter.

2. Open the flowmeter door and remove the sheet metal access cover.

3. Disconnect wiring to the module.

4. Remove the two screws and four insulating washers from the lower corners of the module. Each screw has one washer above and one washer beneath.

5. To prevent damage to the connector, grasp the module by all four edges and slowly lift it straight out from the main board.

6. Align the pins on the new module with the connector on the main board and press the module straight in.

   Caution To ensure proper operation and avoid damage to the module, align the pins on the module properly with the connector before inserting the module into the flowmeter. Ensure that the screw holes in the module align exactly with the mounting posts on the main board. It is possible to incorrectly align the module by one pin and force the holes to line up, causing damage to the module. ▲

   See the figure below.

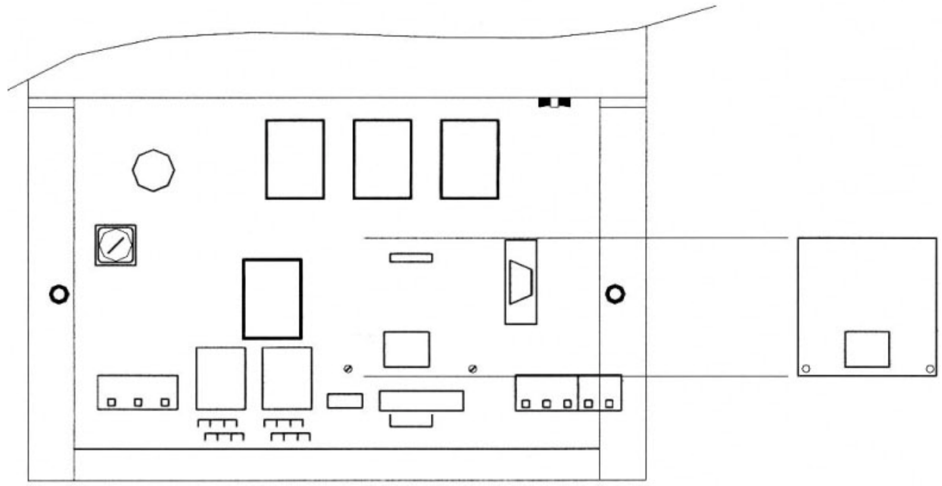

Figure 7–4. Current loop module alignment

7. Replace the two screws and four insulating washers.

8. Select the loop powering option and connect the wiring to the module. Refer to “The Current Loop” (Chapter 3).

9. Replace the sheet metal access cover and reconnect power to the flowmeter.

10. Calibrate the current loop according to “The Calibration Menu” (Chapter 5).

Replacing Sonic Coupling Compound

Any voids or air gaps that exist in the coupling compound beneath the transducers can reduce the signal and render the flowmeter inoperative. Coupling compound should be protected from washout and replaced as required. Annual replacement is recommended for most applications to maintain optimal performance.

Follow the steps below to replace the coupling compound.

1. Remove the transducers from the pipe.

2. Clean the old compound from the transducers and the pipe.

3. Apply a wide bead of compound lengthwise down the center of each transducer face.

4. Remount the transducers. The compound should squeeze out from underneath all sides of the transducers and form a bead along the edges.

The following sonic coupling compounds are recommended:

- Sil-Glyde® (American Grease Stick Company): Made from a silicon base and suited for most transducer installations. Rated for pipe skin temperatures from -40°F to +212°F (-40°C to +100°C).
- Dow Corning® 111 or similar high temperature couplant: Can be used for applications with pipe skin temperatures up to 300°F (150°C).
- General Electric RTV-108 or similar silicon RTV: Should be used for underground or submerged transducer sites or sites where a more permanent bond is required. RTV should be completely cured prior to covering up the transducer site or taking readings.
- Krautkramer® Hitempco (p/n 22861-0001): Good high temperature couplant. Should be used with optional high temperature transducers rated up to 392°F (200°C).

Caution The transducers should not be bonded with epoxy. ▲

Software Upgrades

The current software for your meter is provided at time of shipment. Find out about upgrades by contacting Thermo Fisher.

General Troubleshooting

If the unit does not perform satisfactorily, complete the following steps until the problem is resolved:

1. Verify the flowmeter is properly installed and the installation site is suitable.

2. Verify the flowmeter is properly configured.

3. Perform a master erase (Chapter 7).

4. Contact the installation contractor or representative through whom the flowmeter was purchased.

5. Contact Thermo Fisher to attempt to resolve the problem over the phone. Please have the following information available:
   - Signal strength
   - Transducer type and mounting configuration
   - Pipe orientation
   - Pipe OD
   - Pipe ID
   - Pipe material
   - Fluid type
   - Liner material
   - Liner thickness
   - Model and serial numbers

Contact Information

The local representative is your first contact for support and is well equipped to answer questions and provide application assistance. You can also contact Thermo Fisher directly at the locations below.

Process Instruments		
1410 Gillingham Lane Sugar Land, TX 77478 USA +1 (800) 437-7979 +1 (713) 272-0404 direct +1 (713) 4573 fax	14 Gormley Industrial Avenue Gormley, Ontario L0H 1G0 CANADA +1 (905) 888-8808 +1 (905) 888-8828 fax	Unit 702-715, 7/F Tower West Yonghe Plaza No. 28 Andingmen East Street, Beijing 100007 CHINA +86 (10) 8419-3588 +86 (10) 8419-3580 fax
A-101, 1CC Trade Tower Senapati Bapat Road Pune 411 016 Maharashtra, INDIA +91 (20) 6626 7000 +91 (20) 6626 7001 fax	Ion Path, Road Three Winsford, Cheshire CW7 3GA UNITED KINGDOM +44 (0) 1606 548700 +44 (0) 1606 548711 fax	
www.thermoscientific.com		

Warranty

Thermo Scientific products are warranted to be free from defects in material and workmanship at the time of shipment and for one year thereafter. Any claimed defects in Thermo Scientific products must be reported within the warranty period. Thermo Fisher Scientific shall have the right to inspect such products at Buyer's plant or to require Buyer to return such products to Thermo Fisher plant.

In the event Thermo Fisher requests return of its products, Buyer shall ship with transportation charges paid by the Buyer to Thermo Fisher plant. Shipment of repaired or replacement goods from Thermo Fisher plant shall be F.O.B. Thermo Fisher plant. A quotation of proposed work will be sent to the customer. Thermo Fisher shall be liable only to replace or repair, at its option, free of charge, products which are found by Thermo Fisher to be defective in material or workmanship, and which are reported to Thermo Fisher within the warranty period as provided above. This right to replacement shall be Buyer's exclusive remedy against Thermo Fisher.

Thermo Fisher shall not be liable for labor charges or other losses or damages of any kind or description, including but not limited to, incidental, special or consequential damages caused by defective products. This warranty shall be void if recommendations provided by Thermo Fisher or its Sales Representatives are not followed concerning methods of operation, usage and storage or exposure to harsh conditions.

Materials and/or products furnished to Thermo Fisher by other suppliers shall carry no warranty except such suppliers' warranties as to materials and workmanship. Thermo Fisher disclaims all warranties, expressed or implied, with respect to such products.

EXCEPT AS OTHERWISE AGREED TO IN WRITING BY Thermo Fisher, THE WARRANTIES GIVEN ABOVE ARE IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, AND Thermo Fisher HEREBY DISCLAIMS ALL OTHER WARRANTIES, INCLUDING THOSE OF MERCHANTABILITY AND FITNESS FOR PURPOSE.

Chapter 8
Hazardous Area Installation

General

This chapter covers requirements for installing the instrument in hazardous area applications. Hazardous area certification for North America is provided by the Canadian Standards Association (CSA). Certification for Europe is provided by Laboratoire Central des Industries Electrique (LCIE).

The area classification determines the type of enclosure to be used and if barriers are required. If barriers are required, they are installed by the factory to meet the appropriate agency certification. The standard enclosure for the instrument is a NEMA 4X (IP65). The instrument is also available in an optional, factory-installed NEMA 7 explosion proof enclosure. If transducers are approved for use in hazardous areas, a log of the certifying agency is affixed to the transducers.

North American Certification

The transducers are certified by CSA as follows:

- Intrinsically safe (IS) transducer for Class I and II, Div. 1, Groups C, D, E, F, G (IS barriers required)
- Non-incendive for the following areas (IS barriers not required):

  - Class I, Div. 2, Groups A, B, C, D

  - Class II, Div. 2, Groups E, F, G

The table below lists CSA's hazardous area installation requirements for North America.

Table 8–1. North American hazardous area installation requirements

Item	Division 1	Division 2	Unclassified
Instrument	NEMA 7 enclosure[1]	NEMA 4X enclosure	NEMA 4X enclosure
Transducers	IS, barriers required	Non-incendive, barriers not required	Barriers not required
Installation drawing[2]	Figure 8–1	Figure 8–2	N/A

[1]Instrument should be installed in accordance with National Electrical Code (NEC) Article 500, including use of explosion proof seals for the wiring connections to the enclosure.

[2]The flowmeter must be installed and wired in accordance with the specified installation drawing.

Warning To minimize the possibility of explosion, do not disconnect equipment unless the area is known to be non-hazardous. In addition, do not replace the fuse or output module unless power has been switched off or the area is known to be non-hazardous. ▲

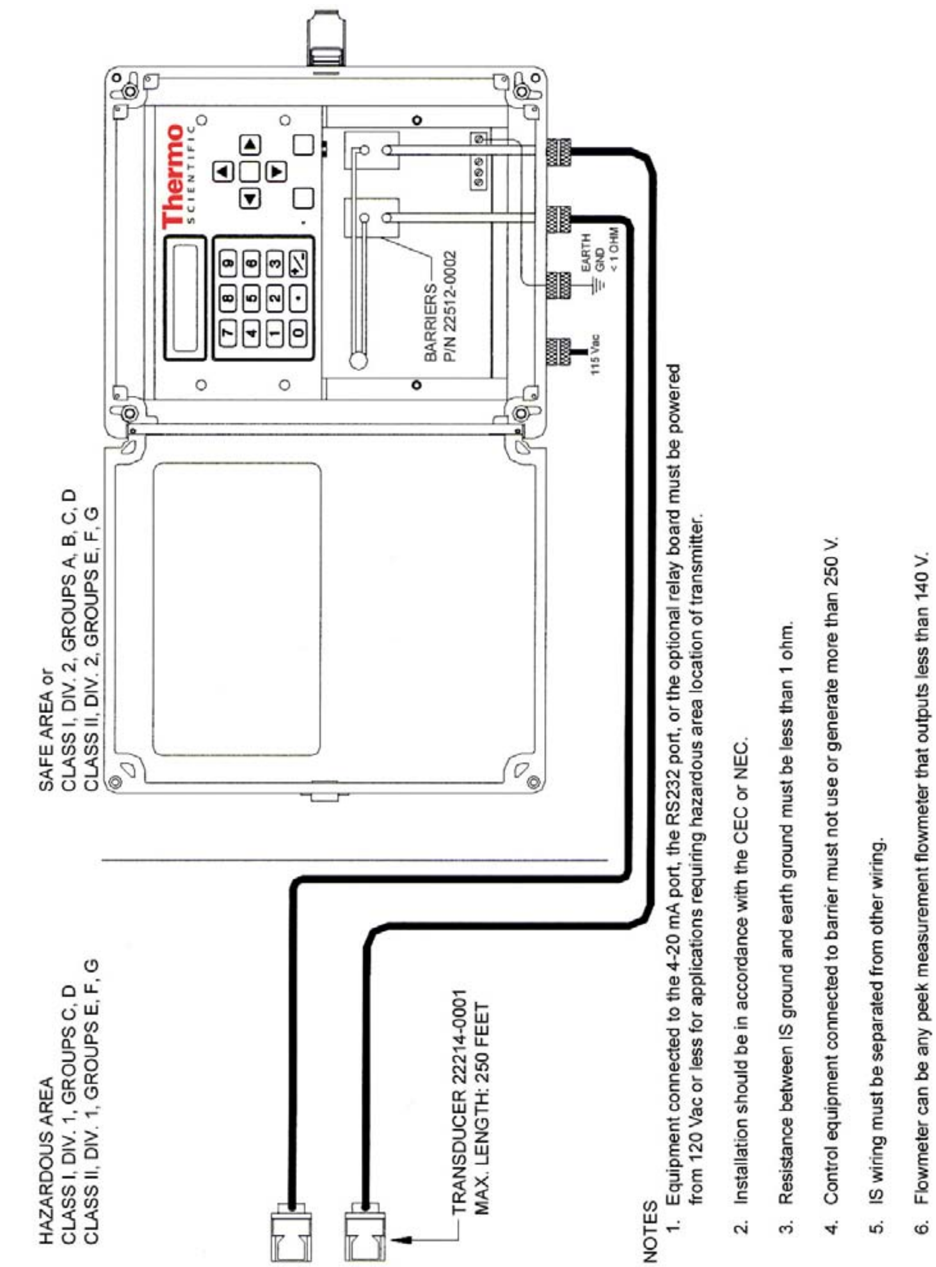

Figure 8–1. North American IS (Div. 1) hazardous area installation (refer to drawing 22493-0003)

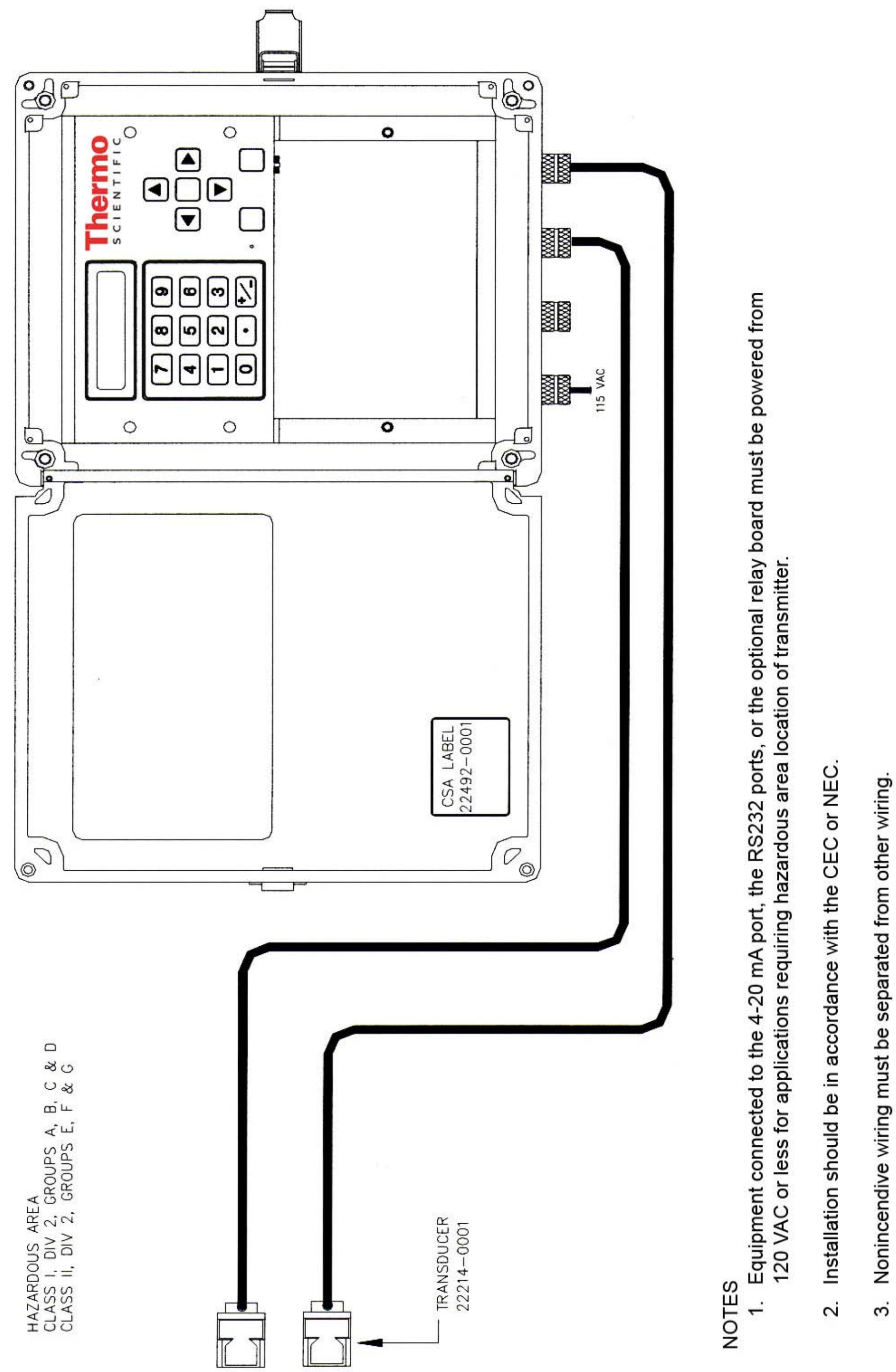

Figure 8–2. North American non-incendive (Div. 2) hazardous area installation (refer to drawing 22493-0001)

European Certification

The transducers are certified IS by LCIE for EEx ia IIB T6 when IS barriers are installed. The table below lists the European hazardous area installation requirements.

Table 8–2. European Hazardous Area Installation Requirements

Item	Zone 0	Zone 1	Zone 2	Unclassified
Instrument	N/A	EExd1 enclosure	EExd1 enclosure	IP65 enclosure
Transducers	EEx ia, barriers required	EEx ia, barriers required	EEx ia, barriers required	Barriers not required
Installation drawing[2]	Figure 8–3	Figure 8–3	Figure 8–3	N/A

[1]Instrument should be installed in accordance with required codes, including use of explosion proof seals for the wiring connections to the enclosure.

[2]The flowmeter must be installed and wired in accordance with the specified installation drawing.

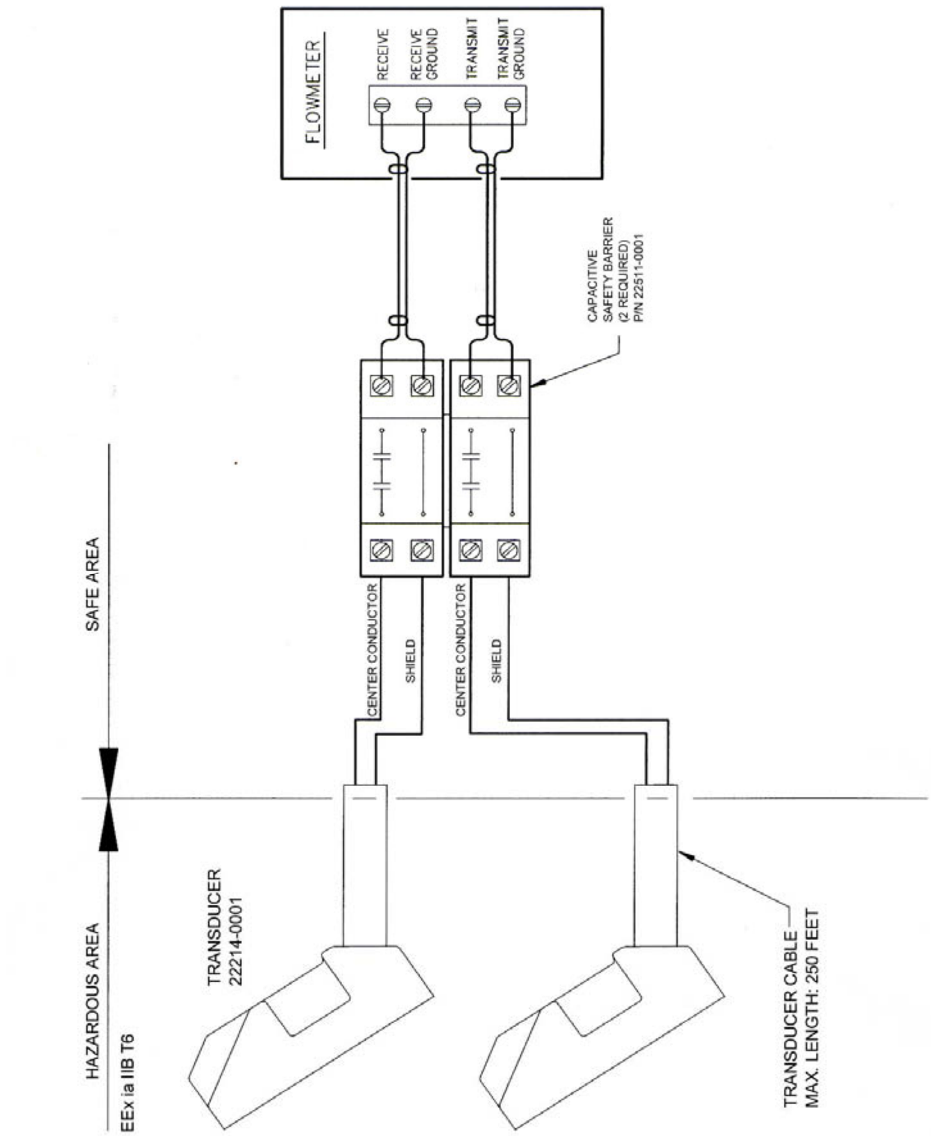

Figure 8–3. European hazardous area installation (refer to drawing 22493-0005)

North American Hazardous Area Installation Definitions

This section provides hazardous area installation definitions for North America to assist in determining the operating environment for the instrument. Refer to the National Electrical Code (NEC) Article 500 for more information on hazardous area definitions for North America.

- Class I: Highly flammable gases or vapors
- Class II: Combustible dust
- Class III: Combustible fibers or flyings
- Division 1: Intermittent or continuous hazard
- Division 2: Hazard under abnormal conditions
- Group A: Atmospheres containing acetylene
- Group B: Atmospheres containing hydrogen or gases of equivalent hazard
- Group C: Atmospheres containing ethyl-ether vapors, ethylene or cyclopropane
- Group D: Atmospheres containing gasoline, hexane, benzene, butane, propane, alcohols, acetone, benzol, lacquer solvent vapors, or natural gas
- Group E: Atmospheres containing metal dust
- Group F: Atmospheres containing coal dust
- Group G: Atmospheres containing grain dust
- NEMA 4X: Watertight enclosures, must pass hose test using 1-inch nozzle delivering 65 gal/min at a 10-ft distance for 5 minutes; additional corrosion-resistant characteristics, having no exposed metal surfaces
- NEMA 7: Explosion proof enclosures for indoor hazardous locations (Class I, Groups A, B, C, D)

European Hazardous Area Installation Definitions

This section provides hazardous area installation definitions for Europe to assist in determining the operating environment for the instrument. Refer to International Electrotechnical Commission (EIC) 79 for more information on hazardous area definitions for Europe.

- EEx ia IIB T6: IS classification; surface industry equipment used in flammable atmospheres equivalent to ethylene or less; maximum surface temperature of 185°F (85°C)
- IP65: Dust-tight enclosure; protection against low pressure jets of water from all directions (limited ingress permitted)

European Safety Requirements

The table below provides supplemental information for compliance with Safety Standard EN61010-1.

Table 8–3. European Safety Requirements

Item	Requirement
Insulation rating	Double
Environmental operating conditions (per EN-61010-1)	Pollution degree: 1 Installation category (over voltage): II
Peripheral connections	Equipment should only be connected to peripherals conforming to installation category II
External isolator	Switch or circuit breaker must be located near the equipment if the equipment is to be permanently connected
Fuses (per EN-61010-1)	User-replaceable fuse for AC powered versions: 500 mA, 250 V, quick acting, 5 x 20 mm User-replaceable fuse for DC powered versions: 1 A, 250 V, quick acting, 5 x 20 mm Non user-replaceable fuse for all versions: 5 A, 250 V, quick acting
Output isolation	5 kVac surge isolation when powered from an external source; not to be connected to continuous voltages in excess of 50 Vac with respect to ground (earth)

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Appendix A
Pipe Schedules

This appendix provides pipe schedules as a convenient reference for the following pipe materials:

- Steel, stainless steel, and PVC (Table A–1)
- Cast iron (Table A–2)
- Ductile iron (Table A–3).

The inside diameters (IDs) listed in the following tables are calculated from the outside diameter (OD) and minimum wall thicknesses as specified in applicable standards. The actual pipe ID may vary from the dimension listed in the tables by as much as 25% of the pipe minimum wall thickness. The accuracy of flow rate measurement is enhanced if the pipe ID is actually measured.

Steel, Stainless Steel and PVC Pipe Standard Schedules Inside Diameter (ID) and Outside Diameter (OD) in Inches

Nominal Pipe Size	Outside Diameter (OD)	Sched. 5	Sched. 10 (Light Wall)	Sched. 20	Sched. 30	Sched. 40	Sched. 60	Sched. 80	Sched. 100	Sched. 120	Sched. 140	Sched. 160	Std. Wall	X STG
1	1.315	1.185	1.097			1.049		0.957				0.815	1.049	0.957
1.25	1.660	1.530	1.442			1.380		1.278				1.160	1.380	1.278
1.5	1.900	1.770	1.682			1.610		1.500				1.338	1.610	1.500
2	2.375	2.245	2.157			2.067		1.939				1.687	2.067	1.939
2.5	2.875	2.709	2.635			2.469		2.323				2.125	2.469	2.323
3	3.500	3.334	3.260			3.068		2.900				2.624	3.068	2.900
3.5	4.000	3.834	3.760			3.548		3.364					3.548	3.364
4	4.500	4.334	4.260			4.026		3.826		3.624		3.438	4.026	3.826
5	5.563	5.345	5.295			5.047		4.813		4.563		4.313	5.047	4.813
6	6.625	6.407	6.357			6.065		5.761		5.501		5.187	6.065	5.761
8	8.625	8.407	8.329	8.125	8.071	7.981	7.813	7.625	7.437	7.187	7.001	6.813	7.981	7.625
10	10.750	10.482	10.420	10.250	10.136	10.020	9.750	9.562	9.312	9.062	8.750	8.500	10.020	9.750
12	12.750	12.438	12.390	12.250	12.090	11.938	11.626	11.374	11.062	10.750	10.500	10.126	12.000	11.750
14	14.000		13.500	13.376	13.250	13.124	12.812	12.500	12.124	11.876	11.500	11.188	13.250	13.000
16	16.000	15.670	15.500	15.376	15.250	15.000	14.688	14.312	13.938	13.562	13.124	12.812	15.250	15.000
18	18.000	17.670	17.500	17.376	17.124	16.876	16.500	16.124	15.688	15.255	14.876	14.438	17.250	17.000
20	20.000	19.634	19.500	19.250	19.000	18.812	18.376	17.938	17.438	17.000	16.500	16.062	19.250	19.000
24	24.000	23.564	23.500	23.250	22.876	22.624	22.062	21.562	20.938	20.376	19.876	19.312	23.250	23.000
30	30.000	29.500	29.376	29.000	28.750	28.500							29.250	29.000
36	36.000		35.376	35.000	34.750	34.500					31.876	31.312	35.250	35.000
42	42.000			41.000	40.750	40.500							41.250	41.000
48	48.000					47.250							47.250	47.000

Table A–1. Steel, stainless steel, and PVC pipe standard schedules

Cast Iron Pipe Standard Classes
Inside Diameter (ID) and Outside Diameter (OD) in Inches

Nominal Pipe Size ( )	Class A		Class B		Class C		Class D		Class E		Class F		Class G		Class H	
	OD	ID	OD	ID	OD	ID	OD	ID	OD	ID	OD	ID	OD	ID	OD	ID
3	3.80	3.02	3.96	3.12	3.96	3.06	3.96	3.00								
4	4.80	3.96	5.00	4.10	5.00	4.04	5.00	3.96								
6	6.90	6.02	7.10	6.14	7.10	6.08	7.10	6.00	7.22	6.06	7.22	6.00	7.38	6.08	7.38	6.00
8	9.05	8.13	9.05	8.03	9.30	8.18	9.30	8.10	9.42	8.10	9.42	8.10	9.60	8.10	9.60	8.00
10	11.10	10.10	11.10	9.96	11.40	10.16	11.40	10.04	11.60	10.12	11.60	10.00	11.84	10.12	11.84	10.00
12	13.20	12.12	13.20	11.96	13.50	12.14	13.50	12.00	13.78	12.14	13.78	12.00	14.08	12.14	14.08	12.00
14	15.30	14.16	15.30	13.98	15.65	14.17	15.65	14.01	15.98	14.18	15.98	14.00	16.32	14.18	16.32	14.00
16	17.40	16.20	17.40	16.00	17.80	16.20	17.80	16.02	18.16	16.20	18.16	16.00	18.54	16.18	18.54	16.00
18	19.50	18.22	19.50	18.00	19.92	18.18	19.92	18.00	20.34	18.20	20.34	18.00	20.78	18.22	20.78	18.00
20	21.60	20.26	21.60	20.00	22.06	20.22	22.06	20.00	22.54	20.24	22.54	20.00	23.02	20.24	23.02	20.00
24	25.80	24.28	25.80	24.02	26.32	24.22	26.32	24.00	26.90	24.28	26.90	24.00	27.76	24.26	27.76	24.00
30	31.74	28.98	32.00	29.94	32.40	30.00	32.74	30.00	33.10	30.00	33.46	30.00				
36	37.96	35.98	38.30	36.00	38.70	35.98	39.16	36.00	39.60	36.00	40.04	36.00				
42	44.20	42.00	44.50	41.94	45.10	42.02	45.58	42.02								
48	50.50	47.98	50.80	47.96	51.40	47.98	51.98	48.00								
54	56.66	53.96	57.10	54.00	57.80	54.00	58.40	53.94								
60	62.80	60.02	63.40	60.06	64.20	60.20	64.82	60.06								
72	75.34	72.10	76.00	72.10	76.88	72.10										
84	87.54	84.10	88.54	84.10												

NOTE: For pipes with cement linings, reduce the pipe inside diameter by two times the lining thickness. Standard and double cement lining thicknesses are listed in Table A-3.

Table A–2. Cast iron pipe standard classes

Ductile Iron Pipe Standard Classes
Inside Diameter (ID) and Outside Diameter (OD) in Inches

Nominal Pipe Size	Outside Diameter (OD)	Inside Diameter							Cement Lining (See Note)	
		Class 50	Class 51	Class 52	Class 53	Class 54	Class 55	Class 56	Standard Thickness	Double Thickness
3	3.96		3.46	3.40	3.34	3.28	3.22	3.16	0.125	0.250
4	4.80		4.28	4.22	4.16	4.10	4.04	3.98		
6	6.90	6.40	6.34	6.28	6.22	6.16	6.10	6.04		
8	9.05	8.51	8.45	8.39	8.33	8.27	8.21	8.15		
10	11.10	10.52	10.46	10.40	10.34	10.28	10.22	10.16		
12	13.20	12.58	12.52	12.46	12.40	12.34	12.28	12.22		
14	15.30	14.64	14.58	14.52	14.46	14.40	14.34	14.28	0.1875	0.375
16	17.40	16.72	16.66	16.60	16.54	16.48	16.42	16.36		
18	19.50	18.80	18.74	18.68	18.62	18.56	18.50	18.44		
20	21.60	20.88	20.82	20.76	20.70	20.64	20.58	20.52		
24	25.80	25.04	24.98	24.92	24.86	24.80	24.74	24.68		
30	32.00	31.22	31.14	31.06	30.98	30.90	30.82	30.74	0.250	0.500
36	38.30	37.44	37.34	37.06	37.14	37.04	36.94	36.84		
42	44.50	43.56	43.44	43.32	43.20	43.08	42.96	42.84		
48	50.80	49.78	49.64	49.50	49.36	49.22	49.08	48.94		
54	57.10	55.96	55.80	55.64	55.48	55.32	55.16	55.00		

Note: For pipes with cement linings, reduce the pipe inside diameter by two times the lining thickness listed above.

Table A–3. Ductile iron pipe standard classes

Appendix B
Fluid Properties

Fluid Sound Speeds & Kinematic Viscosities

This appendix provides a table of fluid sound speeds and kinematic viscosities. The information is based on material from the *Cameron Hydraulic Data Book* (17th ed., Ingersoll-Rand, 1988) and *Table of Physical and Chemical Constants* (13th ed., Longmans, 1966).

Note that viscosity does not have as significant an effect on flow accuracy as sound speed since viscosity is only used to calculate flow profile. Even a comparatively large error in viscosity results in a change of only 2 to 5 percent.

Table B–1. Properties

Liquid	t°C	c(m/s)	t°F	c(ft/s)	cSt
Acetaldehyde CH_3CHO	16.1	--	61	--	0.305
	20	--	68	-	0.295
Acetic acid	50	1584	122	5196	--
10%	15	--	59	--	1.35
50%	15	--	59	--	2.27
80%	15	--	59	--	2.85
Conc.-glacial	15	--	59	--	1.34
Acetic anhydride	24	1384	75	4540	--
	15	--	59	--	0.88
Acetone CH_3COCH_3	20	1190	68	3903	0.41
Acetylene tetrabromide	28	1007	82	3303	--
Acetylene tetrachloride	28	1155	82	3788	--
Alcohol					
allyl	20	--	68	--	1.60
	40	--	104	--	0.90
butyl-n	20	--	68	--	3.64
	70	--	158	--	1.17
ethyl (grain) C_2H_5OH	20	--	68	--	1.52
	37.8	--	100	--	1.2

Liquid	t°C	c(m/s)	t°F	c(ft/s)	cSt
methyl (wood) CH_3OH	15	--	59	--	0.74
	0	--	32	11	1.04
propyl	20	--	68	--	2.8
	50	--	122	--	1.4
Ammonia	-17.8	--	0	--	0.30
Amyl acetate	29.2	1173	85	3847	--
n-Amyl alcohol	28.6	1224	83	4015	--
iso-Amyl ether	26	1153	79	3782	--
Aniline	20	1656	68	5432	4.37
	10	--	50	--	6.4
Argon	-183.0	816.7	-297	2679	--
Asphalt, blended					
RC-0, MC-0, SC-0	25	--	77	--	159 – 324
	37.8	--	100	--	60 – 108
RC-1, MC-1, SC-1	37.8	--	100	--	518 – 1080
	50	--	122	--	159 – 324
RC-2, MC-2, SC-2	50	--	122	--	518 – 1080
	60	--	140	--	215 – 430
RC-3, MC-3, SC-3	50	--	122	--	1295 – 2805
	60	--	140	--	540 – 1080
RC-4, MC-4, SC-4	60	--	140	--	1725 – 4315
	82.8	--	180	--	270 – 540
RC-5, MC-5, SC-5	60	--	140	--	6040 – 18340
	82.8	--	180	--	647 – 1295
RS-1, MS-1, SS-1	25	--	77	--	33 – 216
	37.8	--	100	--	19 – 75
Asphalt emulsions					
Fed #1	25	--	77	--	215 – 1510
	37.8	--	100	--	75 – 367
Fed #2, V, VI	25	--	77	--	33 – 216
	37.8	--	100	--	19 – 75

Liquid	**t°C**	**c(m/s)**	**t°F**	**c(ft/s)**	**cSt**
Automotive crankcase oils					
SAE-5W	-17.8	--	0	--	1295 max
SAE-10W	-17.8	--	0	--	1295 – 2590
SAE-20W	-17.8	-	0	-	2590 – 10350
SAE-20	98.9	--	210	--	5.7 – 9.6
SAE-30	98.9	--	210	--	9.6 – 12.9
SAE-40	98.9	--	210	--	12.9 – 16.8
SAE-50	98.9	--	210	--	16.8 – 22.7
Automotive gear oils					
SAE-75W	98.9	--	210	--	4.2 min
SAE-80W	98.9	--	210	--	7.0 min
SAE-85W	98.9	--	210	--	11.0 min
SAE-90	98.9	--	210	--	14 – 25
SAE-14Q	98.9	--	210	--	25 – 43
SAE 150	98.9	--	210	--	43 min
Beer	20	--	68	--	1.8
Benzene (Benzol) C_6H_6	20	1321	68	4333	0.744
	0	--	32	--	1.00
Benzophenone	100	1316	212	4316	--
Bismuth	285	1663	545	5455	--
Bone oil	54.4	--	130	--	47.5
	100	--	212	--	11.6
Bromine	20	--	68	--	0.34
Bromobenzene	50	1074	122	3523	--
Bromoform	25	908	77	2978	--
Butane-n	-1.1	--	-50	--	0.52
	--	--	30	--	0.35
Butyl acetate	30	1172	86	3844	--
n-Butyl alcohol	20	1257.7	68	4125	--
iso-Butyl bromide	-104	1450	-155	4756	--
Butyric acid n	20	--	68	--	1.61
	0	--	32	--	2.3cp
Cadmium	360	2150	680	7052	--

Liquid	t°C	c(m/s)	t°F	c(ft/s)	cSt
Caesium	130	967	266	3172	--
Calcium chloride					
5%	18.3	--	65	--	1.156
25%	15.6	--	60	--	4.0
Carbolic acid (phenol)	18.3	--	65	--	1
Carbon tetrachloride CCl_4	20	--	68	--	0.612
	37.8	--	100	--	0.53
Carbon disulphide CS_2	25	1149	77	3769	--
	0	--	32	--	0.33
	20	--	68	--	0.298
Carbon tetrachloride	20	938	68	3077	--
Castor oil	18.6	1500	65	4920	--
	37.8	--	100	--	259 – 325
	54.4	--	130	--	98 – 130
China wood oil	20.6	--	69	--	308.5
	37.8	--	100	--	125.5
Chlorine	20	850	68	2788	--
m-Chlornitrobenzene	40	1368	104	4487	--
Chlorobenzene	25	1302	77	4271	--
Chloroform	20	--	68	--	0.38
	25	995	77	3264	--
	60	--	140	--	0.35
Coconut oil	37.8	--	100	--	29.8 – 31.6
	54.4	--	130	--	14.7 – 15.7
Cod oil	37.8	--	100	--	32.1
	54.4	--	130	--	19.4
Corn oil	54.4	--	130	--	28.7
	100	--	212	--	8.6
Corn starch solutions					
22 Baume	21.1	--	70	--	32.1
	37.8	--	100	--	27.5
24 Baume	21.1	--	70	--	129.8
	37.8	--	100	--	95.2

Liquid	t°C	c(m/s)	t°F	c(ft/s)	cSt
25 Baume	21.1	--	70	--	303
	37.8	--	100	--	173.2
Cotton seed oil	37.8	--	100	--	37.9
Crude oil					
48°API	15.6	--	60	--	3.8
	54.4	--	130	--	1.6
40°API	15.6	--	60	--	9.7
	54.4	--	130	--	3.5
35.6°API	15.6	--	60	--	17.8
	54.4	--	130	--	4.9
32.6°API	15.6	--	60	--	23.2
	54.4	--	130	--	7.1
Salt Creek	15.6	--	60	--	77
	54.4	--	130	--	6.1
Cyclohexane	20	1278	68	4192	--
Cyclohexanol	30	1622	86	5320	--
Decane-n	-17.8	--	0	--	2.36
	37.8	--	100	--	1.001
1-Decene	20	1250	68	4100	--
Deuterium oxide	20	1381	68	4530	--
Diesel fuel oils					
2D	37.8	--	100	--	2 – 6
	54.4	--	130	--	1 – 3.97
3D	37.8	--	100	--	6 – 11.75
	54.4	--	130	--	3.97 – 6.78
4D	37.8	--	100	--	29.8 max
	54.4	--	130	--	13.1 max
5D	50	--	122	--	86.6 max
	71.1	--	160	--	35.2 max
Diethyl ether	20	--	68	--	0.32
Diethylene glycol	21.1	--	70	--	32
	30	1533	86	5028	--
Diethylene glycol monoethyl ether	30	1296	86	4251	--

Liquid	t°C	c(m/s)	t°F	c(ft/s)	cSt
Dimethyl siloxane (Dow Corning 200 fluid)	20	912.3	68	2992	--
Diphenyl	100	1271	212	4169	--
Diphenyl ether	30	1462	86	4795	--
Ethanol	20	1156	68	3792	--
Ethanol amide	25	1724	77	5655	--
Ether (diethyl)	25	985	77	3231	--
Ethyl acetate $CH_3COOC_2H_5$	15	--	59	--	0.4
	20	1133	68	3716	0.49
Ethyl alcohol	20	1161.8	68	3811	--
Ethyl bromide C_2H_5Br	10	932	50	3057	--
	20	--	68	--	0.27
Ethyl glycol	30	1606	86	5268	--
Ethyl iodide	20	876	68	2873	--
Ethylene bromide	20	--	68	--	0.787
Ethylene chloride	20	--	68	--	0.668
Ethylene dibromide	24	1014	75	3326	--
Ethylene dichloride	23	1240	73	4067	--
Ethylene glycol	21.1	--	70	--	17.8
	30	1616	86	5300	--
Ethylene glycol monoethyl ether	30	1279	86	4195	--
Ethylene glycol monomethyl ether	30	1339	86	4392	--
Formaldehyde	25	1587	77	5205	--
Formamide	25	1610	77	5281	--
Formic acid	20	1299	68	4261	--
10%	20	--	68	--	1.04
50%	20	--	68	--	1.2
80%	20	--	68	--	1.4
Conc.	20	--	68	--	1.48
Freon					
-11	21.1	--	70	--	0.21
-12	21.1	--	70	--	0.27
-21	21.1	--	70	--	1.45

Liquid	**t°C**	**c(m/s)**	**t°F**	**c(ft/s)**	**cSt**
Fuel oils					
1	21.1	--	70	--	2.39 – 4.28
	37.8	--	100	--	2.69
2	21.1	--	70	--	3.0 – 7.4
	37.8	--	100	--	2.11 – 4.28
3	21.1	--	70	--	2.69 – 5.84
	37.8	--	100	--	2.06 – 3.97
5A	21.1	--	70	--	7.4 – 26.4
	37.8	--	100	--	4.91 – 13.7
5B	21.1	--	70	--	26.4 -
	37.8	--	100	--	13.6 – 67.1
6	50	--	122	--	97.4 – 660
	71.1	--	160	--	37.5 – 172
Gallium	50	2740	122	8987	--
Gas oils	21.1	--	70	--	13.9
	37.8	--	100	--	7.4
Gasolines					
a	15.6	--	60	--	0.88
	37.8	--	100	--	0.71
b	15.6	--	60	--	0.64
c	15.6	--	60	--	0.46
	37.8	--	100	--	0.40
Glycerine	30	1923	86	6307	--
100%	20.3	--	69	--	648
	37.8	--	100	--	176
50% water	20	--	68	--	5.29
	60	--	140	--	1.85cp
Glucose	37.8	--	100	--	7.7M – 22M
	65.6	--	150	--	880 – 2420
Guaicol	100	1252	212	4107	--
Helium	-268.8	179.8	-452	590	--

Liquid	t°C	c(m/s)	t°F	c(ft/s)	cSt
n-Heptane	-17.8	--	0	--	0.928
	22.4	1150	72	3772	--
	37.8	--	100	--	0.511
Heptene	30	1082	86	3549	--
Heptyne	30	1159	86	3802	--
Hexane	20	1203	68	3946	--
n-Hexane	-17.8	--	0	--	0.683
	21.1	1085	70	3559	--
	37.8	--	100	--	0.401
Honey	37.8	--	100	--	73.6
Hydrogen	-256	1187	-429	3893	--
Industrial lubricants					
Turbine oils					
685	15.6	--	60	--	647
SSU at 100°F	93.3	--	200	--	14.5
420	15.6	--	60	--	367
SSU	93.3	--	200	--	11
315	15.6	--	60	--	259
SSU	93.3	--	200	--	8
215	15.6	--	60	--	151
SSU	93.3	--	200	--	7.3
150	15.6	--	60	--	151
SSU	93.3	--	200	--	6
Machine lubricants					
#8	37.8	--	100	--	23 – 34
	54.4	--	130	--	13 – 18
#10	37.8	--	100	--	34 – 72
	54.4	--	130	--	18 – 25
#20	37.8	--	100	--	72 – 83
	54.4	--	130	--	25 -39
#30	37.8	--	100	--	75 – 119
	54.4	--	130	--	39 – 55

Liquid	t°C	c(m/s)	t°F	c(ft/s)	cSt
Cuttings oils					
#1	37.8	--	100	--	30 – 40
	54.4	--	130	--	17 – 23
#2	37.8	--	100	--	40 – 46
	54.4	--	130	--	23 – 26
Indium	260	2215	500	7265	--
Ink, printers	37.8	--	100	--	550 – 2200
	54.4	--	130	--	238 – 660
Insulating oil	21.1	--	70	--	24.1 max
	37.8	--	100	--	11.75 max
Kerosene	20	--	68	--	2.71
	25	1315	77	4313	--
Jet fuel (av)	-34.4	--	-30	--	7.9
Lard	37.8	--	100	--	62.1
	54.4	--	130	--	34.3
Lard oil	37.8	--	100	--	41 – 47.5
	54.4	--	130	--	23.4 – 27.1
Lead	340	1760	644	5773	--
Linseed oil	37.8	--	100	--	30.5
	54.4	--	130	--	18.94
Menhadden oil	37.8	--	100	--	29.8
	54.4	--	130	--	18.2
Menthol	50	1271	122	4169	--
Merck	20.2	1482.3	68	4862	--
Mercury	20	1454	68	4769	--
	21.1	--	70	--	0.118
	37.8	--	100	--	0.11
Methanol	20	1118	68	3667	--
Methyl acetate	20	--	68	--	0.44
	30	1131	86	3710	--
Methyl alcohol	20	1121.2	68	3678	--
Methyl bromide	2	905	36	2968	--
Methylene chloride	23.5	1064	74	3490	--

Liquid	t°C	c(m/s)	t°F	c(ft/s)	cSt
Methylene iodide	24	977.7	75	3207	--
Milk	20	977.7	75	3207	--
Molasses					
A, first	37.8	--	100	--	281 – 5070
	54.4	--	130	--	151 – 1760
B, second	37.8	--	100	--	1410 – 13.2M
	54.4	--	130	--	660 – 3.3M
C, blackstrap	37.8	--	100	--	2630 – 55M
	54.4	--	130	--	1320 – 16.5M
Naphthalene	80	--	176	--	0.9
Naptha	25	1225	77	4018	--
Neatsfoot oil	37.8	--	100	--	49.7
	54.4	--	130	--	27.5
Nitrobenzene	20	--	68	--	1.67
	23.8	1462	75	4795	--
Nitrogen	-188.9	744.7	-308	2443	--
Nonane	20	1248	68	4093	--
1-None	20	1218	68	3995	--
Nonene-n	-17.8	--	0	--	1.728
	37.8	--	100	--	0.807
n-Octane	-17.8	--	0	--	1.266
	20	1192	68	3910	--
	37.8	--	100	--	0.645
Oil (lubricating)	10	1625	50	5330	--
Oil of camphor	25	1390	77	4559	--
Oleic acid	20	1442	68	4730	--
Olive oil	21.7	1440	71	4723	--
	37.8	--	100	--	43.2
	54.4	--	130	--	24.1
Oxygen	-182.9	912	-297	2991	--
Palm oil	37.8	--	100	--	47.8
	54.4	--	130	--	26.4
Paraldehyde	28	1197	82	3926	--

Liquid	t°C	c(m/s)	t°F	c(ft/s)	cSt
Peanut oil	37.8	--	100	--	42
	54.4	--	130	--	23.4
1-Pentadecene	20	1351	68	4431	--
Pentane	20	1008	68	3306	--
iso-Pentane	25	985	77	3231	--
n-Pentane	-17.8	--	0	--	0.508
	20	1044	68	3424	--
	26.7	--	80	--	0.342
Petrolatum	54.4	--	130	--	20.5
	71.1	--	160	--	15
Petroleum ether	15.6	--	60	--	31(est)
Phenol	100	1274	212	4179	--
Potassium	150	1840	302	6035	--
n-Propanol	20	1220	68	4002	--
Propionic acid	20	--	68	--	1.13
n-Propyl acetate	26	1182	79	3877	--
n-Propyl alcohol	20	1223.2	68	4012	--
Propylene glycol	21.1	--	70	--	52
Pyridine	20	1445	68	4740	--
Quenching oil (typical)	--	--	--	--	100 – 120
Rapeseed oil	37.8	--	100	--	54.1
	54.4	--	130	--	31
Rosin oil	37.8	--	100	--	324.7
	54.4	--	130	--	129.9
Rosin (wood)	37.8	--	100	--	216 – 11M
	93.3	--	200	--	108 – 4400
Rubidium	160	1260	320	4133	--
Sesame seed oil	37.8	--	100	--	39.6
	54.4	--	130	--	23
Silicon tetrachloride	30	766.2	86	2513	--
Sodium	150	2500	302	8200	--

Liquid	t°C	c(m/s)	t°F	c(ft/s)	cSt
Sodium chloride (fused)	850	1991	1562	6530	--
5%	20	--	68	--	1.097
25%	15.6	--	60	--	2.4
Sodium hydroxide (caustic soda)					
20%	18.3	--	65	--	4.0
30%	18.3	--	65	--	10.0
Soya bean oil	37.8	--	100	--	35.4
	54.4	--	130	--	19.64
Sperm oil	37.8	--	100	--	21 – 23
	54.4	--	130	--	19.6
Sugar solutions					
Corn syrup					
86.4 Brix	37.8	--	100	--	180Mcp
	82.2	--	180	--	1750cp
84.4 Brix	37.8	--	100	--	48Mcp
	82.2	--	180	--	800cp
82.3 Brix	37.8	--	100	--	17Mcp
	82.2	--	180	--	380cp
80.3 Brix	37.8	--	100	--	6900cp
	82.2	--	180	--	230cp
78.4 Brix	37.8	--	100	--	3200cp
	82.2	--	180	--	160cp
Sucrose					
60 Brix	21.1	--	70	--	49.7
	37.8	--	100	--	18.7
64 Brix	21.1	--	79	--	49.7
	37.8	--	100	--	31.6
68 Brix	21.1	--	70	--	216.4
	37.8	--	100	--	59.5
72 Brix	21.1	--	70	--	595
	37.8	--	100	--	138.6
74 Brix	21.1	--	70	--	1210
	37.8	--	100	--	238

Liquid	t°C	c(m/s)	t°F	c(ft/s)	cSt
76 Brix	21.1	--	70	--	2200
	37.8	--	100	--	440
Sulphur	130	1332	266	4369	--
Sulphuric acid					
100%	20	--	68	--	14.6
95%	20	--	68	--	14.5
60%	20	--	68	--	4.4
Tar, coke oven	21.1	--	70	--	600 – 1760
	37.8	--	100	--	141 – 308
Tar, gas house	21.1	--	70	--	3300 – 66M
	37.8	--	100	--	400 – 4400
Tar, pine	37.8	--	100	--	559
	55.6	--	132	--	108.2
Tar, road					
RT-2	50	--	122	--	43.2 – 64.9
	100	--	212	--	8.88 – 10.2
RT-4	50	--	122	--	86.6 – 154
	100	--	212	--	11.6 – 14.3
RT-6	50	--	122	--	216 – 440
	100	--	212	--	16.8 – 26.2
RT-8	50	--	122	--	660 – 1760
	100	--	212	--	31.8 – 48.3
RT-10	50	--	122	--	4.4M – 13.2M
	100	--	212	--	53.7 – 86.6
RT-12	50	--	122	--	25M – 75M
	100	--	212	--	108 – 173
Tetralin	20	1484	68	4868	--
Tin (molten)	240	2470	464	8102	--
Toluene	20	--	68	--	0.68
	30	1275	86	4182	--
o-Toluidine	22.5	1669	73	5474	--
I-Tridecene	20	1313	68	4307	--
Trielhylene glycol	21.1	--	70	--	40

Liquid	t°C	c(m/s)	t°F	c(ft/s)	cSt
Triethylamine	0	1189	32	3900	--
Turpentine	25	1225	77	4018	--
	37.8	--	100	--	86.6 – 95.2
	54.4	--	130	--	39.9 – 44.3
I-Undecene	20	1275	68	4182	--
Varnish, spar	20	--	68	--	313
	37.8	--	100	--	143
Water					
Distilled	20	1482.9	68	4864	1.0038
Fresh	15.6	--	60	--	1.13
	54.4	--	130	--	0.55
Sea	--	--	--	--	1.15
Water (sea) (Surface, 3.5% salinity)	15	1507.4	59	4944	--
Whale oil	37.8	--	100	--	35 – 39.6
	54.4	--	130	--	19.9 – 23.4
Xylene hexafluoride	25	879	77	2883	--
o-Xylene	20	--	68	--	0.93
	22	1352	72	4435	--
Zinc	450	2700	842	8856	--

Clean Water Sound Speed versus Temperature

Table B–2.

°F	°C	ft/	m/s
32	0	4599.8	1402.019
41	5	4677.8	1425.793
50	10	4747	1446.886
59	15	4808.3	1465.57
68	20	4862.1	1481.968
77	25	4909.1	1496.294
86	30	4949.9	1508.73
95	35	4985	1519.428
104	40	5014.7	1528.481
113	45	5039.4	1536.009
122	50	5059.6	1542.166
131	55	5075.4	1546.982
140	60	5087.2	1550.579
149	65	5095.3	1553.047
158	70	5099.7	1554.389
167	75	5100.8	1554.724
176	80	5098.7	1554.084
185	85	5093.6	1552.529
194	90	5085.6	1550.091
203	95	5074.8	1546.799
212	100	5068.4	1544.848

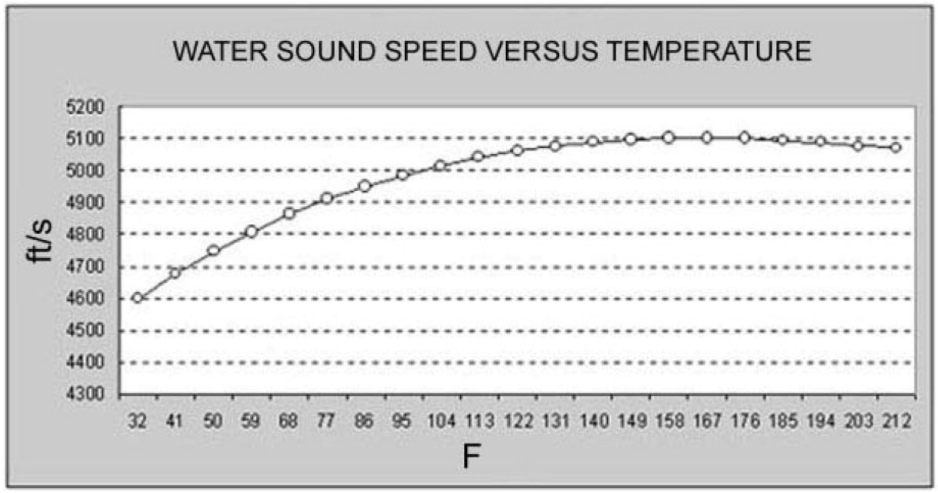
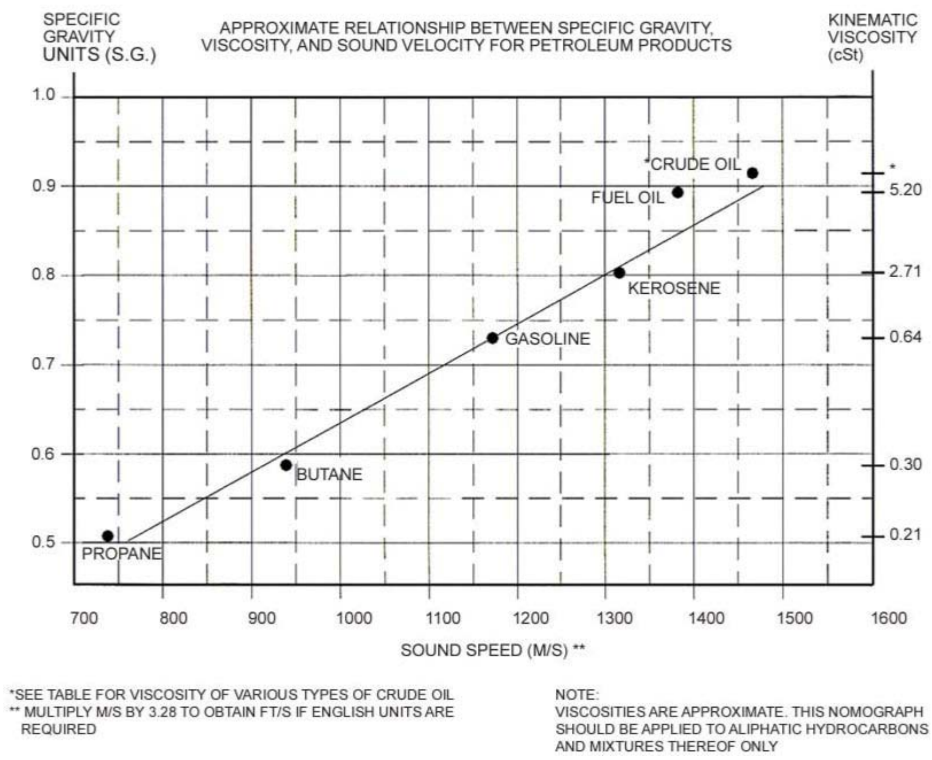


Figure B–1. Graphical representation of Table B–2

Relationship between Specific Gravity, Viscosity, & Sound Velocity for Petroleum Products

The graph below illustrates the approximate relationship between specific gravity, viscosity and sound velocities for aliphatic hydrocarbons (petroleum products).



Appendix C
Monitoring & Downloading Data Logs Using D-Link

Purpose

The Thermo Scientific D-Link utility is a PC-based user interface software that can communicate with the Thermo Scientific DCT6088 and DCT7088 flowmeters. This appendix provides instructions on how to install the software and use it to monitor and download data log information.

Installing D-Link

To install the software, start the PolyCD and select **D-Link** in Communication Software. Follow the instructions to install D-Link.

Establishing Communications with a Flowmeter

1. Go to the Options Group menu (42) and select **D-Link** in the communication options.

2. Connect a RS232 cable from the PC to the flowmeter.

3. Open the D-Link utility. If a Communication Failed dialogue opens, click **OK**. Make necessary adjustments on the CommPort Properties screen (Figure C–1), and click **OK**.

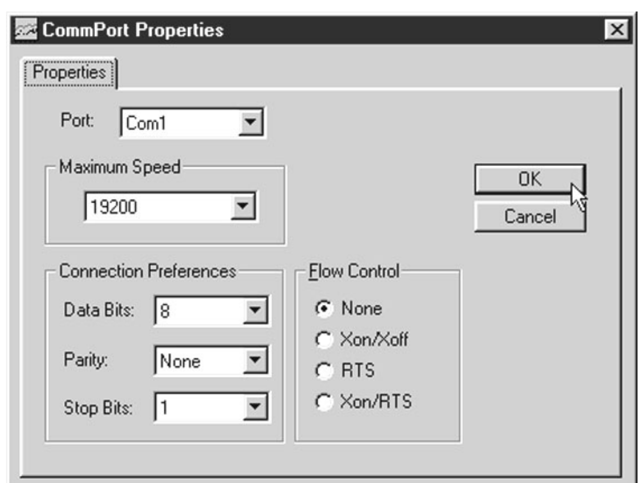


Figure C–1.

If communications still do not establish check the following and correct any errors:

- D-Link is selected as the communication option in the Options Menu (42).
- RS232 cable is connected correctly between the meter and the PC.
- No other software program on the PC is using the comm. port you selected.

Monitoring Data Logs

Once communications between the PC and the meter are established, the program opens. Click the arrow below **Get Log**, and select the log file you want to check. Click **Get Log**.

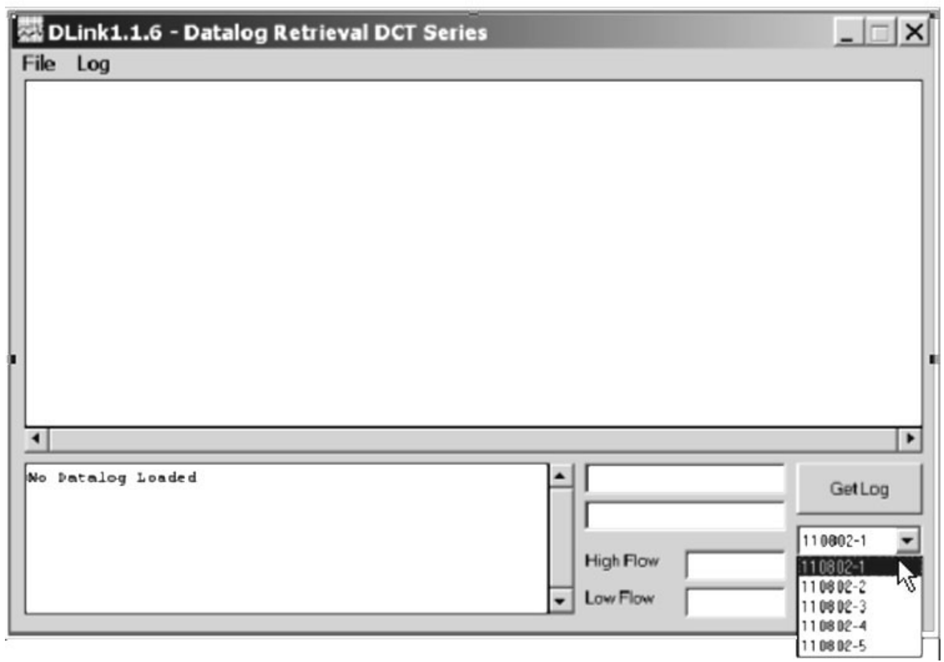


Figure C–2. Selecting a data log

The log information will download and be displayed (Figure C–3). Log information can be downloaded from the meter when the log is still running. This enables you to monitor the flow data without stopping the log. Refer to "The Data Log Menu" (Chapter 5) for instructions on setting up the data logger.

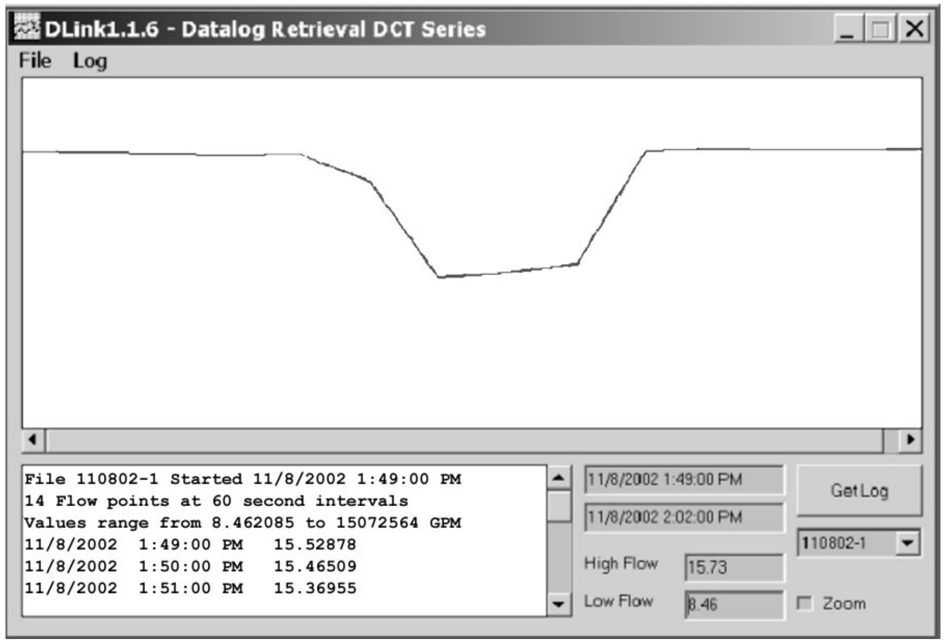


Figure C–3. Data log downloaded

Saving & Loading Data Logs

Once the data log is displayed, you can save it. Go to **File > Save Log**. The file can then be opened in data processing software such as Microsoft® Excel®. To load a previously saved log file, go to **File > Load Log**.

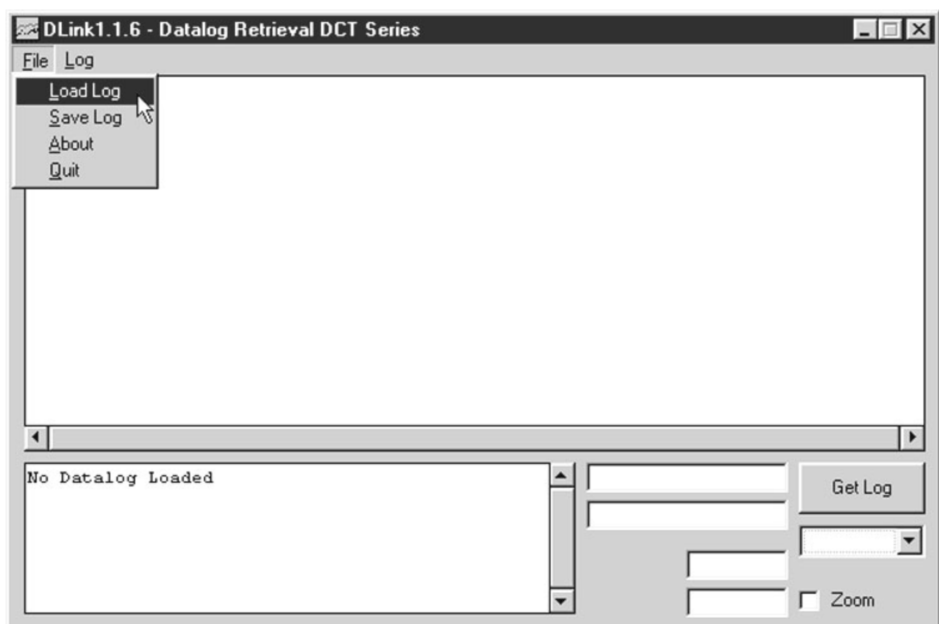


Figure C–4.

Appendix D
Toxic & Hazardous Substances Tables

The English and Chinese versions of the Toxic and Hazardous Substances tables are shown below.

Toxic & Hazardous Substances Table – DCT6088

For Chinese Regulation: Administrative Measure on the Control of Pollution Caused by Electronic Information Products

Names and Content of Toxic and Hazardous Substances or Elements

Parts Name	Toxic and Hazardous Substances or Elements (DCT6088)					
	Pb	Hg	Cd	Cr6+	PBB	PBDE
Housing	o	o	o	o	o	o
Motherboard	x	o	o	o	o	o
Transit Time Board	x	o	o	o	o	o
Power Supply Board	x	o	o	x	o	o
Keypad Assembly	x	o	o	o	o	o
Accessory Kit	x	o	o	o	o	o

○ : Indicates that this toxic or hazardous substance contained in all of the homogeneous materials for this part is below the limit requirement in **SJ/T11363-2006**

x: Indicates that this toxic or hazardous substance contained in at least one of the homogeneous materials used for this part is above the limit requirement in **SJ/T11363-2006**

有毒有害物质名称及含量的标识格式

部件名称	有毒有害物质或元素 (DCT6088)					
	铅 (Pb)	汞 (Hg)	镉 (Cd)	六价铬 (Cr6+)	多溴联苯 (PBB)	多溴二苯醚 (PBDE)
外壳	o	o	o	o	o	o
主板	x	o	o	o	o	o
发射时间电路板	x	o	o	o	o	o
电源板	x	o	o	x	o	o
键盘组件	x	o	o	o	o	o
附件套装	x	o	o	o	o	o

○：表示该有毒有害物质在该部件所有均质材料中的含量均在SJ/T 11363-2006标准规定的限量要求以下

x: 表示该有毒有害物质至少在该部件的某一均质材料中的含量超出SJ/T 11363-2006标准规定的限量要求

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