FP-4400

Portable Clamp-On Ultrasonic Flow Meter
Installation & Operation Guide



ONICON
Flow and Energy Measurement

DOC-0004434 Rev.F

SAFETY INFORMATION

To ensure correct use of the system, please read this manual thoroughly.

Regarding this manual:

- This manual should be passed on to the end user.
- Before use, read this manual thoroughly to comprehend its contents.
- The contents of this manual may be changed without prior notice.
- All rights reserved. No part of this manual may be reproduced in any form without ONICON Incorporated's written permission.
- ONICON Incorporated makes no warranty of any kind with regard to this material, including, but not limited to, implied warranties of merchantability and suitability for a particular purpose.
- All reasonable effort has been made to ensure the accuracy of the contents of this manual. However, if any errors are found, please inform ONICON Incorporated.
- ONICON Incorporated assumes no responsibilities for this product except as stated in the warranty.
- If the customer or any third party is harmed by the use of this product, ONICON Incorporated assumes no responsibility for any such harm owing to any defects in the product which were not predictable, or for any indirect damages.

SAFETY PRECAUTIONS:

The following general safety precautions must be observed during all phases of installation, operation, service, and repair of this product. Failure to comply with these precautions or with specific WARNINGS given elsewhere in this manual violates safety standards of design, manufacture, and intended use of the product. ONICON Incorporated assumes no liability for the customer's failure to comply with these requirements. If this product is used in a manner not specified in this manual, the protection provided by this product may be impaired.

The following messages are used in this manual:

WARNING
Messages identified as "WARNING" contain information regarding the personal safety of individuals involved in the installation, operation or service of this product.

CAUTION
Messages identified as "CAUTION" contain information regarding potential damage to the product or other ancillary products.

IMPORTANT NOTE
Messages identified as "IMPORTANT NOTE" contain information critical to the proper operation of the product.

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SECTION 1.0 GENERAL INFORMATION

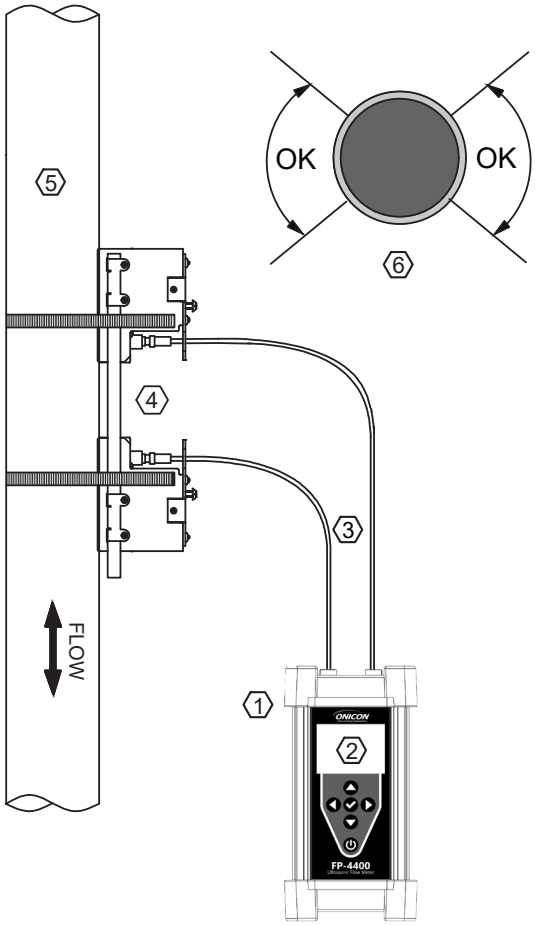
ONICON Incorporated would like to thank you for purchasing our FP-4400 Portable Clamp-on Ultrasonic Flow Meter. As our valued customer, our commitment to you is to provide fast reliable service, while continuing to offer quality products to meet your growing flow measurement needs.

1.1 PRINCIPLE OF OPERATION

The ONICON FP-4400 Portable Clamp-on Ultrasonic Flow Meter utilizes the differential transit time method to measure the velocity of relatively clean liquids in full pipes. By measuring the difference between transit times of ultrasonic sound waves traveling between two transducers, the flow velocity and direction are accurately determined.

1.2 TYPICAL FP-4400 FLOW METER INSTALLATION

The FP-4400 Portable Clamp-on Ultrasonic Flow Meter utilizes clamp-on signal transducers that mount on the outside wall of the pipe. It is suitable for measuring the volumetric flow of liquids in a wide variety of applications including bi-directional flow applications. The meter is housed in an aluminum enclosure with silicone protective end covers. When connected to the transducer cables it provides NEMA 4X (IP67) protection from the environment.



1. Aluminum NEMA4X (IP67) enclosure with silicone protective end covers.
2. Backlit LCD display with menu driven via five (5) programming keys.
3. Pair of 12 ft triaxial transducer cables. Each cable is provided with an IP67 plug on one end for connecting to the meter and a BNC plug on the other end for connecting to the transducer.
4. Mounting hardware: includes mounting brackets, mounting strap kit and an alignment and spacer tool for each transducer type. (Drawing above shown with Series 20 transducers and mounting hardware.)
5. Vertical pipe mounting shown. You must have a full pipe and sufficient back pressure when measuring downward flow.
6. For horizontal pipes, avoid mounting transducers on the top or bottom of the pipe. The best placement on a horizontal pipe is either the 2:00 to 4:00 or 8:00 to 10:00 positions for two (2) cross (Reflect) or four (4) cross (Double Reflect) mode, or one sensor at 9:00 and one sensor at 3:00 for one (1) cross mode (Direct)

1.3 STANDARD FEATURES AND SPECIFICATIONS*

FP-4400 TRANSMITTER		
TRANSMITTER PERFORMANCE	ACCURACY	±1% of reading or ±0.015 ft/s (±0.0046 m/s), whichever is greater
	REPEATABILITY & LINEARITY	±0.25%
	FLOW VELOCITY RANGE	±0.1 to 40 ft/s (±0.03 to 12.2 m/s)
OPERATING CONDITIONS	AMBIENT OPERATING	-5°F to 140°F
INPUT POWER	External mains to USB-C charger with 120-240 VAC, 50-60 Hz, 0.6A input; and 5 VDC, 3A, 15W ouput	
ELECTRONICS ENCLOSURE	IP67 when transducer cables connected. IP65 when transducers cables not connected. Aluminum enclosure with silicone protective end covers.	
	DISPLAY	Color TFT LCD display, IPS type, 2.8" screen size, 320 x 240 resolution, 500 NITS brightness, super wide viewing angle
PROGRAMMING	Menu driven via five (5) programming keys	
APPROVALS	CE	2014/30/EU EMC Directive
FP-4400 TRANSDUCERS		
PERFORMANCE	SENSING METHOD	Ultrasonic differential transit time velocity measurement via non-wetted transducers
OPERATING CONDITIONS	FLUID PROPERTIES	Clean liquids in full (pressurized) pipes
	FLUID VELOCITY RANGE	±0.1 to 40 ft/s (±0.03 to 12.2 m/s) typical
	FLUID TEMPERATURE RANGE	-40°F to 300°F
	PIPE MATERIALS	Suitable for use in a wide range of metallic and non-metallic piping systems
	PIPE SIZE RANGE	½" through 48", based on transducer series selected.
TRANSDUCER DESIGN - 10 SERIES	OPERATING FREQUENCY	2.56 MHz
	PIPE SIZE RANGE	½" through 1½"
	TRANSDUCER HOUSING	CF8M 316 Stainless Steel
	CABLE CONNECTIONS	• Triax cable with BNC style connectors and sealing jacket • Triax cable with NEMA 6 (IP67) direct connection for wet locations
	MOUNTING KIT	304 Stainless Steel mounting brackets with conduit connection, 200 Series Stainless Steel pipe clamps, and alignment and spacer tool
TRANSDUCER DESIGN - 20 SERIES	OPERATING FREQUENCY	1.28 MHz
	PIPE SIZE RANGE	2" through 8"
	TRANSDUCER HOUSING	CF8M 316 Stainless Steel
	CABLE CONNECTIONS	Triax cable with BNC style connectors and sealing jacket
	MOUNTING KIT	304 Stainless Steel mounting brackets with conduit connection, 200 Series Stainless Steel pipe clamps, and alignment and spacer tool

* SPECIFICATIONS subject to change without notice.

1.3 STANDARD FEATURES AND SPECIFICATIONS* (CONTINUED)

FP-4400 TRANSDUCERS (CONTINUED)		
TRANSDUCER DESIGN - 30 SERIES	OPERATING FREQUENCY	640 kHz
	PIPE SIZE RANGE	10" through 48"
	TRANSDUCER HOUSING	CF8M 316 Stainless Steel
	CABLE CONNECTIONS	Triax cable with BNC style connectors and ½" MNPT conduit connection and NEMA 4 (IP66) threaded strain relief.
	MOUNTING KIT	304 Stainless Steel mounting brackets with conduit connection, 200 Series Stainless Steel pipe clamps, and alignment and spacer tool

* SPECIFICATIONS subject to change without notice.

1.4 MODEL NUMBERING CODIFICATION

Meter Model Number Coding = FP-4400-AB

AB = Sensor Type

40 = 10 Series, 20 Series, 30 Series transducers included

1.5 ADDITIONAL HARDWARE THAT MAY BE REQUIRED

A pair of 50 ft transducer extension cables may be ordered separately for use with the FP-4400. The cables are provided with BNC connectors and sealing jackets for the connections.

1.6 WORKING ENVIRONMENT

The FP-4400 was designed for installation and use in typical commercial/ industrial environments. The following considerations must be observed in selecting a location for the meter:

- The ambient operating temperature range is -5°F (-20°C) to 140°F (60°C).
- Do not expose the meter to corrosive liquids or fumes.
- Avoid installation locations that are close to strong sources of electrical interference.
- Avoid exposing the electronics enclosure to direct sunlight whenever possible.
- Avoid installation locations where the transducers will be exposed to strong vibrations in the piping system whenever possible.

1.7 MAINTENANCE

Periodically inspect the transducers, transducer cables, cable glands and the meter enclosure for signs of damage. The battery contained in the meter is not field serviceable. Contact ONICON if you experience issues with the battery.

1.8 SERIAL NUMBER

The serial number of your FP-4400 is located on the rear of the enclosure. Transducers shipped with the meter were calibrated with and will bear their own unique serial numbers. You should have one of these serial numbers available when contacting ONICON for assistance regarding your meter.

SECTION 2.0 UNPACKING

The FP-4400 is generally shipped in one package. Notify the freight carrier and ONICON if any items are damaged in transit.

2.1 CHECKING THAT YOU HAVE RECEIVED EVERYTHING

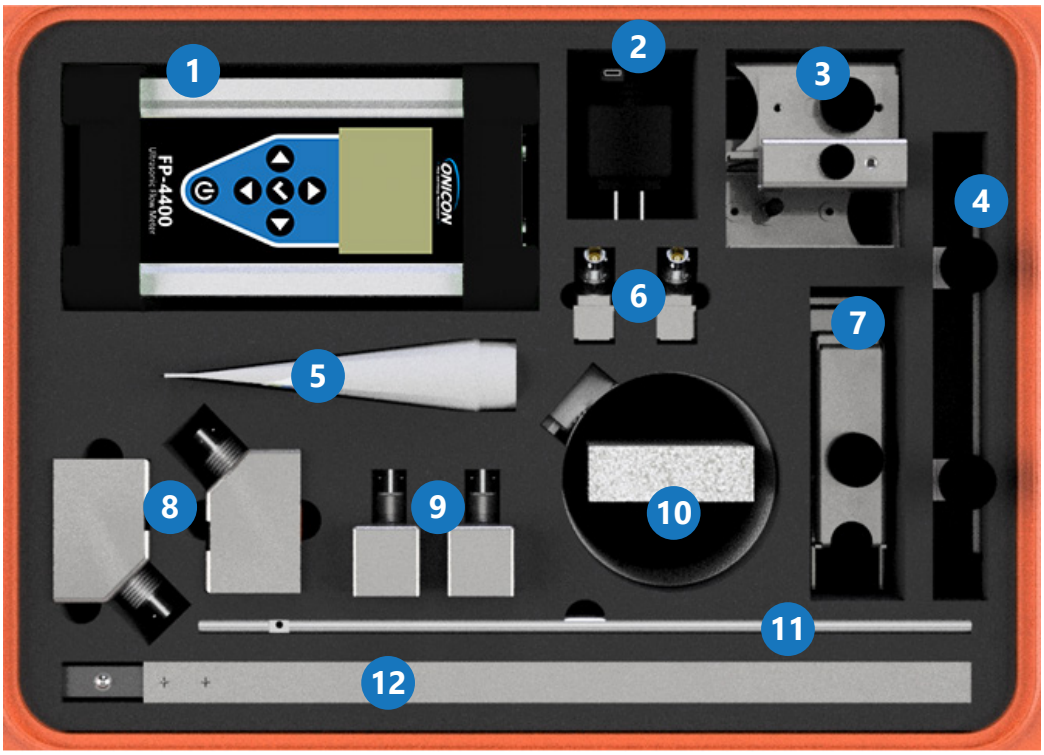
2.1.1 Documentation

Enclosed with each FP-4400 is a comprehensive documentation package that includes the following items:
- One (1) FP-4400 Portable Clamp-on Ultrasonic Flow Meter Installation and Operation Guide
- One (1) Flow Meter Certificate of Calibration

Please notify ONICON if any of these items are missing.

2.1.2 Carry Case

The FP-4400 is packaged in an orange IP67 carry case with protective molded foam. The foam is molded the same for all of the different ways the FP-4400 can be equipped, but filled based on the original order. The drawing below shows how the various components included with the FP-4400 are populated into the molds:



Position	Description	Position	Description
1	FP-4400 electronics enclosure	**7**	20 Series Mounting Brackets
1 (Underneath)	Transducer cables, sanding block	**8**	30 Series Transducers
2	Wall charger	**9**	20 Series Transducers
3	30 Series transducer mounting brackets	**10**	Hose clamps, up to 3 pairs of different sizes, black marker, interchangeable plugs for charger
4	10 Series transducer mounting rail	**11**	20 Series Alignment Rod
5	Coupling compound, 3 oz Super Lube®	**12**	30 Series Alignment Bar w/ Built-In Ruler
6	10 Series transducers		

2.1.3 Internal Battery

WARNING
The FP-4400 includes a lithium-ion battery. For your safety, operate only within the specifications put forth by ONICON.

A built-in rechargeable lithium-ion battery supplies power for approximately 15 hours of continuous operation when fully charged. This battery is not user serviceable. Contact ONICON for assistance if you believe the battery needs replacement.

When you first use the FP-4400, it will take the meter two or three charge/discharge cycles to calibrate itself to the battery. The meter may reach 100% charge or 0% discharge faster than anticipated until this process is complete.

State of charge is shown when the meter is ON, or in STANDBY. High rate charging only occurs when the meter is ON or in STANDBY. For best results, charge the meter in one of these two modes.

When the charge of the battery reaches 100%, the meter will reduce the charge rate to protect the battery. In this state, there will be a very slow discharge. When the meter reaches 98% capacity, charging will resume until a 100% charge is reached. This cycle will repeat until the charger is disconnected or the meter powered OFF.

When the battery reaches 5%, a pop-up message will appear stating that the charge is low, and that the meter will automatically shut-down at 0%. To clear this message permanently, connect the charger. To temporarily clear the message, press any button on the meter. A full charge from empty requires approximately 3 hours of charging using the included 3 Amp (15 Watt) charger.

2.1.4 Charger

Included with the FP-4400 package is a mains-powered USB-C, 5 Volt, 3 Amp (15 Watt) charger. The power outlet connection type can be changed via the included modular plates.

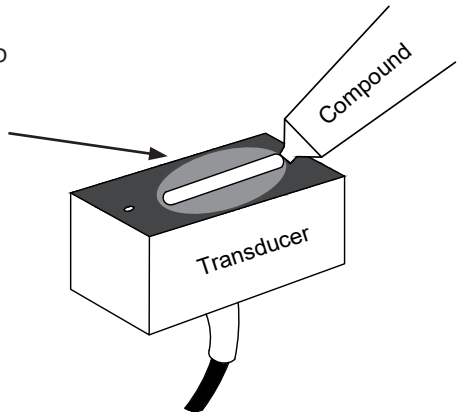
For best results, use the included charger. A third-party USB-C cable connected to a third-party charger or battery bank may also be used. Charging rate may be slower than the included charger if the output is not capable of delivery at least 2 Amps at 5 Volts (10 Watts).

SECTION 3.0 INSTALLATION

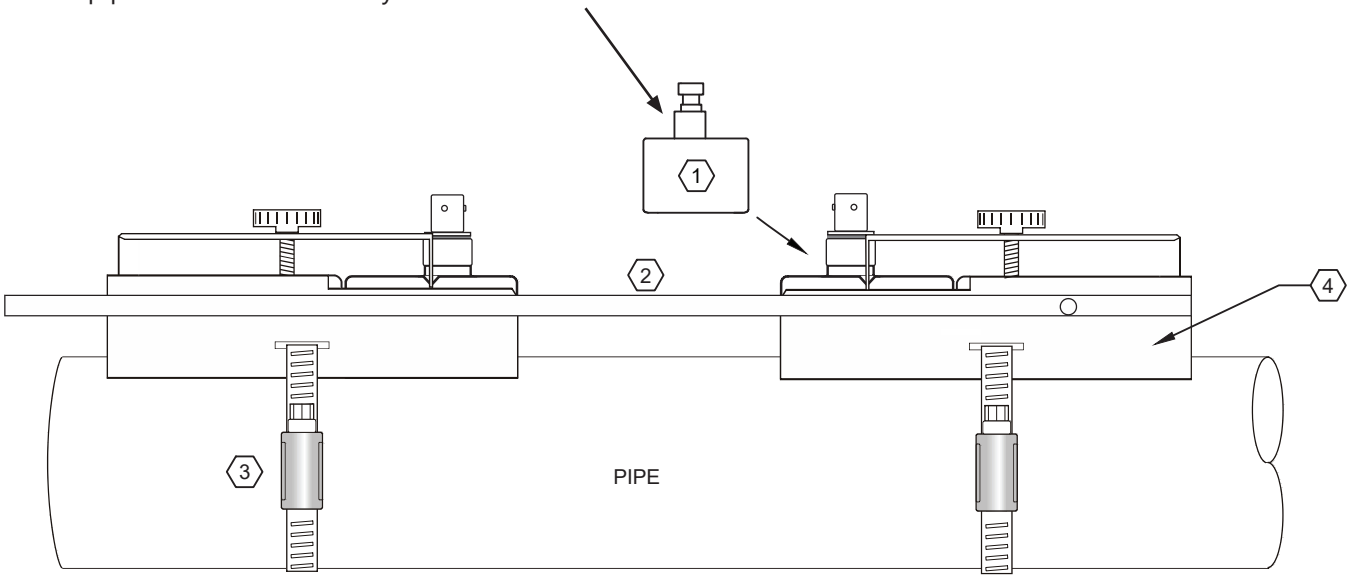
3.1 OVERVIEW

Each FP-4400 Portable Clamp-on Ultrasonic Flow Meter is provided with three different pairs of matched ultrasonic transducers. 10 Series transducers are optimized for small pipes, 20 Series transducers are optimized for mid-range pipe sizes and 30 Series transducers work best on larger pipes. The transducers are mounted (clamped) on to the outside wall of the pipe with the included mounting hardware. 12 ft triaxial cables convey the transducer signals to the meter enclosure that provides power, signal processing and a user interface display.

Apply a small amount of coupling compound to the transducers. A packet of acoustic coupling compound was supplied with the transducers. Contact ONICON if you need more compound.



When installing the transducer, do not allow the bottom face to touch the pipe surface until it is fully inserted to the bracket



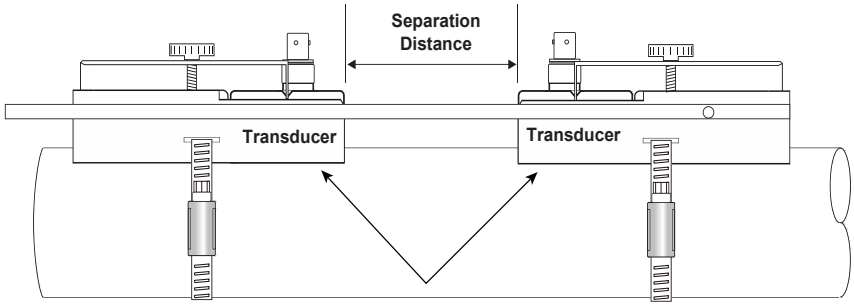
1. Transducer (20 Series shown in drawing)
2. Alignment and spacer tool
3. Adjustable stainless steel pipe clamp
4. Transducer mounting bracket

Ultrasonic transducers may be configured to operate in either 1 (Direct), 2 (Reflect) or 4 (Double Reflect) cross operating modes. In double reflect mode the signal reflects off the pipe wall twice. The meter will recommend the operating mode once you select the transducer type and enter the pipe data (Pipe material, size, etc.). In most cases, the meter will select In most cases, the meter will select 2 cross (Reflect). Reflect mode is the simplest mounting configuration. Direct mode is normally only used to optimize signal strength and double reflect mode is only used on very small pipes. For each installation, the meter will provide the proper transducer spacing distance based on the pipe data you program into the meter.

3.1 OVERVIEW (CONTINUED)

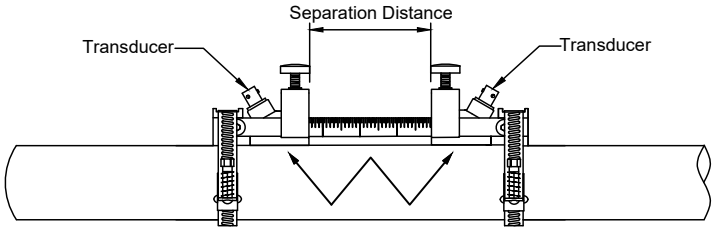
3.1.1 Two (2) (Reflect) or Four (4) (Double Reflect) Cross Mode

Two (2) cross (Reflect) mode is the recommended operating mode whenever possible. It is the simplest way to mount the transducers. Operating in the reflect mode also minimizes the effects of some flow distortions.



2 CROSS SEPARATION DISTANCE (REFLECT)

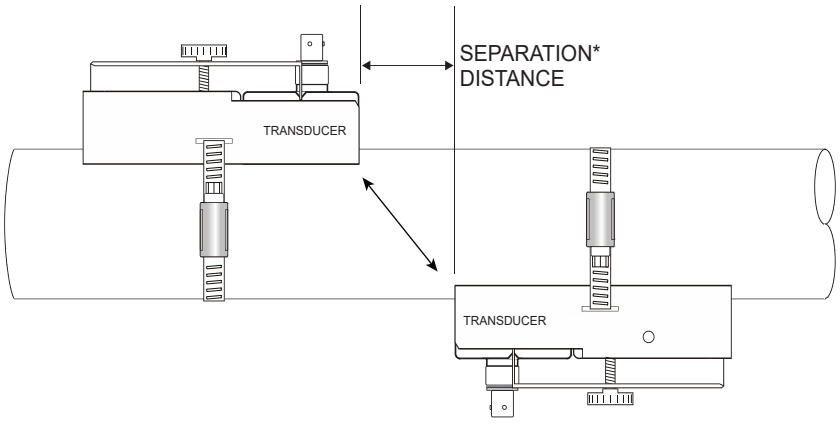
Four (4) cross (Double Reflect) mode is used for some installations in small pipe sizes using the 10 Series transducers.



4 CROSS SEPARATION DISTANCE (DOUBLE REFLECT)

3.1.2 One (1) (Direct) Cross Mode

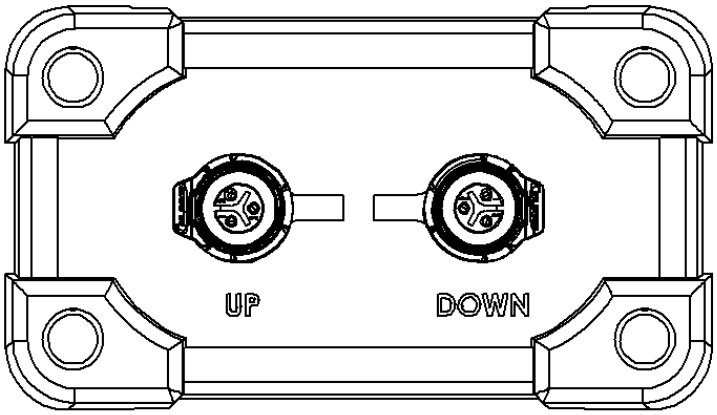
One (1) cross mount provides a shorter sonic path. The shorter path typically improves performance with difficult pipe conditions, such as older and/ or corroded piping. One (1) cross (Direct) mounting requires half the distance between transducers when compared to the two (2) cross (Reflect) mode and may be the only option if the availability of the mounting space is limited.



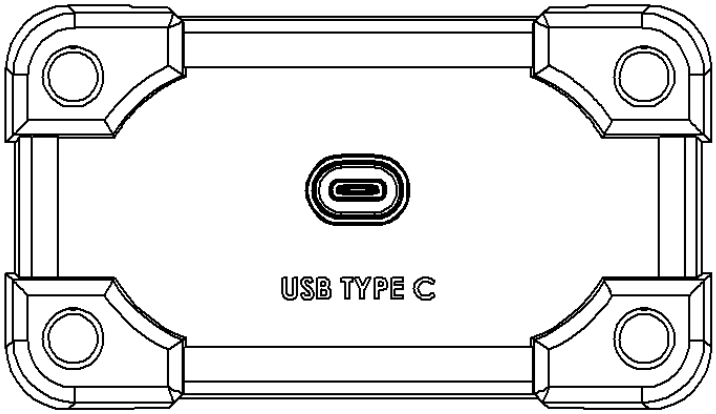
1 CROSS SEPARATION DISTANCE (DIRECT)

3.2 SITE SELECTION

3.2.1 Transducer Connections



3.2.2 USB-C Connections (Charger, Modules)



USB-C is a USB connector system with a non-polarized connector. Devices connected to USB-C may be hosts or peripherals. The FP-4400 is able to make itself both, referred to as “Dual-Role-Data (DRD)” or “USB On-The-Go”.

When connected to a USB power delivery system, like the included wall charger, a laptop port, an automobile port, or a portable USB power delivery device, the FP-4400 becomes the peripheral and will charge.

When connected to a USB storage device, like the included flash drive, the FP-4400 becomes the host and will transfer data to the storage device.

The design of the FP-4400 allows for future deployment of “modules” which will be able to plug in to the USB-C port on the FP-4400, and expand its capability.

IMPORTANT NOTE
If using a USB Drive other than what was provided with the meter, verify that the USB drive is between 8GB and 32GB and is formatted using “FAT32” file structure.

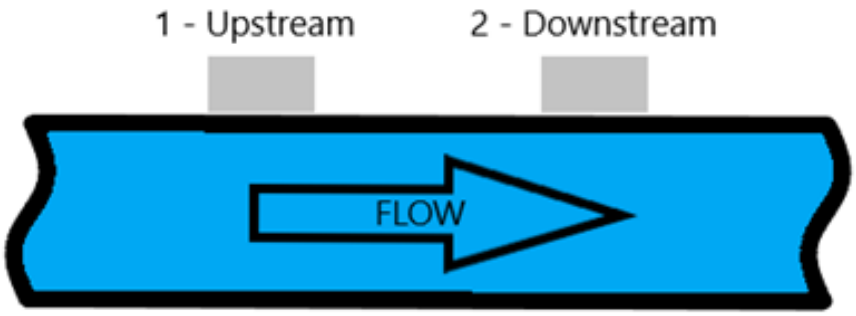
IMPORTANT NOTE
If using a USB Drive other than what was provided with the meter be aware that the USB port is recessed into the protective case and limits the size of the USB drive that can be used. Rectangular drives must be smaller than 0.450" (W) x 0.200" (H) & oval drives must be smaller than 0.530" (W) x 0.300" (H) in order to clear the case. If your USB drive is too large to clear the case, use a short USB-C Male to USB-C Female extension cable to clear the wall of the case.

3.2.3 Transducer Cables

Included with the FP-4400 are a pair of 12 ft (3.4 m) triaxial cables, one end features a BNC plug, and the other an IP67 plug. The BNC plug will connect to any 10 Series, 20 Series or 30 Series FP-4400 transducer. The IP67 plug connects to the socket on the top of the FP-4400.

The triaxial cables are marked on both ends as either upstream or downstream. The same markings are found on the label surrounding the sockets for the IP67 plugs. The purpose of these markings is to assist with connecting the meter to the transducers in the right orientation. As an example, in the picture below, when flow is from LEFT to RIGHT, the number 1 transducer is upstream, and number 2 is downstream. The reverse is true when flow is from RIGHT to LEFT.

Fifty foot transducer extension cables (ordered separately) are also available for use with the FP-4400. The cables are provided with BNC connectors for easy connection to the existing 12 ft cables. Use of the extension cables extends the cable length to a maximum of 62 ft.

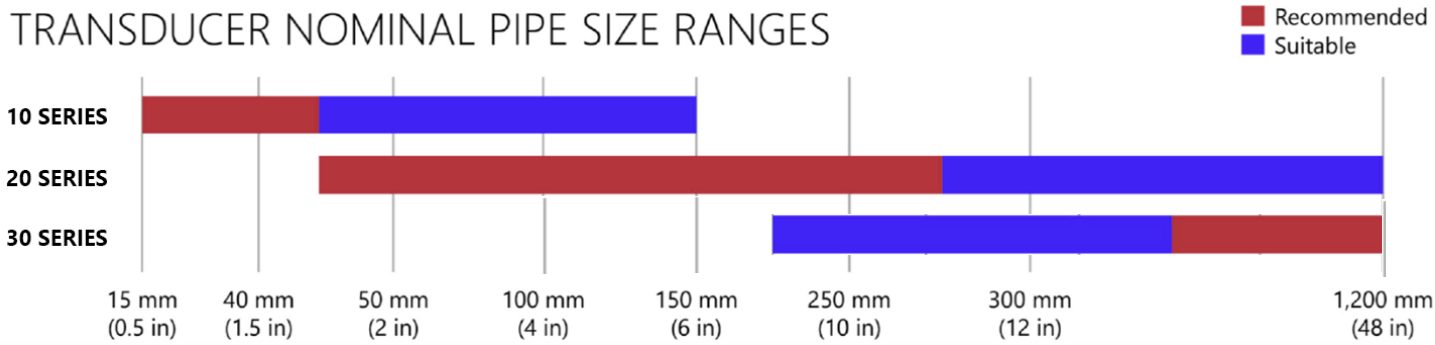


Example 2 cross transducer orientation (reflect) on horizontal pipe

3.2.4 Transducers

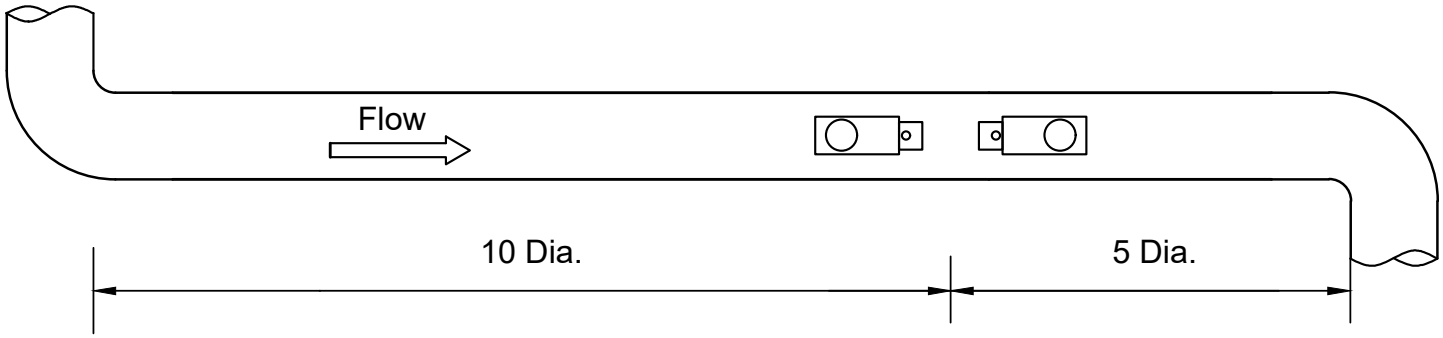
The FP-4400 can be used with 10 Series, 20 Series and 30 Series transducers. The FP-4400 will be wet calibrated against a secondary standard for each transducer set ordered with the meter. When switching between transducer type in the FP-4400 programming menu, the calibration data for each sensor will automatically change, so that the calibration certificate does not need to be referenced each time.

Each transducer type has a specific nominal pipe size range where they are ideal for use (recommended), and another range where they will work under favorable conditions (suitable). See the chart below for the specific range.



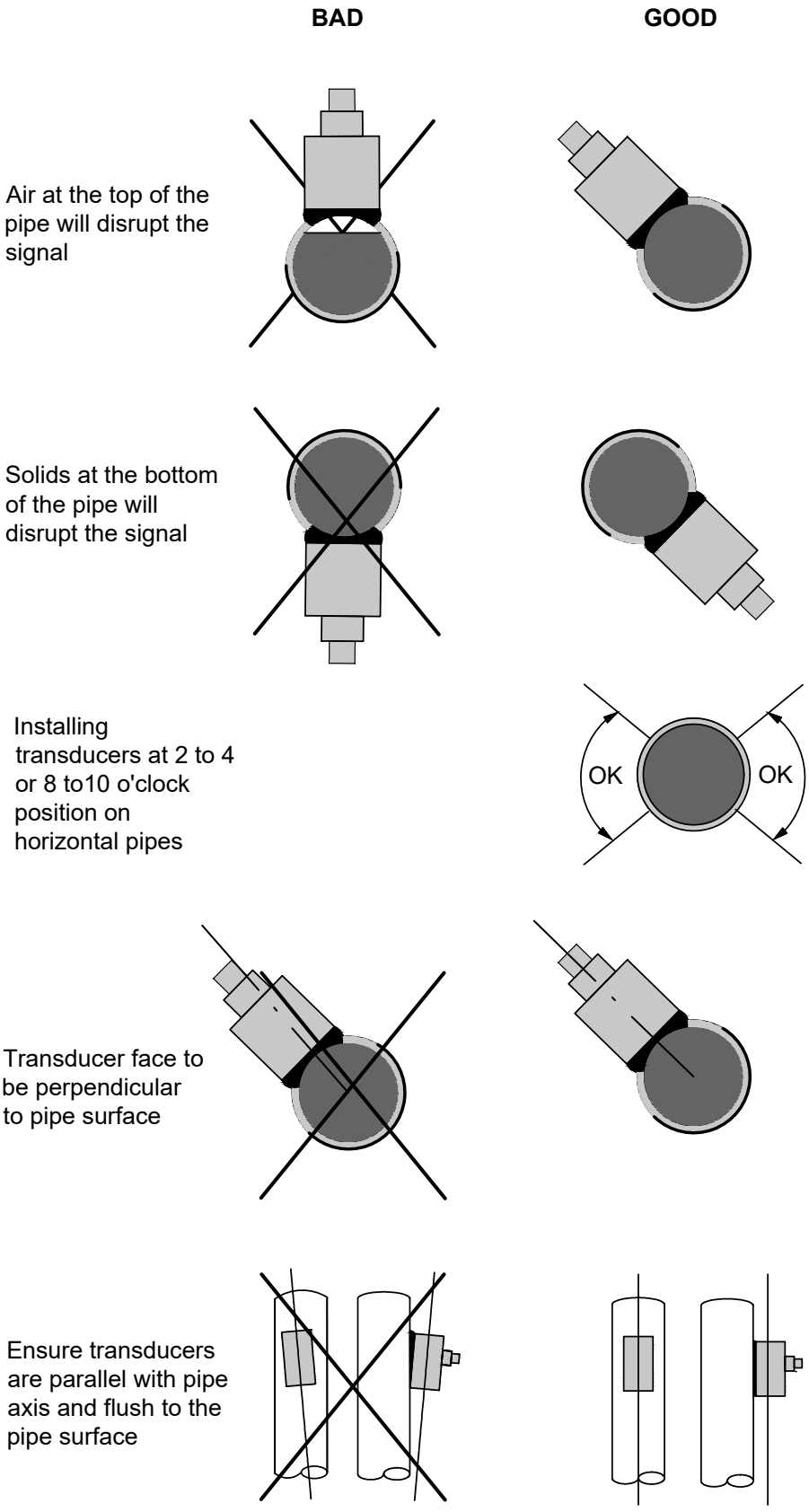
3.2.4 Transducers (Continued)
For best results, the transducers should be installed on a straight run of pipe free of bends, tees, valves, transitions, insertion probes and obstructions of any kind. For most installations, ten straight unobstructed pipe diameters upstream and five diameters downstream of the transducers is the minimum recommended distance for proper operation. Additional considerations are outlined below.

IMPORTANT NOTE
In some cases, longer straight runs may be necessary where the transducers are placed downstream from devices which cause unusual flow profile disruptions or swirl (for example, modulating valves, two elbows in close proximity and out of plane, etc.)



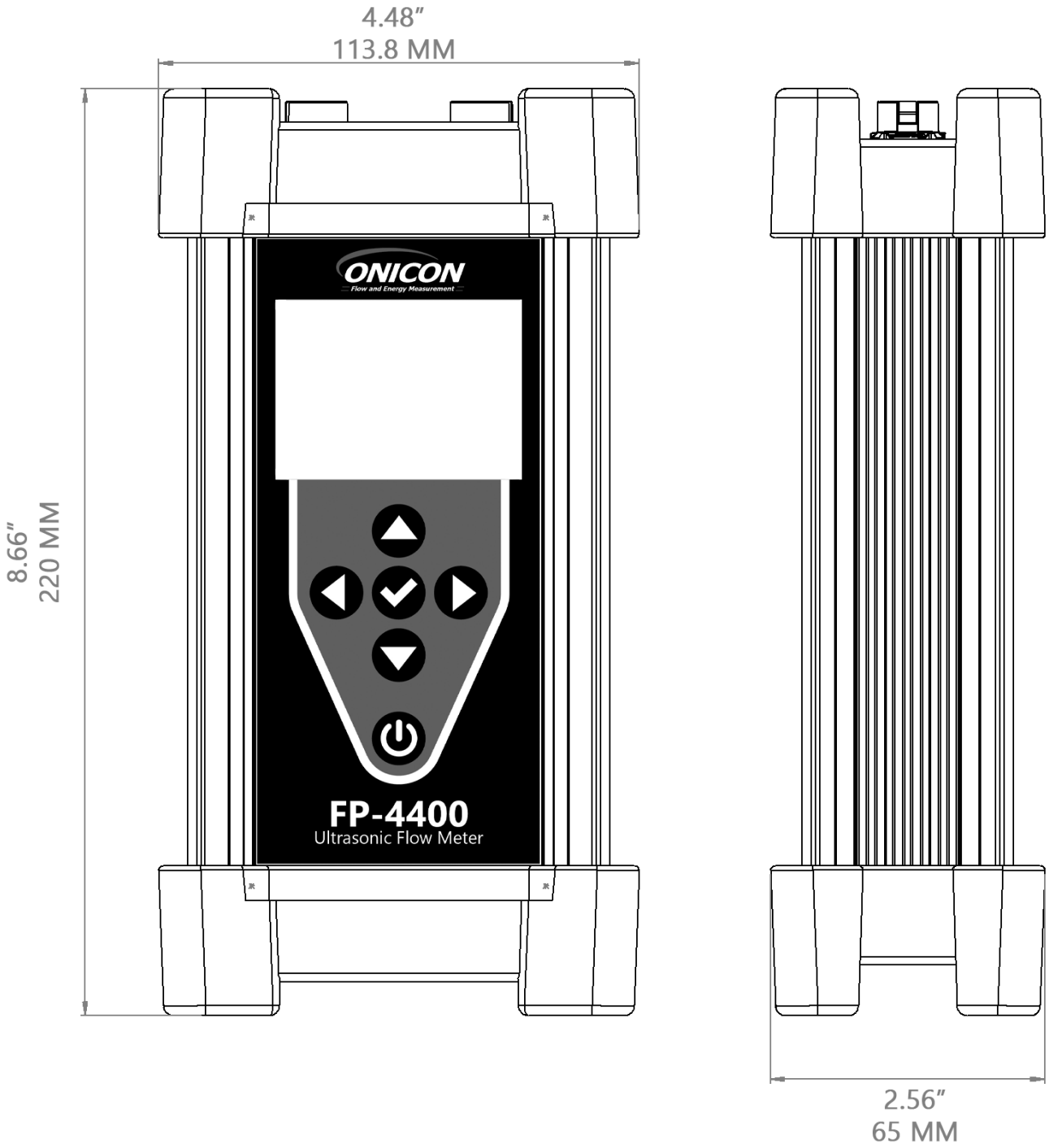
- Avoid installing the transducers downstream from a throttling valve, a mixing tank, the discharge of a positive displacement pump, or any other equipment that could possibly aerate the liquid. The best location will be as free as possible from flow disturbances, vibration, sources of heat, noise, or radiated energy.
- Avoid mounting the transducers on a section of pipe with any external scale. Remove all scale, rust, loose paint, etc., from the location prior to mounting the transducers.
- Do not mount the transducers on a surface aberration (pipe seam, etc.).
- Do not mount transducers from different ultrasonic flow meters on the same pipe.
- Do not run the transducer triaxial cables in common bundles with cables from other instrumentation. You can run these cables through a common conduit ONLY if they originate at the same flow meter.
- Never mount transducers under water.
- Avoid mounting transducers on the top of a horizontal pipe. The best placement on a horizontal pipe is either the 8:00 to 10:00 or 2:00 to 4:00 position for 2 cross (Reflect) or 4 cross (Double Reflect) mode, or one sensor at 9:00 and one sensor at 3:00 for 1 cross mode (Direct).
- Do not mount transducers on the bottom of a horizontal pipe.
- Mounting on a vertical pipe is the recommended installation method if flow is in the upward direction. When mounting on a vertical pipe flowing in a downward direction, make sure there is sufficient back pressure in the system to maintain a full pipe.

3.2.5 Transducer Mounting Recommendations

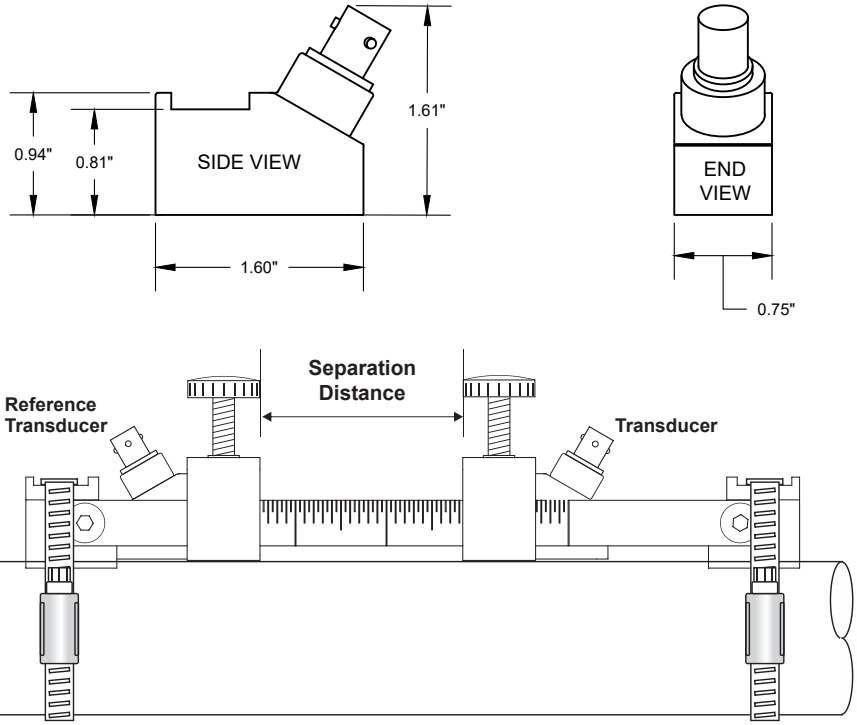


3.3 MECHANICAL INSTALLATION

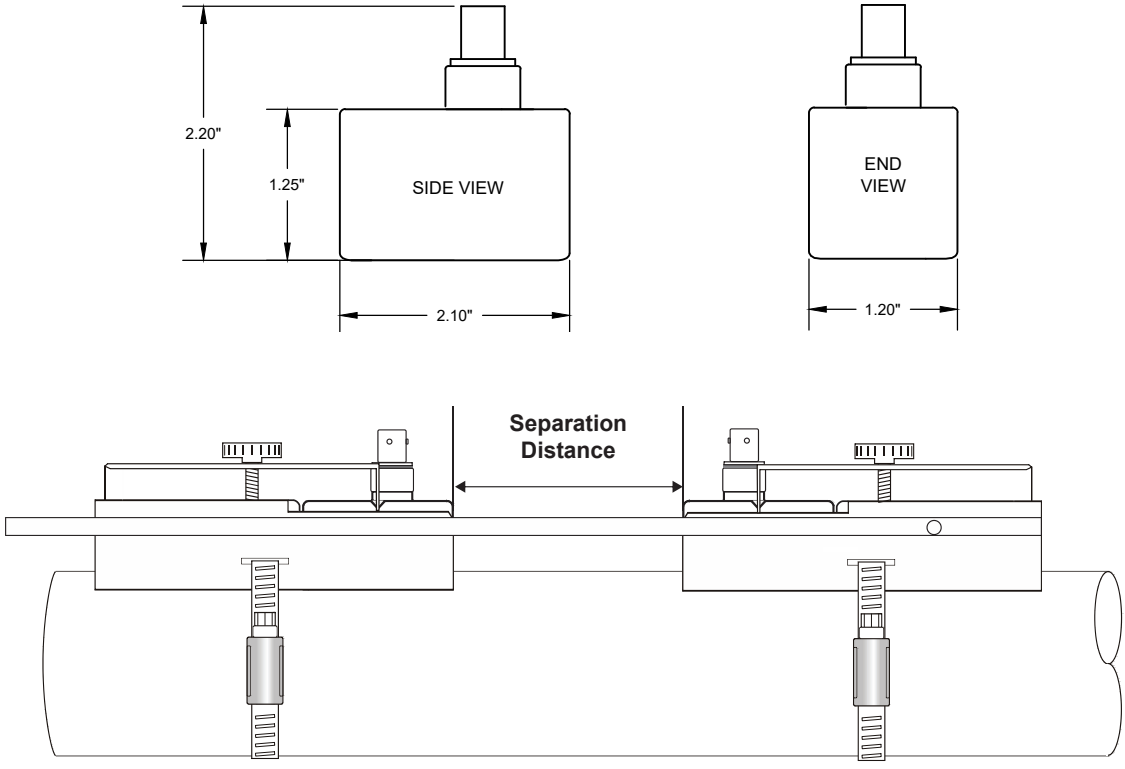
3.3.1 Enclosure Dimensions



3.3.2 10 Series Transducer Dimensions

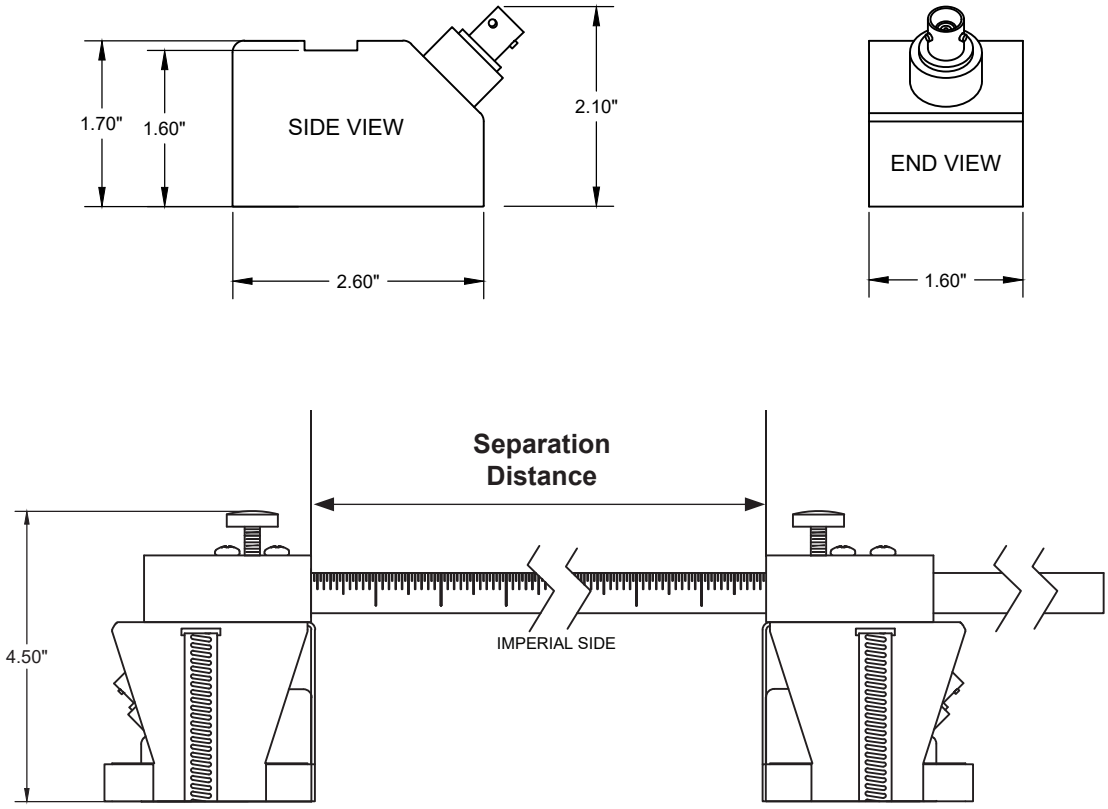


3.3.3 20 Series Transducer Dimensions



Dimension (A) varies based on pipe material, wall thickness, and shown in "Setup" menu after sensor, fluid and pipe parameters are entered. See pg. 25 for more information.

3.3.4 30 Series Transducer Dimensions

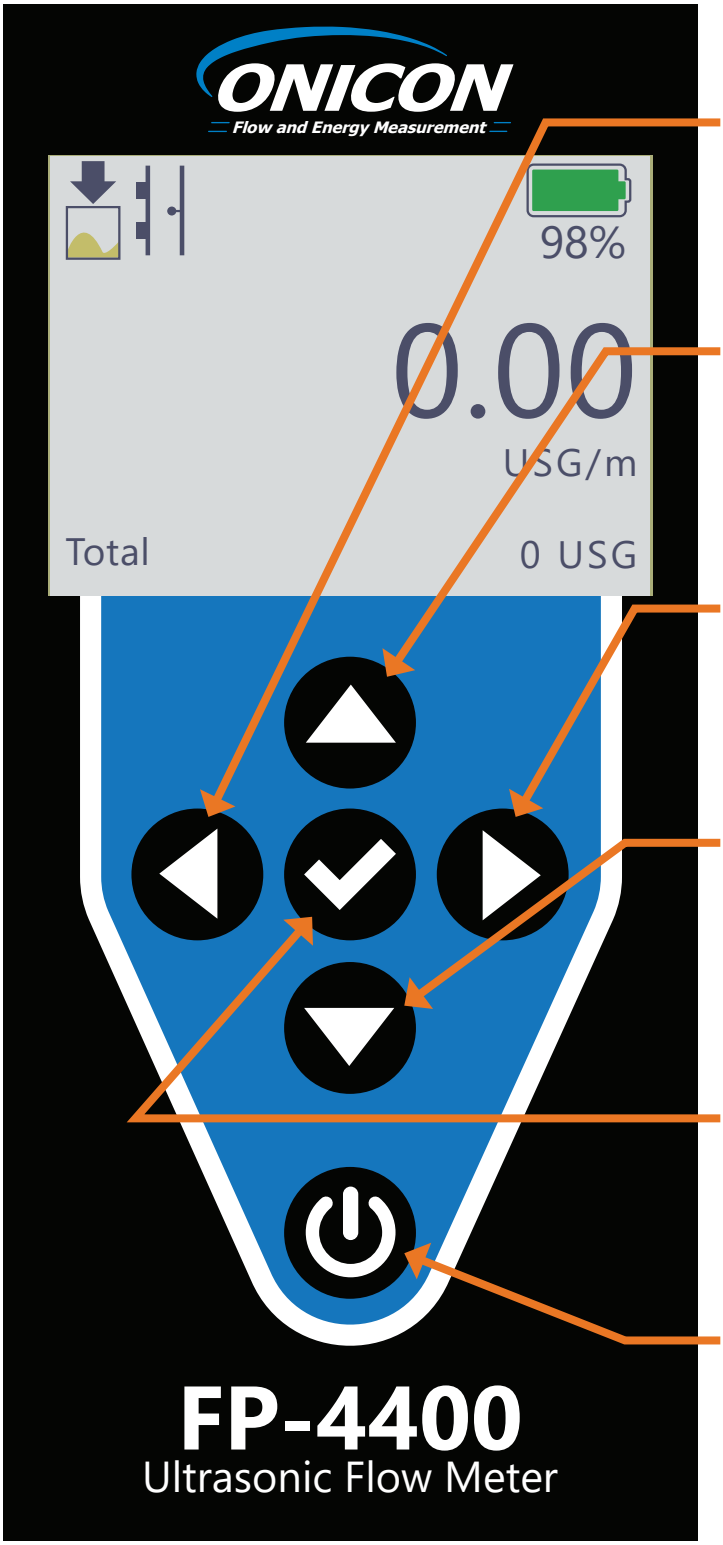


Dimension (B) varies based on pipe material, wall thickness, and shown in "Setup" menu after sensor, fluid and pipe parameters are entered. See pg. 25 for more information.

SECTION 4.0 START-UP

4.1 KEYPAD

Keypad layout and functionality is as shown and described below:



LEFT Arrow:
- From Main screen – Navigate to 24 Hr Log page
- In programming menus – navigate out-of the Main Menu or sub-menu
- In pop-out menus – cancel the selection of a parameter. For numerical entries – moves the cursor left, unless on the left-most number, which will then cancel the numerical entry.

UP Arrow:
- From Main screen – Navigate to Messages page
- In programming menus – navigate up in the menus
- In pop-out menus – change the selection or numeric entry

RIGHT Arrow:
- From Main screen – Navigate to Main Menu programming page or Passcode entry
- In programming menus – navigate into the selected sub-menus, or bring up a pop-out menu for a parameter
- In pop-out menus – change the selected number in a numerical entry

DOWN Arrow:
- From Main screen – Navigate to Status page
- In programming menus – navigate down in the menus
- In pop-out menus – change the selection or numeric entry

CHECK Button:
- From Main screen – not applicable
- In programming menus – will move the cursor back one level. Example: if in the Units/Mode sub menu, CHECK will move back to Main Menu.
- In pop-out menus – confirms the selection of a parameter or numerical entry.

POWER Button:
- From Main screen – Press & hold for one second for the Power Mode selection pop-out. Immediately release to enter STANDBY mode. Continue holding for POWER OFF.
- In programming menus – exits to Main screen
- In pop-out menus – exits to Main screen

4.2 POWER ON/OFF & CHARGING

Press and hold the POWER button for 3-5 seconds to turn the meter on or off. When powering on, the meter will display a boot-up screen with the ONICON logo:



When powering off, the meter will display a pop-up message that continuing to hold the POWER button will completely shut off the meter, while releasing the POWER button will put the meter into stand-by mode:



Caution
Leaving the meter in Standby will slowly drain the battery. Do not leave the meter in standby for prolonged periods of time.

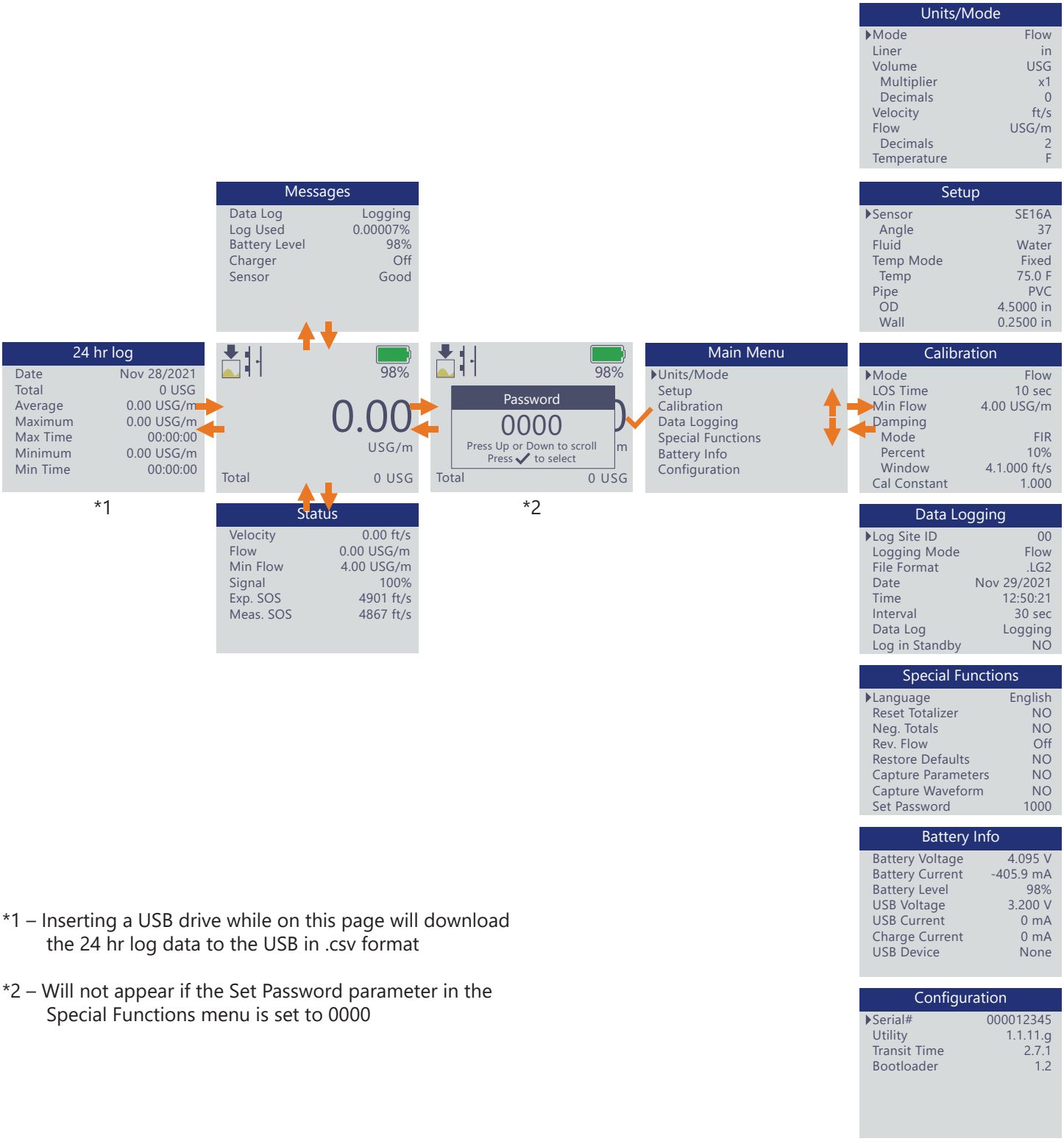
Standby mode puts the meter in a low power state while keeping the processor awake. Future versions of the operating system will allow for periodic data logging while in standby. The periodic logging function is not active in this meter.

For best results, charging should be done with the meter ON. This allows the regulation circuitry to charge at the optimum rate, ensuring a fast and efficient charge, and maximizing battery life. The meter will automatically slow the charging rate when maximum charge is approached. Once the battery charge drains slightly, to 98% with the charger still connected, the meter will automatically turn on the charger current again to return to 100%.

Third-party USB-C charging devices or battery banks are acceptable to use. Charge speed may be slower than the included charger if the output is not capable of delivering 2 Amps at 5 Volts (10 Watts).

4.3 RUN MODE & PROGRAMMING PAGE LAYOUT

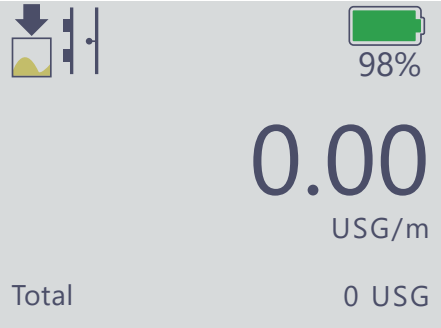
The structure of the menu pages on the FP-4400 is as follows. Using the buttons as shown below (shown in orange) will navigate between the different menus:



*1 – Inserting a USB drive while on this page will download the 24 hr log data to the USB in .csv format

*2 – Will not appear if the Set Password parameter in the Special Functions menu is set to 0000

4.4 RUN MODE PAGES



MAIN DISPLAY

The main display's top row shows icons for the status of the data logger, signal path and quality, charging status, battery fuel gauge percentage, and data logging download status when a USB-C drive is inserted while on this page.
In the middle row of the main display you will see the present value of either the flow rate or velocity, and the associated units of measurement as selected in the Units/Mode menu.

The bottom row shows the total volume accumulated over time, with associated units of measurement as selected in the Units/Mode menu.

ICONS:


Data Logger LOGGING


Data Logger STOPPED


Sensor Good & Signal Strength > 0%
Sensors will be on same side of pipe in 2 or 4 cross (shown), and signal path animation matches 2 or 4 cross as well
Sensors will be across the pipe in 1 cross


Sensor Good & Signal Strength = 0%


Sensor Open (flashing "X") & Sensor Short (static "X")
Message next to icon will also specify sensor status


Data Logger downloading (animation shows USB filling)


Data Logger download complete


Battery charging

MESSAGES

Messages	
Data Log	Logging
Log Used	0.00007%
Battery Level	98%
Charger	Off
Sensor	Good

Pressing the UP arrow button from the Main Display will take you to the Messages page. This page shows the status of the Data Log in plain text, percentage of the Log Used, the Battery Level fuel gauge in plain text, Charger status, and Sensor status in plain text. Press DOWN, CHECK, or POWER to return to the Main Display.

Data Log – Status can be Stopped (not logging) or Logging. Matches state of the icon on the Main Display.

Log Used – Percentage used of the internal storage for the data log. The FP-4400 has storage for approximately 12.5 million logs, or almost 4 years at the fastest logging interval of 10 seconds/log.

Battery Level – Percentage remaining in the fuel gauge. Meter will automatically shut-down at 0% with no charger connected.

Charger – Shows either Charging or Off. Meter indicates charging when connected to a charger attached to mains power and the battery level is below 98%. Indicates Off with or without the charger connected when the charge reaches 100%.

Sensor – Shows Good, Low Signal, Short, or Open. Low Signal indicates that the transducer connections are good, but there is no signal (entrained air or solids in the line, or empty pipe). Sensor Short or Sensor Open indicates a short or open connection in the transducer cable(s) or transducer(s) themselves. Use a multimeter to check for shorts or opens in the cable(s) and transducer(s).

STATUS

Status	
Velocity	0.00 ft/s
Flow	0.00 USG/m
Min Flow	4.00 USG/m
Signal	100%
Exp. SOS	4901 ft/s
Meas. SOS	4867 ft/s

Pressing DOWN from the Main Display will take you to the Status page. This page shows the status of the measurement itself, present flow Velocity, present Flow rate, Min Flow (read-only) as set in the Calibration menu, Signal strength, Exp. SOS (Expected fluid Speed Of Sound), and Meas. SOS (Measured fluid Speed Of Sound). Press UP, CHECK, or POWER to return to the Main Display.

Velocity – Shows the measured velocity in either ft/s or m/s, as set in the Units/Mode menu.

Flow – Shows the measured flow rate in units set in the Units/Mode menu.

Min Flow – Shows the min flow rate as set in the Calibration menu. Any flow rate below the Min Flow results in the flow rate displaying as 0.0

Signal – Shows the magnitude of signal being received by the ultrasonic sensors. 100% is the ideal signal strength. Signal strengths less than 100% could indicate poor pipe conditions (corrosion), highly aerated water, or programmed setup parameters which don't closely match field conditions. Consideration should be made to use 1-cross installation method in such cases, if not already using it.

STATUS (CONTINUED)

Status	
Velocity	0.00 ft/s
Flow	0.00 USG/m
Min Flow	4.00 USG/m
Signal	100%
Exp. SOS	4901 ft/s
Meas. SOS	4867 ft/s

Exp. SOS - Displays the expected fluid speed of sound measurement, in units that match the Velocity. The expected speed of sound is based on the pipe, fluid, and temperature selection in the Setup menu.

Meas. SOS - Displays the measured fluid speed of sound, in units that match Exp. SOS. The meter calculates this value based on the time it takes for the signal to arrive from one transducer to another. Large differences between expected and measured speed of sound (> 10%) typically indicate an error in the setup of the instrument. Verify the following are correct in the Setup menu and with the physical installation of the transducers:

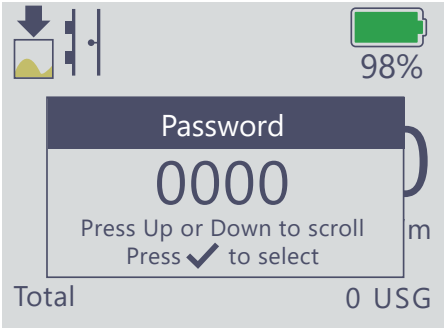
- Pipe Material
- Pipe OD
- Pipe Wall Thickness
- Liner Type
- Liner Thickness
- Fluid Type
- Fluid Temperature
- Crossings
- Separation Distance

24 HR LOG

24 hr log	
Date	Nov 28/2021
Total	0 USG
Average	0.00 USG/m
Maximum	0.00 USG/m
Max Time	00:00:00
Minimum	0.00 USG/m
Min Time	00:00:00

Pressing LEFT from the Main Display will take you to the 24 HR LOG page. This page shows a summary view of the flow, starting with today's data. Pressing the DOWN or UP arrows will scroll to previous day's data. Up to 365 days will be stored. Newer data will overwrite the oldest, automatically, once the 365 day limit is reached. Press RIGHT, CHECK, or POWER to return to the Main Display.

PASSWORD



The password (a number from 0000 to 9999) prevents unauthorized access to the Main Menu for programming.

Pressing RIGHT from the Main Display will take you to the Password pop-out screen if the factory default Set Password parameter in the Special Functions menu was changed from 0000. If a password is required, the cursor will automatically be flashing on the leftmost numeral. Press either UP or DOWN to change the selection of that numeral, and RIGHT or LEFT to change the flashing cursor position. Press the CHECK button to accept the password and proceed to the Main Menu, or, press the POWER button to return to the Main Display.

IMPORTANT NOTE
If you have misplaced your password, contact ONICON for assistance recovering it.

MAIN MENU

Main Menu
▶Units/Mode
Setup
Calibration
Data Logging
Special Functions
Battery Info
Configuration

Pressing RIGHT from the Main Display (Set Password in Special Functions = 0000, default) or CHECK from the Password pop-out (Set Password ≠ 0000) will bring you to the Main Menu screen. The Main Menu functions to provide a simple, easy to understand starting point to navigate the programming parameters. The function of each page is described in subsequent sections. Use UP or DOWN to move the cursor position (▶) and RIGHT to navigate in-to the selected menu.

UNITS/MODE

Units/Mode	
▶Mode	Flow
Liner	in
Volume	USG
Multiplier	x1
Decimals	0
Velocity	ft/s
Flow	USG/m
Decimals	2
Temperature	F

Pressing RIGHT on Units/Mode in the Main Menu will bring you to the Units/Mode programming sub-menu. In this menu you can use UP and DOWN to move the cursor, then RIGHT to change any value. When changing a value, a pop-up message will appear. Follow the on-screen prompts to change the value, CHECK to accept the change, or LEFT to cancel.

Mode – Select "Flow" (default) or "Velocity" for the mode of operation in the Main Display and Data Log.

Linear – Select "in" (inches, default), "ft" (feet), "mm" (millimeters), or "m" (meters) to define distances for pipe diameter, pipe wall thickness, separation distance, etc.

Volume – Select engineering units for the flow volume (totalizer) on the Main Display and Data Log. Options:

Option	Description	Option	Description
USG	US gallons (US default)	**m^3**	cubic meters
USMG	US million gallons	**L**	liters (metric default)
IG	imperial gallons	**bbl**	barrels (1 bbl = 42 USG)
IMG	imperial million gallons	**ft^3**	cubic feet

Multiplier – Select the multiplier for the Volume totalizer. As examples, Multipliers are used when resolution down to the singles place is not required, or when you don't want to convert from gallons to thousands of gallons. Default = x1.

Decimals – Select the number of decimals to show for the Volume totalizer. Default = 0. Options = 0, 1, 2

Velocity – Select the units for flow velocity. US Default = ft/s. Metric Default = m/s. Options = ft/s or m/s.

UNITS/MODE (CONTINUED)

Units/Mode	
▶Mode	Flow
Liner	in
Volume	USG
Multiplier	x1
Decimals	0
Velocity	ft/s
Flow	USG/m
Decimals	2
Temperature	F

Flow – Select engineering units for the flow rate on the Main Display and Data Log. Options:

Option	Description	Option	Description
USG/d	US gallons per day	**L/d**	liters per day
USG/h	US gallons per hour	**L/h**	liters per hour
USG/m	US gallons per minute (US default)	**L/m**	liters per minute
USG/s	US gallons per second	**L/s**	liters per second (metric default)
ft3/d	cubic feet per day	**m3/d**	cubic meters per day
ft3/h	cubic feet per hour	**m3/h**	cubic meters per hour
ft3/m	cubic feet per minute	**m3/m**	cubic meters per minute
ft3/s	cubic feet per second	**m3/s**	cubic meters per second
bbl/d	barrels per day (1 bbl = 42 USG)	**IG/d**	imperial gallons per day
bbl/h	barrels per hour (1 bbl = 42 USG)	**IG/h**	imperial gallons per hour
bbl/m	barrels per minute (1 bbl = 42 USG)	**IG/m**	imperial gallons per minute
bbl/s	barrels per second (1 bbl = 42 USG)	**IG/s**	imperial gallons per second
USMG/d	US million gallons per day	**IMG/d**	imperial million gallons per day
USMG/h	US million gallons per hour	**IMG/h**	imperial million gallons per hour
USMG/m	US million gallons per minute	**IMG/m**	imperial million gallons per minute
USMG/s	US million gallons per second	**IMG/s**	imperial million gallons per second

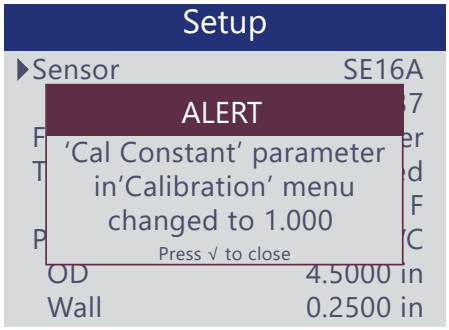
Decimals - Select the number of decimals to show for the Flow rate. Default = 0. Options = 0, 1, 2

Temperature – Select the engineering units for defining the temperature of the fluid in the Setup menu. US default = F, Metric Default = C. Options = F or C.

SETUP

Setup	
▶Sensor	SE16A
Angle	37
Fluid	Water
Temp Mode	Fixed
Temp	75.0 F
Pipe	PVC
OD	4.5000 in
Wall	0.2500 in
Lining	None
Crossing	2
Zero Tare	NO
Sens Space	2.850 in
Velocity	0.00 ft/s
Signal Strength	100%

Sensor – Select the sensor (transducer) type connected to the FP-4400. Choices are 10 Series (SE 16A), 20 Series (SE 16B) and 30 Series (SE 16C). Restoring default parameters does not affect this selection. When changing from one transducer to another, the Cal Constant in the Calibration menu will automatically update to the stored value for that sensor type. The following pop-up menu will appear when that occurs:



Angle – Only applies to 20 Series transducers. All 20 Series transducers shipped with the FP-4400 have an Angle of 37. It is possible to use 20 Series transducers from the F-4300 with the FP-4400. Before using F-4300 20 Series transducers check the model number to confirm the angle. Contact ONICON for further assistance, if necessary.

Fluid – Select fluid type. Default = Water. Options = Water, Other, Prop Glycol, Eth Glycol, Hydraulic Oil, and Diesel Oil.

Vel@25C - When Fluid = Other, enter the fluid sound velocity (speed of sound) at 25C from the reference table in this manual, or other reference. Engineering units will match Velocity selection in the Units/Mode menu.

dV/C – When Fluid = Other, enter the change in fluid sound velocity (speed of sound) per degree C, from the reference table in this manual, or other reference. Engineering units will match Velocity selection in the Units/Mode menu.

Temp Mode – Read-only. Temp Mode = Fixed.

Temp – Enter the temperature of the fluid. Engineering units will match the selection of Temperature in the Units/Mode menu.

Pipe – Select the pipe material. Default = PVC. Options = PVC, Poly HD, Poly LD, Nylon, Iron, FRP (Fiberglass), Ductile Iron, CPVC, Copper, Cast Iron, Carbon Steel, Brass, Aluminum, Acrylic, ABS, Other, Stainless 430, Stainless 410, Stainless 347, Stainless 316, Stainless 304, Stainless 303, Stainless 302, and Mild Steel.

OD – Enter the outside pipe diameter for the pipe the FP-4400 transducers will be mounted on. The pipe OD should be as precise as possible. Refer to the pipe charts in this manual for the outside diameter of common pipe materials and schedules. If unsure of the pipe size for lookup on the reference charts, or the OD, use the included tape measure to measure the circumference of the pipe, then divide by 3.14 to calculate the OD. Default = 4.5 in (114.3 mm).

Vel – When Pipe = Other, enter the shear-wave sound velocity (speed of sound) of the pipe the sensors will be mounted on. Engineering units match the selection of Velocity in the Units/Mode menu.

Setup	
▶Sensor	SE16A
Angle	37
Fluid	Water
Temp Mode	Fixed
Temp	75.0 F
Pipe	PVC
OD	4.5000 in
Wall	0.2500 in
Lining	None
Crossing	2
Zero Tare	NO
Sens Space	2.850 in
Velocity	0.00 ft/s
Signal Strength	100%

SETUP (CONTINUED)

Wall – Enter the wall thickness of the pipe the sensors will be mounted on. The wall thickness should be entered as precise as possible. Refer to the pipe charts in this manual for wall thicknesses of common pipe materials and schedules. Default = 0.25 in (6.35 mm)

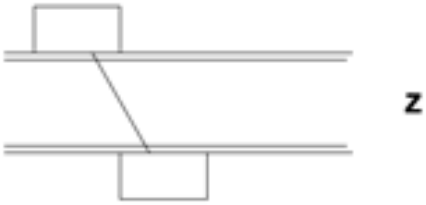
Lining – Select the liner on the inside of the pipe, if applicable. Default = None. Options = None, Tar Epoxy, Rubber, Mortar, Asb Cement, and Other.

Vel – When Lining = Other, enter the shear-wave sound velocity (speed of sound) of the liner material. Engineering units match the selection of Velocity in the Units/Mode menu.

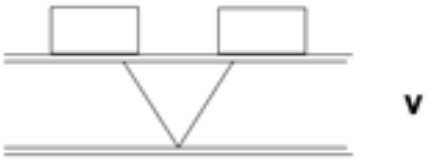
Thickness – When Lining ≠ None, enter the thickness of the liner. The thickness of the liner should be entered as precise as possible. Refer to the pipe charts in this manual for liner thicknesses of common pipe materials and schedules where liners are used (e.g. Ductile Iron).

Crossings – Select the number of crossings for the ultrasound signal. Default = 2. Options = 1, 2, and 4.

Crossings 1 = Z mounting



Crossings 2 = V mounting



Crossings 4 = W mounting



Nominal Pipe Size, Inches	Recommended Crossings, 10 Series	Recommended Crossings, 20 Series	Recommended Crossings, 30 Series
0.5-1.5	4	N/A	N/A
2-3	2	2	N/A
4-6	2	2	2
8-10	N/A	2	2
12-24	N/A	2	2
26-48	N/A	1	2

SETUP (CONTINUED)

Setup	
▶Sensor	SE16A
Angle	37
Fluid	Water
Temp Mode	Fixed
Temp	75.0 F
Pipe	PVC
OD	4.5000 in
Wall	0.2500 in
Lining	None
Crossing	2
Zero Tare	NO
Sens Space	2.850 in
Velocity	0.00 ft/s
Signal Strength	100%

Older pipes are often degraded, corroded, or scaled on the inside. These conditions can attenuate (weaken) the signal as it bounces (2, 4 cross) or passes through (all crossings) the pipe wall. Consider starting at 2 crosses instead of 4, or 1 cross instead of 2 if you have a pipe known to be very old.

Zero Tare – Select YES to tare (set-to-zero) the current measurement of the FP-4400. While the zero flow stability of the FP-4400 is very good, there might be instances where the reading does not repeatedly report 0 when there is confirmed 0 flow in the pipe. To properly use the Zero Tare, ensure that the flow in the pipe is actually stopped, and make sure the Min Flow is set to the flow rate equivalent of 0.1 ft/s (0.03 m/s) flow velocity in the programmed pipe size.

IMPORTANT NOTE
Setting a Zero Tare with flow in the pipe will create a significant accuracy issue. Correcting this problem requires re-establishing the Zero Tare with confirmed no flow in the pipe.

Sens Space – After selecting/entering the Sensor, Fluid, Temp, Pipe, Pipe OD, Pipe Wall, Lining, and Crossings, the FP-4400 will calculate the geometry of the ideal sensor placement and provide the Sens Space. This is the ideal distance between the front of each transducer. When installing the transducers on the pipe, ensure that the distance between the transducers matches this Sens Space value.

Signal Strength – After selecting/entering the required information for the Sens Spacing, and installing the transducers on the pipe full of water/other fluid, a Signal Strength will appear.

The Signal Strength should be 100% under ideal operating conditions. Signal Strengths between 1-99% do not indicate that the meter is not reliable under the current installation, however, it will be more susceptible to complete signal loss should process conditions worsen from the current state.

Diagnostics available in the Setup menu, and the Capture WF (Wave Form) parameter in the Special Functions menu can be used to help determine the exact cause of the less-than-ideal Signal Strength.

CALIBRATION

Calibration	
▶Mode	Flow
LOS Time	10 sec
Min Flow	4.00 USG/m
Damping	
Mode	FIR
Percent	10%
Window	4.1.000 ft/s
Cal Constant	1.000

Mode – Read-only. Shows the selected Mode from the Units/Mode menu.

LOS Time – Enter the LOS Time to suppress intermittent loss of signal. As an example: systems with high concentrations of undissolved gasses will cause fluctuations in signal strength when the gasses move past the ultrasonic signal.

If a complete loss of signal is experienced, the FP-4400 will hold the last valid reading for the duration of the LOS Time. If the signal strength returns before the LOS Time is expired, the meter will return to normal operation automatically. If signal strength does not return after the LOS Time has expired, then the meter will report zero flow on the LCD display and produce a Low Signal alarm. Default = 10 seconds. Options = 0-99 sec.

Min Flow – Enter the Min Flow cutoff, which means any flow rate below Min Flow measured by the FP-4400 will result in 0 flow on the display and data log. Default = 4 GPM (0.25 L/s) for a 4 in (100 mm) nominal pipe, which is the approximately equal to 0.1 ft/s (0.03 m/s) flow velocity. This is the suggested flow velocity to be used for Min Flow values in other nominal pipe sizes.

Setting the Min Flow to 0 will result in small measurements being displayed and accumulated on the totalizer, so this should be avoided. It is possible to set the Min Flow below a flow velocity of 0.1 ft/s, but a Zero Tare in the Setup menu may need to be invoked to avoid false readings at zero.

Damping Mode - Select OFF, FIR (Default), or LOW PASS. When measured flows are outside the Window of the previous measurement, the FIR filter will reduce the damping average so that a fast response can be made to the sudden change in flow rate. The LOW PASS filter will ignore measured flow rates outside the Window, while holding the previous measurement, until there are enough measurements made outside the Window to cause a step response to the most current measured value. While measured flows are within the Window of the previous measurement, both the FIR and LOW PASS filter behave the same.

Damping Percent - Higher percentages increase the number of measurements which are averaged together to produce a stable flow reading. Higher percentages also increase the time it takes for the meter to make a step-response to the measured flow rate outside the Window in the LOW PASS Mode. Default = 10%. Options = 0-100%.

Damping Window - Defines the Window around the running average, in units of Velocity set in the Units/Mode menu. Measurements made inside the Window are added to the running average, and measurements outside the Window effect the response of the meter as described in the Mode section. Default = 1 ft/s (0.3 m/s). Options = 0-20 ft/s (6.096 m/s).

Cal Constant – Calibration constant defined when the FP-4400 was calibrated at the factory. Specific to the sensor (transducer) model selected in the Setup menu. When changing the Sensor model, a pop-up menu appears notifying the user that this value automatically changed to the last stored value. Should this value accidentally be changed, reference the calibration certificate included with the FP-4400 in order to determine the factory Cal Constant.

Data Logging	
▶Log Site ID	00
Logging Mode	Flow
File Format	.LG2
Date	Nov 29/2021
Time	12:50:21
Interval	30 sec
Data Log	Logging
Log in Standby	NO

DATA LOGGING

Log Site ID – Enter a number from 00 (Default) to 99. The Site ID will become part of the filename for any file downloaded from the FP-4400, to help distinguish from other installation sites. This parameter can be changed at any time.

Logging Mode – Select the logging mode. Default = Flow. Options = Flow, Velocity. This setting cannot be changed if Data Log = Logging. Either STOP or DELETE the Data Log to change the Logging Mode.

File Format – Choose the file format for downloading the log. Default = .LG2. Options = .LG2, .CSV. LG2 format is used for viewing the logged data with the free ONICON Logger Software. CSV format is used for importing into spreadsheet software like Microsoft Excel. This parameter can be changed at any time.

Date – Select the current Date in MM/DD/YYYY format. It is strongly suggested that the Data Log is deleted and restarted after changing the Date, Time, and Interval.

Time – Select the current Time in HH:MM:SS format. Options: 00:00:00-23:59:59. It is strongly suggested that the Data Log is deleted and restarted after changing the Date, Time, and Interval.

Interval – Select the interval between samples to be stored to the data log. Smaller intervals provide better resolution and understanding of changes in flow rate or velocity over time, at the expense of file size and storage capacity. The FP-4400 has capacity for approximately 3.8 years of continuous logged data at a 10 second interval. Default = 30 sec. Options = 10 sec, 30 sec, 1 min, 2 min, 5 min, 10 min, 15 min, 30 min, and 60 min.

Data Log – Shows the status of the Data Log, and is used to change the status. Logging = Data Log is active. Stopped = Data Log is stopped. Delete = deleted the Data Log and sets the status to Stopped. Start = starts the Data Log and sets the status to Logging. Stop = stops the Data Log and sets the status to Stopped.

Log In Standby – Currently not used.

RETRIEVING LOG FILE



Plug a USB-C drive (one is included with the FP-4400) into the USB-C port on the bottom the electronics enclosure. The display will show a downloading icon, then a check mark on the icon when the download is complete. When the check mark appears, the USB-C drive can be removed.

The downloaded file name will appear in this format: **FP-4400__0A.LG2**. The "0" will change, based on the Log Site ID parameter. The "A" will increment: B, C, etc.; with each subsequent download of the data log.

IMPORTANT NOTE
Downloading the file in .LG2 format will take approximately 2.75 minutes each 1% log used. Downloading in .CSV format will take approximately 5.7 minutes each 1% log used.

IMPORTANT NOTE
See section 3.2.2 for USB drive requirement.

SPECIAL FUNCTIONS

Special Functions	
▶Language	English
Reset Totalizer	NO
Neg. Totals	NO
Rev. Flow	Off
Restore Defaults	NO
Capture Parameters	NO
Capture Waveform	NO
Set Password	1000

Language – Select the language for the user interface. Options = English (Default), Spanish, or French.

Backlight – Select the backlight level, which effects brightness for readability in sunlight, as well as energy usage. Options = Very Low, Low, Medium, High (Default), and Very High. There is approximately 100mA difference in operating current between the Very Low and Very High brightness levels.

Mode – Select the mode for the backlight level. Options = Fixed (Default), Dark 10 sec, Dark 30 sec, Dark 60 sec. The "Dark" options will set the backlight to the level selected in the Backlight parameter when any button is pressed, then go to dark (slightly less brightness compared to Backlight = Very Low), until a button is pressed again. When in a "Dark" mode, the first button press after the screen has gone dark will set the brightness to the Backlight level.

Reset Totalizer – Selecting Yes will reset the volume totalizer on the Main Display to 0. Choose No or press the LEFT arrow to exit this menu option without making a change.

Neg. Totals – This parameter turns the totalizer on the Main Display into a NET totalizer. Positive flow will increment the totalizer and negative flow will decrement the totalizer. Options = No (Default), Yes Note: This feature is only available when Rev. Flow ≠ Off.

Rev. Flow – This parameter enables the flow direction indication on the FP- 4400. When Rev. Flow is = On positive flow is indicated when the fluid is moving in the direction of upstream to downstream transducer. When flow velocity moves in the direction of downstream to upstream transducer negative flow is indicated. When Rev. Flow = Off (Default) the meter reports the absolute flow value and does not indicate flow direction.

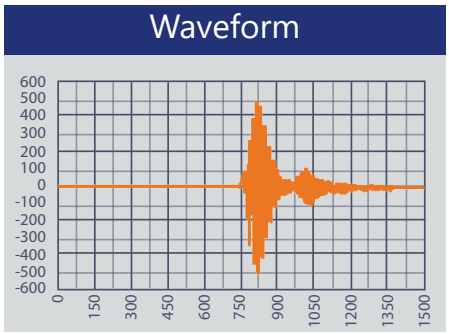
Restore Defaults – The parameter restores the configuration settings to the factory default values. Options = US, Metr. The "US" option will set the units in the Units/Mode menu to US/Imperial defaults, while the "Metr" option will set them to the Metric defaults. This parameter does not change any factory calibration settings, like the Cal Constant in the Calibration menu. It does not change any settings in the Data Logging menu.

Capture Parameter – Choose Yes to download the programming parameters and current measurements to a USB drive. After selecting Yes, the meter will take a couple seconds to package the parameters, then prompt you to Insrt USB (flashing). Insert your USB-C drive when this prompt appears, and the transfer will occur automatically while displaying Saving (flashing). Once the save is complete, the meter will display Done (static). Remove the USB-C drive and the pop-out menu automatically clears.

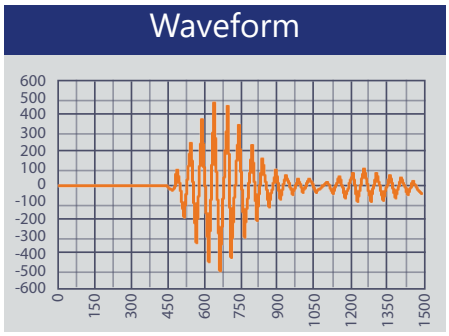
SPECIAL FUNCTIONS (CONTINUED)

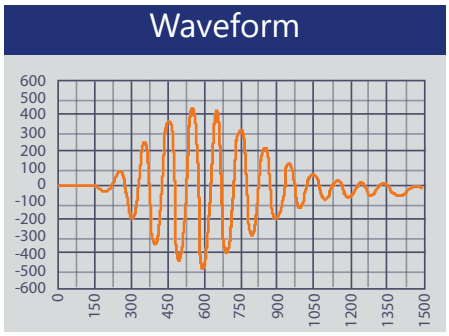
Special Functions	
▶Language	English
Reset Totalizer	NO
Neg. Totals	NO
Rev. Flow	Off
Restore Defaults	NO
Capture Parameters	NO
Capture Waveform	NO
Set Password	1000

Capture Waveform – Choose Yes to capture and display the waveform on the display of the FP-4400. After selecting Yes, Working (blinking) will appear, and then the waveform will appear on the screen, an example is shown below. This will only work when the sensors are connected properly, and no "Sensor Short" or "Sensor Open" message appears on the Messages page.



Pressing the UP arrow button while in this view will allow you to zoom in for more resolution. You will zoom in at the 750 count mark on the x-axis, so if the waveform is positioned closer to the edges of the window, you will need to then use the LEFT or RIGHT arrow buttons to scroll when zoomed in. Press the DOWN arrow to zoom back out. Zoom levels:





If you press the CHECK button while on the Waveform screen, a pop-up message will appear, providing the following options: Exit, Recapture, Save. Choosing Exit will return you to the Special Functions menu. Recapture will take another waveform at that instant and display it on the screen. Save will take the waveform and package it for download to a USB-C drive. When prompted on the screen via Insrt USB, insert your USB-C drive into the meter, and the FP-4400 will save the file. We will occasionally ask for this file in order to help diagnose measurement questions.

Set Password – The default password of 0000 allows for unrestricted access to the programming Main Menu and its sub-menus. Change the password to restrict access for those who do not know the password.

BATTERY INFO

Battery Info	
Battery Voltage	4.095 V
Battery Current	-405.9 mA
Battery Level	98%
USB Voltage	3.200 V
USB Current	0 mA
Charge Current	0 mA
USB Device	None

The Battery Info page is used for diagnostic purposes, and is not used for any configuration of meter behavior.

Battery Voltage – Shows the battery voltage in volts (V).

Battery Current – Shows the charge (positive) or discharge (negative) current in milliamps (mA).

Battery Level – Shows the battery fuel gauge charge percent. Matches the percentage shown on the Main Display and Messages page.

USB Voltage – Shows the voltage on the USB connector. Typically 3.2 V when no charger is connected, and 5.0 V when a charger is connected.

USB Current – Shows the current from the external USB-C charger.

Charge Current – Shows the current into the battery.

USB Device – Shows the state of the USB connection: None, Charger, Drive

CONFIGURATION

Configuration	
▶Serial#	000012345
Utility	1.1.11.g
Transit Time	2.7.1
Bootloader	1.2

The Configuration page shows the serial number of the FP-4400, and the firmware versions of the utility board, transit time board, and bootloader. ONICON may ask for this information to help diagnose measurement questions.

SECTION 5.0 COMMON QUESTIONS AND ANSWERS

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

The flow meter must be installed in a high noise environment. Will this affect operation?
ONICON's transit time flow meters are designed to discriminate between environmental noise and the transit time signal. High noise environments may affect the flow meter's performance where low signal strength and/or low flow velocities are being measured. Relocate the sensor in a quieter environment if possible.

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

What effect do pipe liners have on the flow meter?
Typically, there is little to no effect of a well-bonded liner such as cement, epoxy, or tar inside the pipe. Should there be an air gap between loose insertion liners and the pipe wall, this will prevent the transit time signal from entering the fluid. An on-site test is recommended to determine if the application is suitable for a transit time flow meter when an unbonded liner is possible.

Why is transit time recommended for clean liquids?
The transducers transmit sound across the flow stream in order to measure sound velocity and therefore requires a fluid medium that does not significantly attenuate the ultrasonic signal as it travels through it. The transit time system will not function when there is high volume of solids or aeration. As a guideline, ONICON transit time flow meters are recommended for clean liquids with solids or bubbles content less than 2% by volume. Most applications such as water, chemicals and oils will meet this minimum requirement. When in doubt, an on-site test is recommended to determine if the application is suitable for transit time.

Can the transducers be submerged in water?
Yes, for short periods of time or by accident, but it is not recommended for continuous operation. The sensor is constructed to withstand submersion to 1m depth for 30 minutes without damage. Plastic seal jackets and BNC connectors on the sensor cables should be filled with coupling compound to provide additional moisture protection for the BNC connectors.

What is the purpose of the Signal Strength Display?
The primary function of the signal strength display is to assist as feedback when mounting transducers. Signal Strength can also be a useful diagnostics tool when troubleshooting problems with an installation. A signal strength less than 100% may indicate a problem with the installation or other issues such as a mis-programmed pipe size, pipe material, fluid type or temperature, or wrong transducer spacing. A signal strength less than 100% may also simply indicate a lot of aeration, or deteriorated pipe. Consideration should be made to use a 1 cross installation in such a case.

Does the FP-4400 require periodic recalibration?
FP-4400 calibration does not normally drift over time. ONICON offers a calibration service to verify instrument accuracy. Please use the contact information on the subsequent pages to set up a RMA.
ISO 9001 or similar quality management systems may require periodic and verifiable recalibration of flow meters. FP-4400 Flow Meters may be returned to ONICON Measurement for factory calibration and issue of a new NIST traceable certificate.

Can the internal batteries be replaced?
The built-in rechargeable LiPo battery pack is not user-serviceable. The meter should be returned to ONICON for battery service. Significant harm could occur to the user or property if the lithium battery is damaged, so do not attempt to operate the meter outside of our recommendations.

APPENDIX A - CONVERSION TABLE

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

Note: BARRELS are U.S. oil barrels.

APPENDIX B - SPEED OF SOUND IN PURE WATER TABLE (IMPERIAL UNITS)

Sonic Velocity Relative to Temperature of Pure Water								
Temp °F	Temp °C	Velocity ft/s	Temp °F	Temp °C	Velocity ft/s	Temp °F	Temp °C	Velocity ft/s
0.0	-17.8	4240	100.0	37.8	5003	200.0	93.3	5080
2.0	-16.7	4267	102.0	38.9	5010	202.0	94.4	5077
4.0	-15.6	4293	104.0	40.0	5016	204.0	95.6	5075
6.0	-14.4	4319	106.0	41.1	5022	206.0	96.7	5077
8.0	-13.3	4344	108.0	42.2	5028	208.0	97.8	5069
10.0	-12.2	4368	110.0	43.3	5033	210.0	98.9	5066
12.0	11.0	4392	112.0	44.4	5038	212.0	100.0	5063
14.0	10.0	4416	114.0	45.6	5043	214.0	101.1	5059
16.0	-8.9	4438	116.0	46.7	5048	216.0	102.2	5056
18.0	-7.8	4460	118.0	47.8	5052	218.0	103.3	5052
20.0	-6.7	4482	120.0	48.9	5057	220.0	104.4	5049
22.0	-5.6	4503	122.0	50.0	5061	222.0	105.6	5045
24.0	-4.4	4524	124.0	51.1	5065	224.0	106.7	5041
26.8	-3.3	4544	126.0	52.2	5068	226.0	107.8	5037
28.0	-2.2	4563	128.0	53.3	5072	228.0	108.9	5033
30.0	-1.1	4582	130.0	54.4	5075	230.0	110.0	5029
32.0	0.0	4601	132.0	55.6	5078	232.0	111.1	5024
34.0	1.1	4619	134.0	56.7	5081	234.0	112.2	5020
36.0	2.2	4637	136.0	57.8	5084	236.0	113.3	5015
38.0	3.3	4654	138.0	58.9	5086	238.0	114.4	5011
40.0	4.4	4671	140.0	60.0	5089	240.0	115.6	5006
42.0	5.6	4687	142.0	61.1	5091	242.0	116.7	5001
44.0	6.7	4703	144.0	62.2	5093	244.0	117.8	4996
46.0	7.8	4719	146.0	63.3	5094	246.0	118.9	4991
48.0	8.9	4734	148.0	64.4	5096	248.0	120.0	4986
50.0	10.0	4748	150.0	65.6	5097	250.0	121.1	4981
52.0	11.1	4763	152.0	66.7	5098	260.0	126.7	4944
54.0	12.2	4776	154.0	67.8	5099	270.0	132.2	4911
56.0	13.3	4790	156.0	68.9	5100	280.0	137.8	4879
58.0	14.4	4803	158.0	70.0	5101	290.0	143.3	4843
60.0	.15.56	4816	160.0	71.1	5102	300.0	148.9	4806
62.0	16.7	4828	162.0	72.2	5102	310.0	154.4	4767
64.0	17.9	4840	164.0	73.3	5102	320.0	160.0	4724
66.0	18.9	4852	166.0	74.4	5102	330.0	165.6	4678
68.0	20.0	4863	168.0	75.6	5102	340.0	171.1	4633
70.0	21.1	4874	170.0	76.7	5102	350.0	176.7	4587
72.0	22.2	4885	172.0	77.8	5101	360.0	182.2	4537
74.0	23.3	4895	174.0	78.9	5101	370.0	187.8	4488
76.0	24.4	4905	176.0	80.0	5100	380.0	193.3	4439
78.0	25.6	4915	178.0	81.1	5099	390.0	198.9	4386
80.0	26.7	4925	180.0	82.2	5098	400.0	204.4	4331
82.0	27.8	4934	182.0	83.3	5097	410.0	210.0	4272
84.0	28.9	4943	184.0	84.4	5096	420.0	215.6	4209
86.0	30.0	4951	186.0	85.6	5094	430.0	221.1	4147
88.0	31.1	4959	188.0	86.7	5093	440.0	226.7	4081
90.0	32.2	4967	190.0	87.8	5091	450.0	232.2	4003
92.0	33.3	4975	192.0	88.9	5089	460.0	237.8	3937
94.0	34.4	4983	194.0	90.0	5087	470.0	243.3	3871
96.0	35.6	4990	196.0	91.1	5085	480.0	248.9	3806
98.0	36.7	4997	198.0	92.2	5082	490.0	254.4	3740

APPENDIX C - SPEED OF SOUND IN PURE WATER TABLE (SI UNITS)

Sonic Velocity Relative to Temperature of Pure Water								
Temperature		Velocity	Temperature		Velocity	Temperature		Velocity
°F	°C	m/s	°F	°C	m/s	°F	°C	m/s
0.0	-17.8	1292.45	100.0	37.8	1525.03	200.0	93.3	1548.38
2.0	-16.67	1300.64	102.0	38.9	1526.99	202.0	94.4	1547.60
4.0	-15.55	1308.63	104.0	40.0	1528.86	204.0	95.6	1546.78
6.0	-14.44	1316.44	106.0	41.1	1530.67	206.0	96.7	1547.60
8.0	-13.33	1324.06	108.0	42.2	1532.4	208.0	97.8	1545.02
10.0	-12.22	1331.50	110.0	43.3	1534.06	210.0	98.9	1544.08
12.0	-11.00	1338.77	112.0	44.4	1535.64	212.0	100.0	1543.11
14.0	-10.0	1345.86	114.0	45.6	1537.16	214.0	101.1	1542.10
16.0	-8.89	1352.78	116.0	46.7	1538.61	216.0	102.2	1541.05
18.0	-7.78	1359.53	118.0	47.8	1539.99	218.0	103.3	1539.97
20.0	-6.67	1366.12	120.0	48.9	1541.30	220.0	104.4	1538.85
22.0	-5.56	1372.55	122.0	50.0	1542.55	222.0	105.6	1537.70
24.0	-4.44	1378.82	124.0	51.1	1543.74	224.0	106.7	1536.51
26.8	-3.33	1384.94	126.0	52.2	1544.86	226.0	107.8	1535.29
28.0	-2.22	1390.90	128.0	53.3	1545.91	228.0	108.9	1534.03
30.0	-1.11	1396.72	130.0	54.4	1546.91	230.0	110.0	1532.74
32.0	0.0	1402.39	132.0	55.6	1547.84	232.0	111.1	1531.42
34.0	1.11	1407.91	134.0	56.7	1548.72	234.0	112.2	1530.06
36.0	2.22	1413.30	136.0	57.8	1549.53	236.0	113.3	1528.67
38.0	3.33	1418.55	138.0	58.9	1550.29	238.0	114.4	1527.26
40.0	4.44	1423.66	140.0	60.0	1550.99	240.0	115.6	1525.81
42.0	5.56	1428.64	142.0	61.1	1551.63	242.0	116.7	1524.33
44.0	6.67	1433.48	144.0	62.2	1552.21	244.0	117.8	1522.83
46.0	7.78	1438.20	146.0	63.3	1552.74	246.0	118.9	1521.29
48.0	8.89	1442.80	148.0	64.4	1553.22	248.0	120.0	1519.73
50.0	10.0	1447.27	150.0	65.6	1553.64	250.0	121.1	1518.14
52.0	11.11	1451.62	152.0	66.7	1554.01	260.0	126.7	1507.00
54.0	12.22	1455.85	154.0	67.8	1554.32	270.0	132.2	1497.00
56.0	13.33	1459.97	156.0	68.9	1554.59	280.0	137.8	1487.00
58.0	14.44	1463.97	158.0	70.0	1554.80	290.0	143.3	1476.00
60.0	.15.56	1467.86	160.0	71.1	1554.98	300.0	148.9	1465.00
62.0	16.67	1471.64	162.0	72.2	1555.07	310.0	154.4	1453.00
64.0	17.89	1475.31	164.0	73.3	1555.13	320.0	160.0	1440.00
66.0	18.89	1478.88	166.0	74.4	1555.15	330.0	165.6	1426.00
68.0	20.0	1482.34	168.0	75.6	1555.11	340.0	171.1	1412.00
70.0	21.1	1485.70	170.0	76.7	1555.03	350.0	176.7	1398.00
72.0	22.2	1488.96	172.0	77.8	1554.90	360.0	182.2	1383.00
74.0	23.3	1492.13	174.0	78.9	1554.72	370.0	187.8	1368.00
76.0	24.4	1495.19	176.0	80.0	1554.49	380.0	193.3	1353.00
78.0	25.6	1498.16	178.0	81.1	1554.22	390.0	198.9	1337.00
80.0	26.7	1501.04	180.0	82.2	1553.91	400.0	204.4	1320.00
82.0	27.8	1503.82	182.0	83.3	1553.55	410.0	210.0	1302.00
84.0	28.9	1506.52	184.0	84.4	1553.14	420.0	215.6	1283.00
86.0	30.0	1509.13	186.0	85.6	1552.70	430.0	221.1	1264.00
88.0	31.1	1511.65	188.0	86.7	1552.21	440.0	226.7	1244.00
90.0	32.2	1514.08	190.0	87.8	1551.67	450.0	232.2	1220.00
92.0	33.3	1516.44	192.0	88.9	1551.10	460.0	237.8	1200.00
94.0	34.4	1518.70	194.0	90.0	1550.48	470.0	243.3	1180.00
96.0	35.6	1520.89	196.0	91.1	1549.82	480.0	248.9	1160.00
98.0	36.7	1523.00	198.0	92.2	1549.12	490.0	254.4	1140.00

APPENDIX D - SPEED OF SOUND IN GLYCOL WATER TABLE

GLYCOL TYPE	PERCENT GLYCOL	SPEED OF SOUND (ft/s)	SPEED OF SOUND (m/s)
PROPYLENE GLYCOL	10	5052	1540
PROPYLENE GLYCOL	15	5167	1575
PROPYLENE GLYCOL	20	5282	1610
PROPYLENE GLYCOL	25	5364	1635
PROPYLENE GLYCOL	28	5413	1650
PROPYLENE GLYCOL	30	5446	1660
PROPYLENE GLYCOL	31	5449	1661
PROPYLENE GLYCOL	32	5456	1663
PROPYLENE GLYCOL	33	5463	1665
PROPYLENE GLYCOL	34	5466	1666
PROPYLENE GLYCOL	35	5472	1668
PROPYLENE GLYCOL	36	5476	1669
PROPYLENE GLYCOL	37	5482	1671
PROPYLENE GLYCOL	38	5485	1672
PROPYLENE GLYCOL	39	5492	1674
PROPYLENE GLYCOL	40	5495	1675
PROPYLENE GLYCOL	50	5545	1690
ETHYLENE GLYCOL	10	5013	1528
ETHYLENE GLYCOL	15	5089	1551
ETHYLENE GLYCOL	20	5167	1575
ETHYLENE GLYCOL	23	5236	1596
ETHYLENE GLYCOL	25	5282	1610
ETHYLENE GLYCOL	30	5348	1630
ETHYLENE GLYCOL	31	5354	1632
ETHYLENE GLYCOL	32	5361	1634
ETHYLENE GLYCOL	33	5367	1636
ETHYLENE GLYCOL	34	5374	1638
ETHYLENE GLYCOL	35	5381	1640
ETHYLENE GLYCOL	36	5394	1644
ETHYLENE GLYCOL	37	5407	1648
ETHYLENE GLYCOL	38	5420	1652
ETHYLENE GLYCOL	39	5433	1656
ETHYLENE GLYCOL	40	5446	1660
ETHYLENE GLYCOL	50	5528	1685

APPENDIX E - PIPE CHARTS

IMPORTANT NOTE

Not all pipe types allowed in programming have charts below. Pipe dimensions will need to be acquired from pipe markings or the pipe manufacturer in such cases.

Carbon Steel / PVC / Aluminum - Pipe Dimensions

<- Thinner Wall <- | -> Thicker Wall ->

Pipe Size	Pipe O.D.	SCH 10		SCH 20		SCH 30		SCH Standard		SCH 40		SCH X-Strong		SCH 60	
		I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL
1/2	0.840							0.622	0.109	0.622	0.109	0.546	0.147		
3/4	1.050							0.824	0.113	0.824	0.113	0.742	0.154		
1	1.315							1.049	0.133	1.049	0.133	0.957	0.179		
1 1/4	1.660							1.380	0.140	1.380	0.140	1.278	0.191		
1 1/2	1.900							1.610	0.145	1.610	0.145	1.500	0.200		
2	2.375							2.067	0.154	2.067	0.154	1.939	0.218		
2 1/2	2.875							2.469	0.203	2.469	0.203	2.323	0.276		
3	3.500							3.068	0.216	3.068	0.216	2.900	0.300		
3 1/2	4.000							3.548	0.226	3.548	0.226	3.364	0.318		
4	4.500							4.026	0.237	4.026	0.237	3.826	0.337		
5	5.563							5.047	0.258	5.047	0.258	4.813	0.375		
6	6.625							6.065	0.280	6.065	0.280	5.761	0.432		
8	8.625			8.125	0.250	8.071	0.277	7.981	0.322	7.981	0.322	7.625	0.500	7.813	0.406
10	10.750			10.250	0.250	10.136	0.307	10.020	0.365	10.020	0.365	9.750	0.500	9.750	0.500
12	12.750			12.250	0.250	12.090	0.330	12.000	0.375	11.938	0.406	11.750	0.500	11.626	0.562
14	14.000	13.500	0.250	13.376	0.312	13.250	0.375	13.250	0.375	13.124	0.438	13.000	0.500	12.814	0.593
16	16.000	15.500	0.250	15.376	0.312	15.250	0.375	15.250	0.375	15.000	0.500	15.000	0.500	14.688	0.656
18	18.000	17.500	0.250	17.376	0.312	17.124	0.438	17.250	0.375	16.876	0.562	17.000	0.500	16.500	0.750
20	20.000	19.500	0.250	19.250	0.375	19.000	0.500	19.250	0.375	18.814	0.593	19.000	0.500	18.376	0.812
22	22.000	21.500	0.250	21.250	0.375	21.000	0.500	21.250	0.375			21.000	0.500	20.250	0.875
24	24.000	23.500	0.250	23.250	0.375	22.876	0.562	23.250	0.375	22.626	0.687	23.000	0.500	22.064	0.968
26	26.000	25.376	0.312	25.000	0.500			25.250	0.375			25.000	0.500		
28	28.000	27.376	0.312	27.000	0.500	26.750	0.625	27.250	0.375			27.000	0.500		
30	30.000	29.376	0.312	29.000	0.500	28.750	0.625	29.250	0.375			29.000	0.500		
32	32.000	31.376	0.312	31.000	0.500	30.750	0.625	31.250	0.375			31.000	0.500		
34	34.000	33.376	0.312	33.000	0.500	32.750	0.625	33.250	0.375			33.000	0.500		
36	36.000	35.376	0.312	35.000	0.500	34.750	0.625	35.250	0.375			35.000	0.500		
42	42.000			41.000	0.500	40.750	0.625	41.250	0.375			41.000	0.500		

<- Thinner Wall <- | -> Thicker Wall ->

Pipe Size	Pipe O.D.	SCH 80		SCH 100		SCH 120		SCH 140		SCH XX-Strong		SCH 160	
		I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL
1/2	0.840	0.546	0.147							0.252	0.294	0.466	0.187
3/4	1.050	0.742	0.154							0.434	0.308	0.614	0.218
1	1.315	0.957	0.179							0.599	0.358	0.815	0.250
1 1/4	1.660	1.278	0.191							0.896	0.382	1.160	0.250
1 1/2	1.900	1.500	0.200							1.100	0.400	1.338	0.281
2	2.375	1.939	0.218							1.503	0.436	1.689	0.343
2 1/2	2.875	2.323	0.276							1.771	0.552	2.125	0.375
3	3.500	2.900	0.300							2.300	0.600	2.624	0.438
3 1/2	4.000	3.364	0.318							2.728	0.636		
4	4.500	3.826	0.337			3.624	0.438			3.152	0.674	3.438	0.531
5	5.563	4.813	0.375			4.563	0.500			4.063	0.750	4.313	0.625
6	6.625	5.761	0.432			5.501	0.562			4.897	0.864	5.189	0.718
8	8.625	7.625	0.500	7.439	0.593	7.189	0.718	7.001	0.812	6.875	0.875	6.813	0.906
10	10.750	9.564	0.593	9.314	0.718	9.064	0.843	8.750	1.000	8.750	1.000	8.500	1.125
12	12.750	11.376	0.687	11.064	0.843	10.750	1.000	10.500	1.125	10.750	1.000	10.126	1.312
14	14.000	12.500	0.750	12.126	0.937	11.814	1.093	11.500	1.250			11.188	1.406
16	16.000	14.314	0.843	13.938	1.031	13.564	1.218	13.124	1.438			12.814	1.593
18	18.000	16.126	0.937	15.688	1.156	15.250	1.375	14.876	1.562			14.438	1.781
20	20.000	17.938	1.031	17.438	1.281	17.000	1.500	16.500	1.750			16.064	1.968
22	22.000	19.750	1.125	19.250	1.375	18.750	1.625	18.250	1.875			17.750	2.125
24	24.000	21.564	1.218	20.938	1.531	20.376	1.812	19.876	2.062			19.314	2.343

APPENDIX E - PIPE CHARTS (CONTINUED)

Stainless, Titianum, Hastelloy "C" - Pipe Dimensions									
<- Thinner Wall <- | -> Thicker Wall ->									
Pipe Size	O.D.	Schedule 5S		Schedule 10S		Schedule 40S		Schedule 80S	
		I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL
1/2	0.840	0.710	0.065	0.674	0.083	0.622	0.109	0.546	0.147
3/4	1.050	0.920	0.065	0.884	0.083	0.824	0.113	0.742	0.154
1	1.315	1.185	0.065	1.097	0.109	1.049	0.133	0.957	0.179
1 1/4	1.660	1.530	0.065	1.442	0.109	1.380	0.140	1.278	0.191
1 1/2	1.900	1.770	0.065	1.682	0.109	1.610	0.145	1.500	0.200
2	2.375	2.245	0.065	2.157	0.109	2.067	0.154	1.939	0.218
2 1/2	2.875	2.709	0.083	2.635	0.120	2.469	0.203	2.323	0.276
3	3.500	3.334	0.083	3.260	0.120	3.068	0.216	2.900	0.300
3 1/2	4.000	3.834	0.083	3.760	0.120	3.548	0.226	3.364	0.318
4	4.500	4.334	0.083	4.260	0.120	4.026	0.237	3.826	0.337
5	5.563	5.345	0.109	5.295	0.134	5.047	0.258	4.813	0.375
6	6.625	6.407	0.109	6.357	0.134	6.065	0.280	5.761	0.432
8	8.625	8.407	0.109	8.329	0.148	7.981	0.322	7.625	0.500
10	10.750	10.482	0.134	10.420	0.165	10.020	0.365	9.750	0.500
12	12.750	12.438	0.156	12.390	0.180	12.000	0.375	11.750	0.500
14	14.000	13.688	0.156	13.624	0.188				
16	16.000	15.670	0.165	15.624	0.188				
18	18.000	17.670	0.165	17.624	0.188				
20	20.000	19.624	0.188	19.564	0.218				
22	22.000	21.624	0.188	21.564	0.218				
24	24.000	23.564	0.218	23.500	0.250				
30	30.000	29.500	0.250	29.376	0.312				

Ductile Iron Pipe - Standard Classes																	
<- Thinner Wall <- | -> Thicker Wall ->																	
Pipe Size	O.D.	Class 50		Class 51		Class 52		Class 53		Class 54		Class 55		Class 56		CEMENT LINING	
		WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.	**STD THICKNESS	**DOUBLE THICKNESS
3	3.96			0.25	3.46	0.28	3.40	0.31	3.34	0.34	3.28	0.37	3.22	0.41	3.14		
4	4.80			0.26	4.28	0.29	4.22	0.32	4.16	0.35	4.10	0.38	4.04	0.41	3.98		
6	6.90	0.25	6.40	0.28	6.34	0.31	6.28	0.34	6.22	0.37	6.16	0.40	6.10	0.43	6.04	0.125	0.250
8	9.05	0.27	8.51	0.30	8.45	0.33	8.39	0.36	8.33	0.39	8.27	0.42	8.21	0.45	8.15		
10	11.10	0.29	10.52	0.32	10.46	0.35	10.40	0.38	10.34	0.41	10.28	0.44	10.22	0.47	10.16		
12	13.20	0.31	12.58	0.34	12.52	0.37	12.46	0.40	12.40	0.43	12.34	0.46	12.28	0.49	12.22		
14	15.30	0.33	14.64	0.36	14.58	0.39	14.52	0.42	14.46	0.45	14.40	0.48	14.34	0.51	14.28		
16	17.40	0.34	16.72	0.37	16.66	0.40	16.60	0.43	16.54	0.46	16.48	0.49	16.42	0.52	16.36		
18	19.50	0.35	18.80	0.38	18.74	0.41	18.68	0.44	18.62	0.47	18.56	0.50	18.50	0.53	18.44	0.188	0.375
20	21.60	0.36	20.88	0.39	20.82	0.42	20.76	0.45	20.70	0.48	20.64	0.51	20.58	0.54	20.52		
24	25.80	0.38	25.04	0.41	24.98	0.44	24.92	0.47	24.86	0.50	24.80	0.53	24.74	0.56	24.68		
30	32.00	0.39	31.22	0.43	31.14	0.47	31.06	0.51	30.98	0.55	30.90	0.59	30.82	0.63	30.74		
36	38.30	0.43	37.44	0.48	37.34	0.53	37.24	0.58	37.14	0.63	37.04	0.68	36.94	0.73	36.84		
42	44.50	0.47	43.56	0.53	43.44	0.59	43.32	0.65	43.20	0.71	43.08	0.77	42.96	0.83	42.84	0.250	0.500
48	50.80	0.51	49.78	0.58	49.64	0.65	49.50	0.72	49.36	0.79	49.22	0.86	49.08	0.93	48.94		
54	57.10	0.57	55.96	0.65	55.80	0.73	55.64	0.81	55.48	0.89	55.32	0.97	55.16	1.05	55.00		

** Reduce pipe ID by amount shown in this column

APPENDIX E - PIPE CHARTS (CONTINUED)

Cast Iron Pipe Dimensions - ASA Standard

<- Thinner Wall <- | -> Thicker Wall ->

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

Cast Iron Pipe - AWWA Standard

<- Thinner Wall <- | -> Thicker Wall ->

Pipe Size	Class A 100 ft / 43 PSIG			Class B 200 ft / 86 PSIG			Class C 300 ft / 130 PSIG			Class D 400ft / 173 PSIG		
	O.D.	I.D.	WALL	O.D.	I.D.	WALL	O.D.	I.D.	WALL	O.D.	I.D.	WALL
3	3.80	3.02	0.39	3.96	3.12	0.42	3.96	3.06	0.45	3.96	3.00	0.48
4	4.80	3.96	0.42	5.00	4.10	0.45	5.00	4.04	0.48	5.00	3.96	0.52
6	6.90	6.02	0.44	7.10	6.14	0.48	7.10	6.08	0.51	7.10	6.00	0.55
8	9.05	8.13	0.46	9.05	8.03	0.51	9.30	8.18	0.56	9.30	8.10	0.60
10	11.10	10.10	0.50	11.10	9.96	0.57	11.40	10.16	0.62	11.40	10.04	0.68
12	13.20	12.12	0.54	13.20	11.96	0.62	13.50	12.14	0.68	13.50	12.00	0.75
14	15.30	14.16	0.57	15.30	13.98	0.66	15.65	14.17	0.74	15.65	14.01	0.82
16	17.40	16.20	0.60	17.40	16.00	0.70	17.80	16.20	0.80	17.80	16.02	0.89
18	19.50	18.22	0.64	19.50	18.00	0.75	19.92	18.18	0.87	19.92	18.00	0.96
20	21.60	20.26	0.67	24.60	20.00	2.30	22.06	20.22	0.92	22.06	20.00	1.03
24	25.80	24.28	0.76	25.80	24.02	0.89	26.32	24.22	1.05	26.32	24.00	1.16
30	31.74	29.98	0.88	32.00	29.94	1.03	32.40	30.00	1.20	32.74	30.00	1.37
36	37.96	35.98	0.99	38.30	36.00	1.15	38.70	35.98	1.36	39.16	36.00	1.58
42	44.20	42.00	1.10	44.50	41.94	1.28	45.10	42.02	1.54	45.58	42.02	1.78
48	50.50	47.98	1.26	50.80	47.96	1.42	51.40	47.98	1.71	51.98	48.06	1.96
54	56.66	53.96	1.35	57.10	54.00	1.55	57.80	54.00	1.90	58.40	53.94	2.23
60	62.80	60.02	1.39	63.40	60.06	1.67	64.20	60.20	2.00	64.82	60.06	2.38
72	75.34	72.10	1.62	76.00	72.10	1.95	76.88	72.10	2.39			
84	87.54	84.10	1.72	88.54	84.10	2.22						

<- Thinner Wall <- | -> Thicker Wall ->

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

APPENDIX E - PIPE CHARTS (CONTINUED)

Copper & Brass - Tube & Pipe												
<- Thinner Wall <- | -> Thicker Wall ->												
Pipe Size	Copper Type M			Copper Type L			Copper Type K			Brass Pipe - ASTM B43		
	O.D.	I.D.	WALL	O.D.	I.D.	WALL	O.D.	I.D.	WALL	O.D.	I.D.	WALL
1/2	0.625	0.569	0.028	0.625	0.545	0.040	0.625	0.527	0.049	0.840	0.626	0.107
5/8	0.750	0.690	0.030	0.750	0.666	0.042	0.750	0.652	0.049			
3/4	0.875	0.811	0.032	0.875	0.785	0.045	0.875	0.745	0.065	1.050	0.822	0.114
1	1.125	1.055	0.035	1.125	1.025	0.050	1.125	0.995	0.065	1.315	1.063	0.126
1 1/4	1.375	1.291	0.042	1.375	1.265	0.055	1.375	1.245	0.065	1.660	1.368	0.146
1 1/2	1.625	1.527	0.049	1.625	1.505	0.060	1.625	1.481	0.072	1.900	1.600	0.150
2	2.125	2.009	0.058	2.125	1.985	0.070	2.125	1.959	0.083	2.375	2.063	0.156
2 1/2	2.625	2.495	0.065	2.625	2.465	0.080	2.625	2.435	0.095	2.875	2.501	0.187
3	3.125	2.981	0.072	3.125	2.945	0.090	3.125	2.907	0.109	3.500	3.062	0.219
3 1/2	3.625	3.459	0.083	3.625	3.425	0.100	3.625	3.385	0.120	4.000	3.500	0.250
4	4.125	3.935	0.095	4.125	3.905	0.110	4.125	3.857	0.134	4.500	4.000	0.250
5	5.125	4.907	0.109	5.125	4.875	0.125	5.125	4.805	0.160	5.563	5.063	0.250
6	6.125	5.881	0.122	6.125	5.845	0.140	6.125	5.741	0.192	6.625	6.125	0.250
8	8.125	7.785	0.170	8.125	7.725	0.200	8.125	7.583	0.271	8.625	8.000	0.313
10	10.125	9.701	0.212	10.125	9.625	0.250	10.125	9.449	0.338	10.750	10.020	0.365
12	12.125	11.617	0.254	12.125	11.565	0.280	12.125	11.315	0.405	12.750	12.000	0.375