F-4300 with MODBUS TCP/IP
Clamp-on Ultrasonic Flow Meter
Installation & Operation Guide

SAFETY INFORMATION

This meter was calibrated at the factory before shipment. To ensure correct use of the meter, 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's written permission.
- ONICON 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.
- ONICON 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 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 symbols 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.

TABLE OF CONTENTS

APPENDIX

SECTION 1.0: INTRODUCTION

1.1 PURPOSE OF THIS GUIDE

The purpose of this guide is to provide installation and commissioning procedures and basic operating and servicing instructions for the ONICON F-4300 Clamp-on Ultrasonic Flow Meter.

1.2 PRINCIPLE OF OPERATION

The ONICON F-4300 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 travelling between two transducers, the flow velocity and direction are accurately determined.

1.3 TYPICAL F-4300 FLOW METER

The F-4300 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 a polycarbonate wall-mounted enclosure with a built-in user interface/display.

TYPICAL INSTALLATION

Horizontal pipes: Install transducers
   at 2 or 10 o'clock position

Vertical Pipes: Install transducers at
   any position

Triaxial
Transducer
Cables

Conduit-ready
Fittings

Mounting Hardware
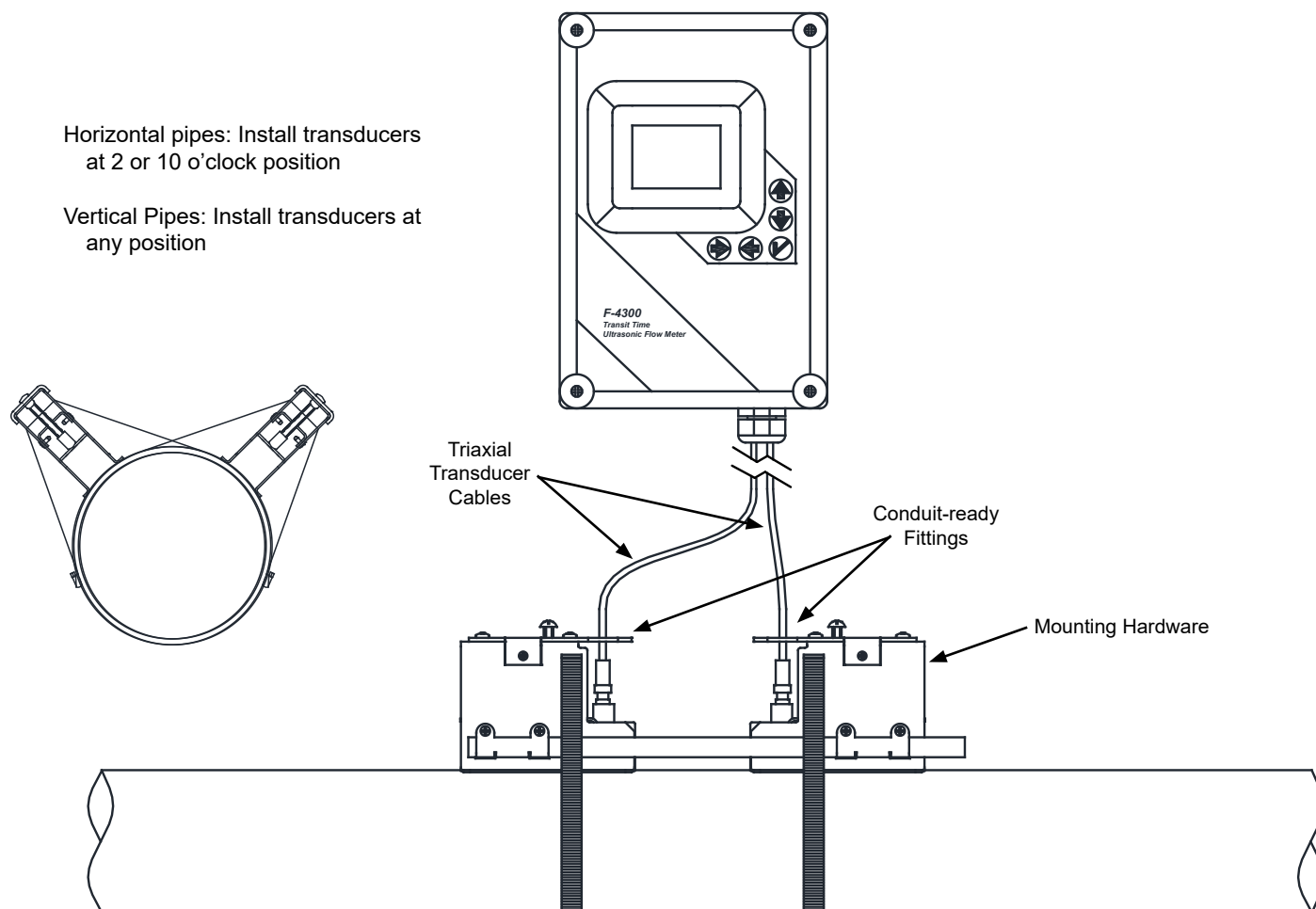
1.4 STANDARD FEATURES AND SPECIFICATIONS

- Wall-mounted NEMA 4X polycarbonate enclosure with backlit alphanumeric user interface/display
- One internally powered electrically isolated 4-20 mA analog output for flow rate or flow velocity.
- Two scalable electrically isolated dry contact pulse output for totalizing flow, indicating flow direction or flow alarm.

GENERAL SPECIFICATIONS

ACCURACY
± 1.0% of reading from 1 to 20 ft/sec
± 0.01 ft/s for velocities below 1 ft/sec

OVERALL FLOW RANGE
0.1 to 20 ft/sec

SENSING METHOD
Clamp-on ultrasonic, differential transit time method in direct or reflect mode

PIPE SIZE RANGE
2" through 24" nominal diameter

PROGRAMMING
Factory programmed for specific application

MEMORY
Non-volatile memory retains all program parameters and totalized values in the event of power loss.

DISPLAY
White, backlit alphanumeric display shows:
5-digit flow rate with floating decimal, 14-digit totalizer, pulse output status, operating status, and provides field configuration.
Displays total flow, flow rate, flow velocity, signal strength, flow direction, alarm conditions, relay status & logger status
Rate display range: 0 - 9,999,999
Totalizer display range: 0 – 99,999,999
Totalizers will roll over to zero when maximum count is exceeded.

OUTPUT SIGNALS PROVIDED
Analog output: Isolated 4-20 mA/0-5 VDC
(Internally powered, 1000Ω max impedance field selectable)
Two Programmable pulse outputs:
Optically isolated dry contacts
Contact rating: 30 VDC, 10 mA maximum
Pulse duration: 50 ms
Programmable for scaled pulse, flow direction, or flow alarm
Serial communications: MODBUS® TCP/IP

FLUID TEMPERATURE RANGE
Standard: -40° F to 250° F

AMBIENT OPERATING TEMPERATURE RANGE
-5° F to 140° F

MECHANICAL

MATERIALS OF CONSTRUCTION
Electronics enclosure: Wall-mount, polycarbonate with clear, shatter proof enclosure
Transducer mounting hardware: Anodized aluminum and stainless steel
Transducers: Stainless Steel and plastic

ENCLOSURE RATINGS
Wall mount, NEMA 4X polycarbonate with clear, shatter-proof enclosure

ELECTRICAL

This equipment is intended for INSTALLATION CATEGORY (OVERVOLTAGE CATEGORY) II applications. Installations must comply with all local, state and federal building codes.

INPUT POWER – Factory selectable
24 VDC ONLY!! 10 Watts maximum
(Fuse not field replaceable)

ELECTRICAL CONNECTIONS
Enclosed terminal connections, cable access through three standard ½" conduit openings & one standard ¾" conduit opening
Transducer signals: (2) BNC-connectors
Input power: 2 terminal removable connector (12 – 28 AWG)
Signal inputs/outputs: Removable connectors, 2 or 3 terminal (12 – 28 AWG)

WIRING
Transducer signals: Only use ONICON provided triaxial cable.
24 VDC input power: Use cable with a wire gauge suitable for the length of run and required maximum current carrying capacity.
Signal inputs/outputs: Use shielded cable with a wire gauge suitable for the length of run and required maximum current carrying capacity.

1.5 MAINTENANCE

Periodically inspect the power cables, transducer cables, cable glands and the enclosure for signs of damage. Inspect transducer installation and mounting hardware for loose connections, or diminished ultrasonic couplant.

1.6 ADDITIONAL HARDWARE THAT MAY BE REQUIRED

Flex conduit may be required to connect transducer mounting bracket to rigid conduit. Do not connect transducers mounting brackets to rigid conduit.

1.7 WORKING ENVIRONMENT

The F-4300 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 installing the electronics enclosure in direct sunlight.
- Avoid installation locations where the transducers will be exposed to vibrations in the piping system.
- Always run transducer cables in dedicated conduit separate from signal and power cables.
- Do not run signal cables for the meter in conduit with mains (AC) power cables.

1.8 SERIAL NUMBER

Serial Number

The serial number of your F-4300 is located outside and inside the enclosure. Transducers will be packaged inside the enclosure they 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 F-4300 is generally shipped in one package. Notify the freight carrier (all products are shipped insured) and ONICON if any items are damaged in transit.

2.1   CHECKING THAT YOU HAVE RECEIVED EVERYTHING

- **Standard Documentation**

  Enclosed with each F-4300 is a comprehensive documentation package that includes the following items:
  - This F-4300 Ultrasonic Flow Meter Installation and Operation Guide
  - The Flow Meter Certificate of Calibration
  - Site Installation Details Document

Please notify ONICON if any of these items are missing.

> **IMPORTANT NOTE**
>
> The ONICON F-4300 Ultrasonic Flow Meter is a custom calibrated system. Unless specifically noted in writing by ONICON, ALL COMPONENTS (electronics enclosure and ultrasonic transducers) share associated serial numbers, and must be installed together as a system. Mixing components from different systems will result in significant errors in measurement.

- **The Wall Mount Enclosure**

  Remove the F-4300 enclosure from the shipping carton and inspect it inside and out for physical damage. Please notify ONICON immediately if you discover any damage.

  Transducers are shipped inside the enclosure. Inspect the transducers for signs of damage. Each transducer will have a label attached with a serial number associated with it that can be found on the F-4300 enclosure.

- **Transducers Cables**

  Transducer cables are coiled and included inside the shipping carton. One end of each cable is already terminated with a BNC connector for connection to the transducers. The other end is pre-terminated for connection to the electronics. An easily removable strain-relief fitting is also included.

- **Installation Hardware**

  Installation hardware includes mounting brackets and a spacer bar. Also included with this hardware will be a mounting strap kit. This kit includes the mounting straps used to secure the hardware onto the pipe. The shipping carton will also include a copy of the F-4300 Site Installation Details for this meter. This document provides specific details such as transducer spacing distance. This information is unique to the specific installation site and is identified by the meter location tag name and the serial number of the meter. Included with the installation hardware is one tube of coupling compound.

SECTION 3.0: INSTALLATION

3.1   OVERVIEW

Each F-4300 Ultrasonic Flow Meter is provided with a pair of matched ultrasonic transducers. The transducers are mounted (clamped) on to the outside wall of the pipe. Triaxial cables convey the transducer signals to the wall mount enclosure containing the signal processing circuitry and the user interface display. Ultrasonic transducers can be configured to operate in either 1 (Direct), 2 (Reflect) or 4 (Double Reflect) cross operating modes. The choice of operating mode is dictated by the configuration settings programmed into the meter. For new installations, configuration data is programmed into the meter prior to shipment. Programming data determines the transducer operating mode and the spacing between the transducers. This information is provided with the installation hardware in a document titled, "F-4300 Site Installation Details".
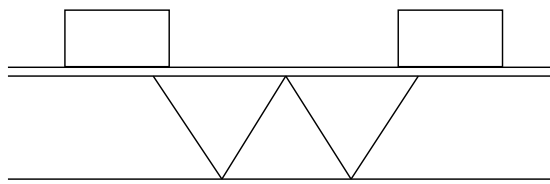
1 Cross Z or (Direct)
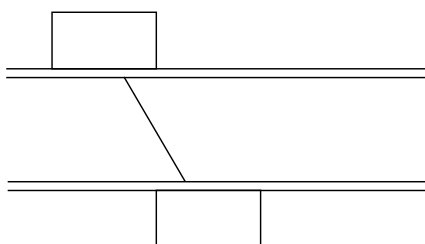
2 Cross V or (Reflect)
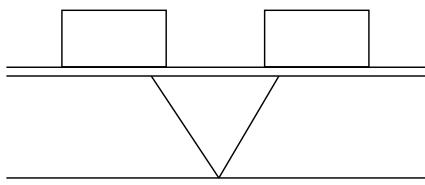
4 Cross W or (Double Reflect)

1 Cross Mode (Direct)

1 cross mount provides a shorter sonic beam path. This usually improves performance with sonically attentive liquids or pipe materials. Direct mounting only requires half the distance between electrodes when compared to the reflect mode and may be the only option if the availability of mounting space is limited.

2 or 4 Cross Mode (Reflect, Double Reflect)

2 or 4 cross mount 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.

Careful attention to the site selection for the system components will help the installers with the initial installation, reduce start-up problems and make future maintenance easier. When selecting a site for mounting the system components, consider the criteria under Section 1.7 WORKING ENVIRONMENT, as well as the following:

The Wall-Mount Enclosure

Find an easily accessible location where wire connections can be made and meter readings can be taken from floor level. Mount the enclosure on a vibration-free surface. Avoid sites such as the plenum of a fan coil, heat exchanger, or other housings containing motors. Avoid mounting the enclosure in close proximity to VFD's, electric motors or other strong sources of electrical interference.

IMPORTANT NOTE

The maximum allowable distance between the wall-mount enclosure and the transducers installed on the pipe is 100 feet. Only ONICON furnished cable may be used between wall-mount enclosure and the transducers.
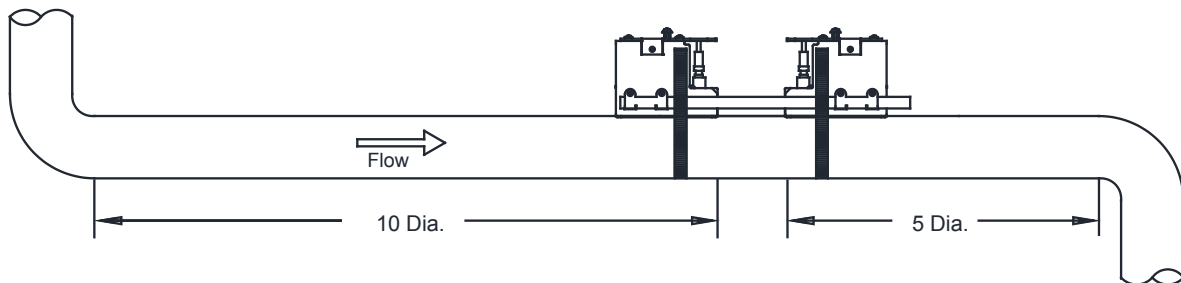
The Transducers

For best results, the transducers must 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.

> (i)
>
> **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 or two elbows in close proximity and out of plane, etc.

Flow

10 Dia.   5 Dia.

- 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 10:00 or 2:00 position for 4 or 2 cross mode (Reflect), 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 recommended only 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.
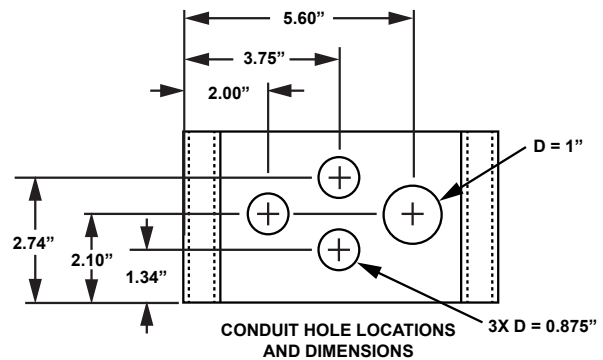
> **IMPORTANT NOTE**
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> i
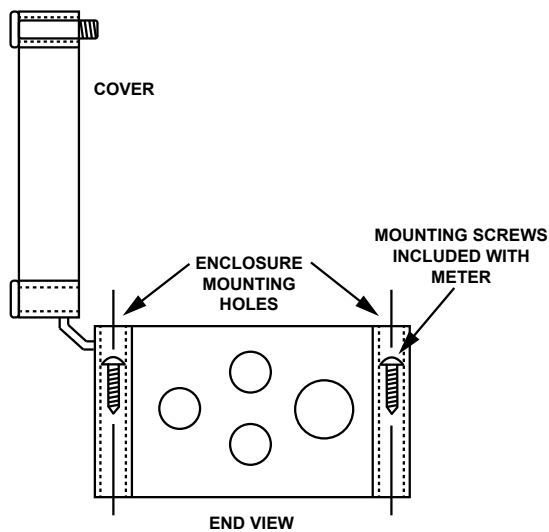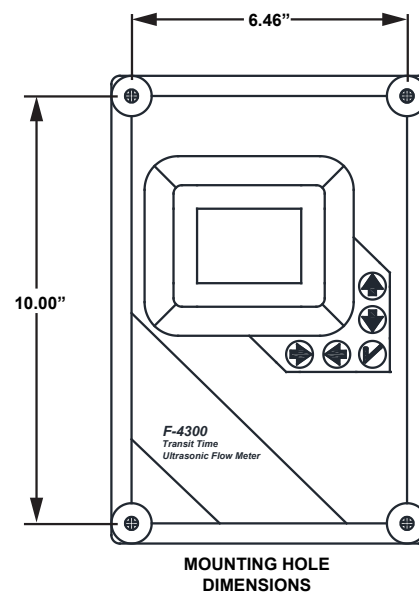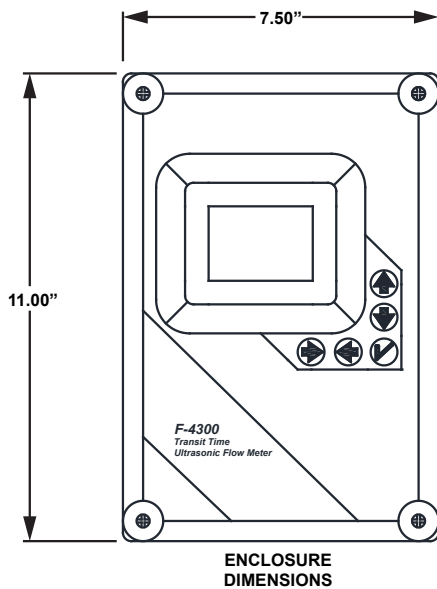>
> This ONICON F-4300 Ultrasonic Flow Meter is a custom calibrated system. Unless specifically noted in writing by ONICON, ALL COMPONENTS (electronics enclosure and matched transducers) share associated serial number and must be installed together as a system. Mixing components from different systems will result in significant errors in calibration.

> **CAUTION**
>
> ⚠
>
> Do not drill additional holes in this enclosure. Doing so may damage the electronic circuitry contained within and will void all warranties.

ENCLOSURE DIMENSIONS

7.50"
11.00"

F-4300
Transit Time
Ultrasonic Flow Meter

MOUNTING HOLE DIMENSIONS

6.46"
10.00"

F-4300
Transit Time
Ultrasonic Flow Meter

COVER

ENCLOSURE MOUNTING HOLES

MOUNTING SCREWS INCLUDED WITH METER

END VIEW

5.60"
3.75"
2.00"
2.74"
2.10"
1.34"
D = 1"
3X D = 0.875"

CONDUIT HOLE LOCATIONS AND DIMENSIONS

3.3.1   Preparing the Pipe

Once a suitable section of straight pipe has been located, the pipe surface must be prepared. Refer to the Site Installation Details document provided with the installation hardware to determine the transducer spacing dimensions. Prepare the pipe surface as shown below. Clean and de-grease two rectangles where the transducers will be located. Use sand-paper as necessary to remove any grit, corrosion, rust, loose paint or other contaminants. The cleaned surface should extend at least ½" beyond the length and width of the transducers.
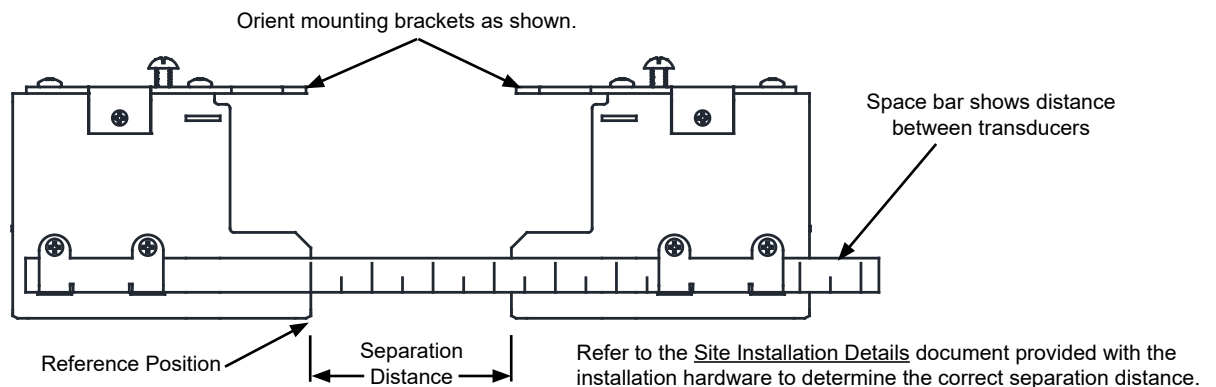
Always install hardware at the 10:00 or 2:00 position on horizontal pipes. This prevents the flow meter from being affect by air trapped at the top of the pipe.

Refer to site installation details document for transducer spacing.

Prepare mounting locations for transducers.

For horizontal pipes, locate transducers at the 10:00 or 2:00 position.
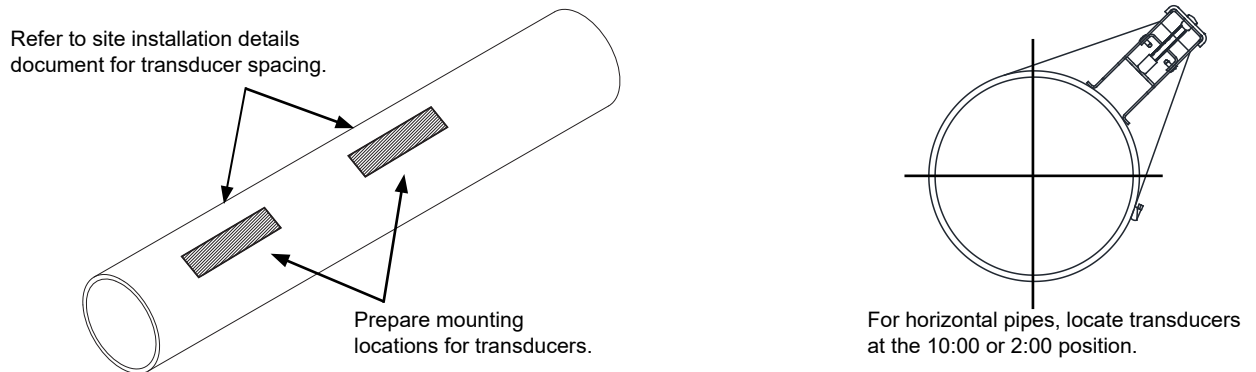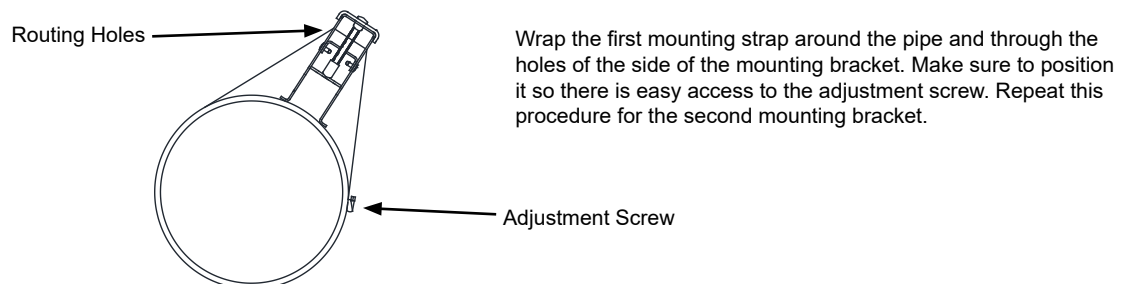
3.3.2   2 or 4 Cross Mode (Reflect) Mounting Using Frames and Spacer Bar

1. Prepare the pipe surface as described in section 3.3.2.
2. On a flat surface, assemble the hardware as shown in the drawing below.

Orient mounting brackets as shown.

Space bar shows distance between transducers

Reference Position

Separation Distance

Refer to the Site Installation Details document provided with the installation hardware to determine the correct separation distance.

3. Install the mounting straps as shown below. For larger pipes, use multiple straps connected end-to-end to increase the length of each strap. Leave enough slack in the straps to allow the assembly to be correctly positioned on the pipe. The location of the routing hole allows for the straps to mount outside of the pipe insulation, if the pipe is insulated.

Routing Holes

Wrap the first mounting strap around the pipe and through the holes of the side of the mounting bracket. Make sure to position it so there is easy access to the adjustment screw. Repeat this procedure for the second mounting bracket.

Adjustment Screw

4. Move the hardware assembly to its final position on the pipe. Align the brackets with the prepared surface for each transducer, ensuring that the entire assembly is properly oriented along the axis of the pipe. Tighten the assembly firmly on the pipe. Do not over tighten the straps.

3.3.3　1 Cross Mode (Direct) Mounting Using Brackets and Spacer Bar

1. Once the installation site selection process described in section 3.2 is complete, prepare the pipe where the first sensor will be mounted.

IMPORTANT NOTE

1 Cross mode mounting requires that transducers be installed on opposite sides of the pipe. For horizontal pipes, the transducers should be located at the 3 o'clock and 9 o'clock positions.
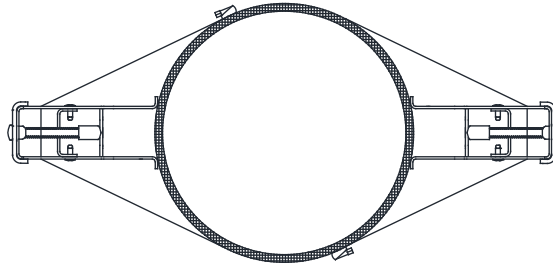
2. To prepare the pipe, temporarily position a mounting bracket on the pipe where you will be mounting it. Ensure that the pipe surface is smooth without any raised areas (seams, etc.) With a pencil, marker or chalk, draw a generous rectangle around the bracket. Clean and de-grease the area within the rectangle. Use the small sanding block provided with the installation hardware as necessary to remove any grit, corrosion, rust, loose paint or other contaminants. Be sure to wipe the surface clean after sanding. The cleaned surface should extend at least ½" beyond the length and width of the mounting bracket.

3. Attach the spacer bar to one of the mounting brackets at the reference mark on the ruler.

4. Position the mounting bracket and spacer bar in the center of the cleaned area and secure it in place with a mounting strap as shown below. Make sure the mounting strap tightening screw is facing up. While tightening the strap, check to ensure that the bracket remains centered on the pipe. (The bracket is centered on the pipe when the bottom edges of both stainless side plates on the bracket are in full contact with the pipe surface.)

5. Attach the second bracket to the spacer bar at the separation distance specified on the site installation details document provided with the installation hardware.

Orient mounting brackets as shown.

Reference Hole

Separation Distance

Refer to the Site Installation Details document provided with the installation hardware to determine the correct hole location.
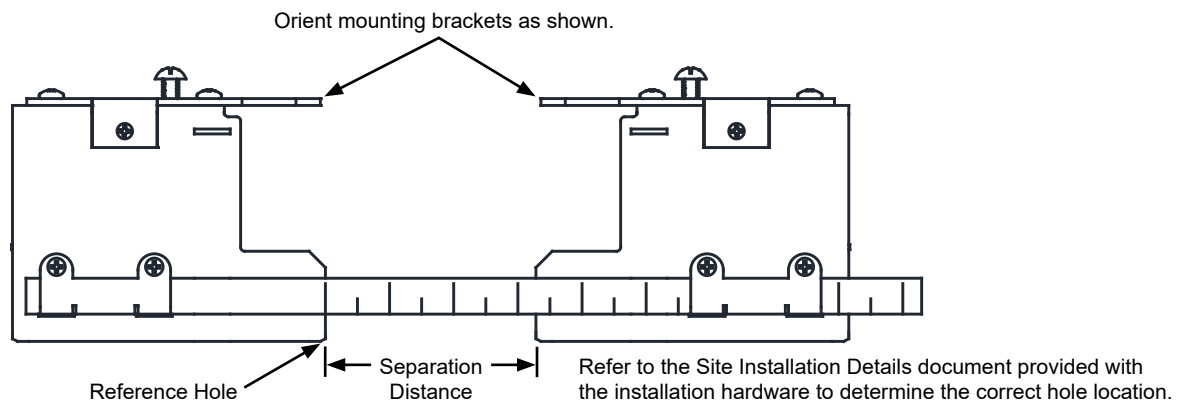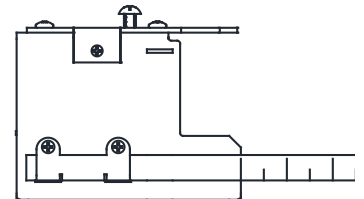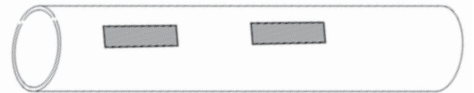
6. Check to ensure that this bracket is lined up on the center of the pipe. While holding the bracket centered on the pipe, place a mark (with pencil or chalk) at the center of the bottom of the bracket as shown below. Next, mark along the edge of the bracket as indicated in the drawing below.

Place mark at center of bracket roller.

Draw line along edge of bracket.
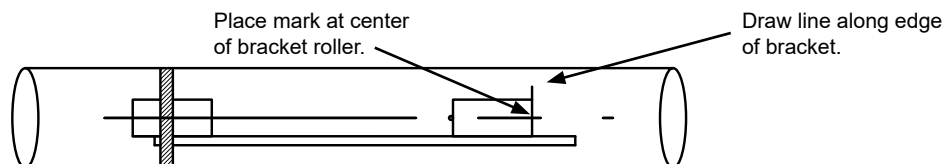
7. Remove the bracket from the spacer bar and then remove the spacer bar from the remaining bracket that is strapped to the pipe. Using the spacer bar as a straight edge, draw a line down the center of the pipe intersecting the mark made at the center of the tapered roller and the line drawn against the edge of the bracket as shown below.

Spacer bar

Draw line using spacer bar as edge.
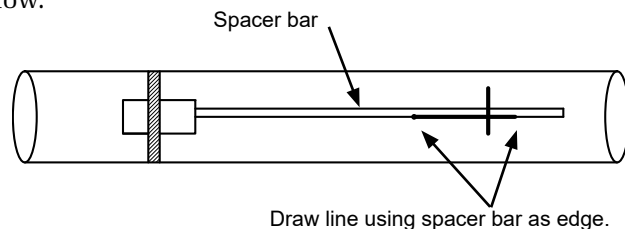
8. Wrap a spacing guide (could be a wire, hose clamp) around the pipe so that the left edge is against the transducer edge mark. Arrange so that one end overlaps the other. Ensure that it is snug around the pipe and mark along the overlapping edge.

Draw the guide tightly around the pipe and mark at the overlapping edge.
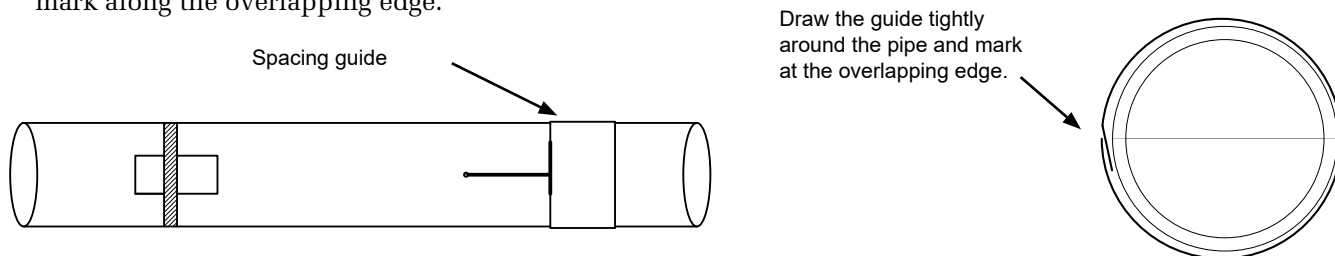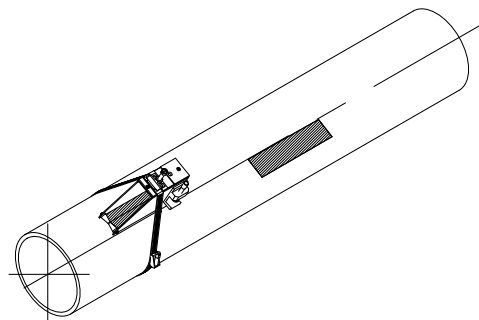
Spacing guide

9. Remove the spacing guide and lay it out on a flat surface. Either measure the exact distance half-way between the overlap edge and the mark at the overlap, or fold the guide from the overlap edge to overlap mark and draw a line at the fold or halfway point.

←——— 50% ———→ ←——— 50% ———→   Overlap edge mark
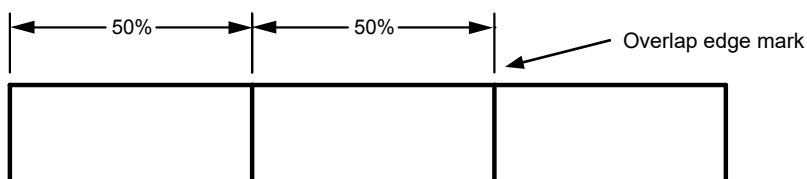
10. Reinstall the spacing guide; its edge abutting the bracket edge mark on the pipe and the overlapping edge in line with the line drawn down the center of the pipe. Tape it in this position on the pipe. Take the second bracket and place it against the edge of the guide with it centered on the half way mark drawn on the guide.

11. Ensure that the bracket is sitting on a smooth area without any raised spots (seams, etc.). Mark a generous rectangle around the bracket with a pencil, marker or chalk. Remove the bracket and the spacing guide.

12. Clean and de-grease the area within the rectangle. Use the small sanding block provided with the installation hardware as necessary to remove any grit, corrosion, rust, loose paint or other contaminants. The cleaned surface should extend at least ½" beyond the length and width of the mounting bracket.

13. Replace the spacing guide back in the same position it was in and re-tape it to the pipe.

14. Position the bracket as before against the edge of the guide with the center of the bracket centered on the half way mark drawn on the guide. Secure it in place with a mounting strap. Make sure the mounting strap tightening screw is facing toward the bracket so you can hold it in place while tightening the screw. While tightening the strap, check to ensure that the bracket remains centered on the pipe. (The bracket is centered on the pipe when the bottom edges of both stainless steel side plates on the bracket are in full contact with the pipe surface.)

3.3.4 Installing Transducers In Bracket and Spacer Bar Hardware

1. Apply the coupling to the transducer as show below. A packet of acoustic coupling compound was supplied with the transducers. Contact ONICON if you need more compound.
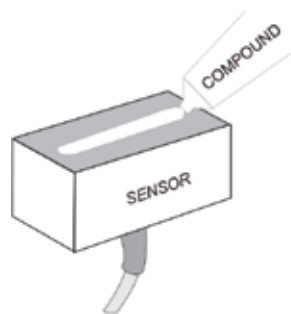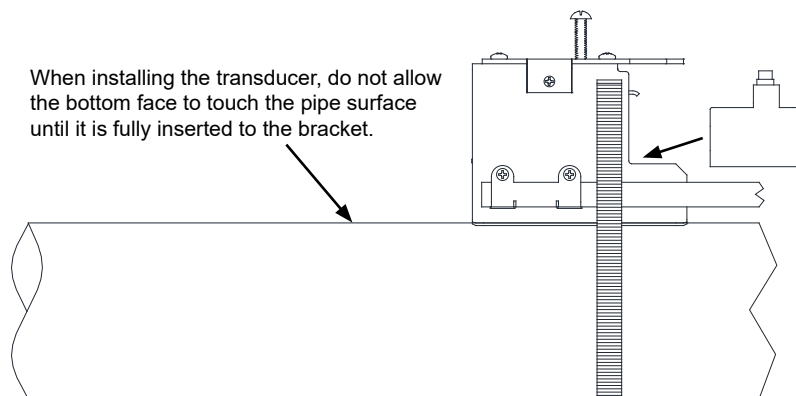
Apply a continuous lengthwise ¼" wide bead of coupling compound down the center of the transducer.
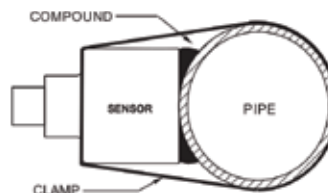
2. Slide the transducer into the mounting bracket. Do not allow the bottom of the transducer to make contact with the pipe until it butts against the mounting bracket. The clamping bracket can be retracted such that the transducer can be directly over the correct position before making contact with the pipe. Push down firmly on the transducer to mate with pipe.

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

3. Tighten the transducer clamping screw to hold the transducer firmly in place. Do not over tighten the screw. If you are not routing flexible conduit all the way to the mounting bracket, you can remove the conduit adapters to make installation easier.

Conduit Adapter

Transducer Clamping Screw
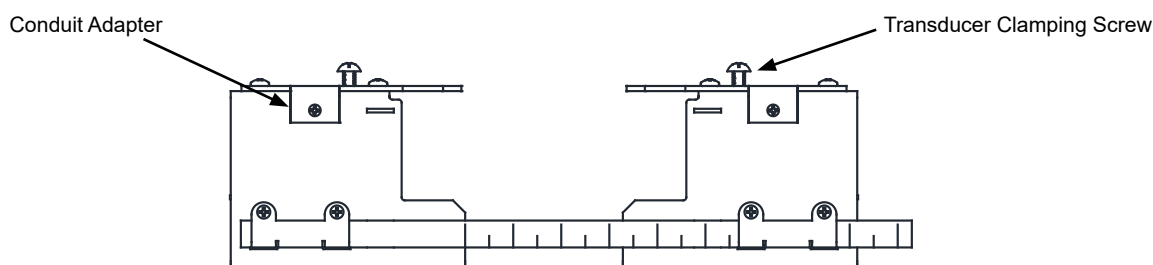
4. Connect transducer cable female BNC to transducer male BNC. Slide the protective rubber boot over the transducer's BNC connector. In environments where condensation may occur (chilled water systems), apply a generous amount of acoustic coupling compound dielectric grease inside the boot before sliding it over the BNC connector.

5. Repeat procedure for the second transducer.

Sensor Mounting / Coupling Recommendations

BAD	GOOD

Air at the top of the pipe well disrupt the signal

Solids at the bottom of the pipe will disrupt the signal

Too little grease

Transducer face should be perpendicular to pipe surface.

Ensure transducers are parallel with pipe axis and flush to the pipe surface
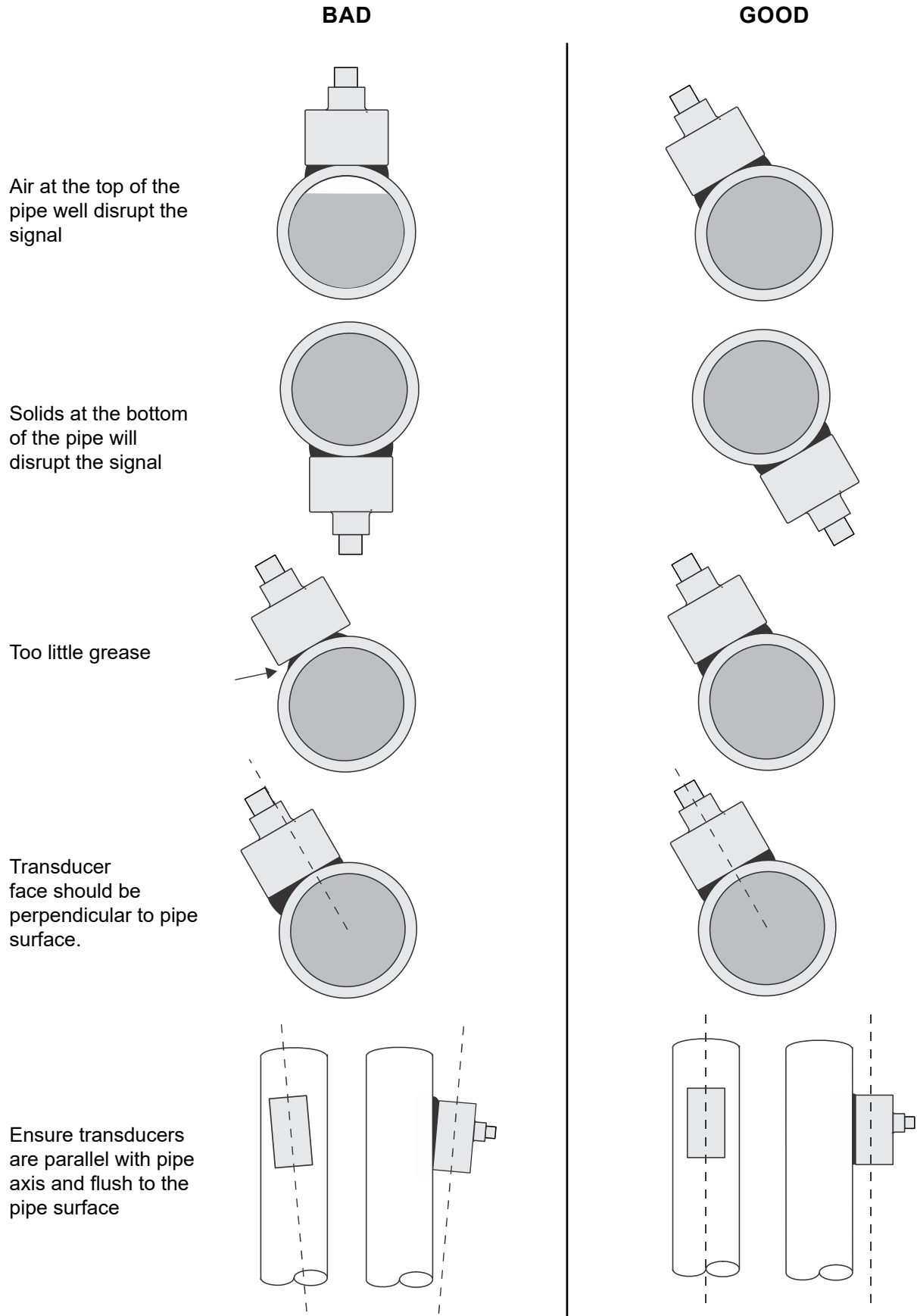
3.4 CONNECTING THE TRANSDUCER SIGNAL CABLES

ONICON F-4300 transducer cables are special purpose triaxial cables. Care must be taken when installing the cables to ensure that electrical noise will not affect the performance of the meter. The cables must NOT be bundled or run in conduit with any other signal or power cables. The maximum allowable cable length is 100 ft.

To install the cables, first locate and install the wall-mount electronics enclosure and the transducers.
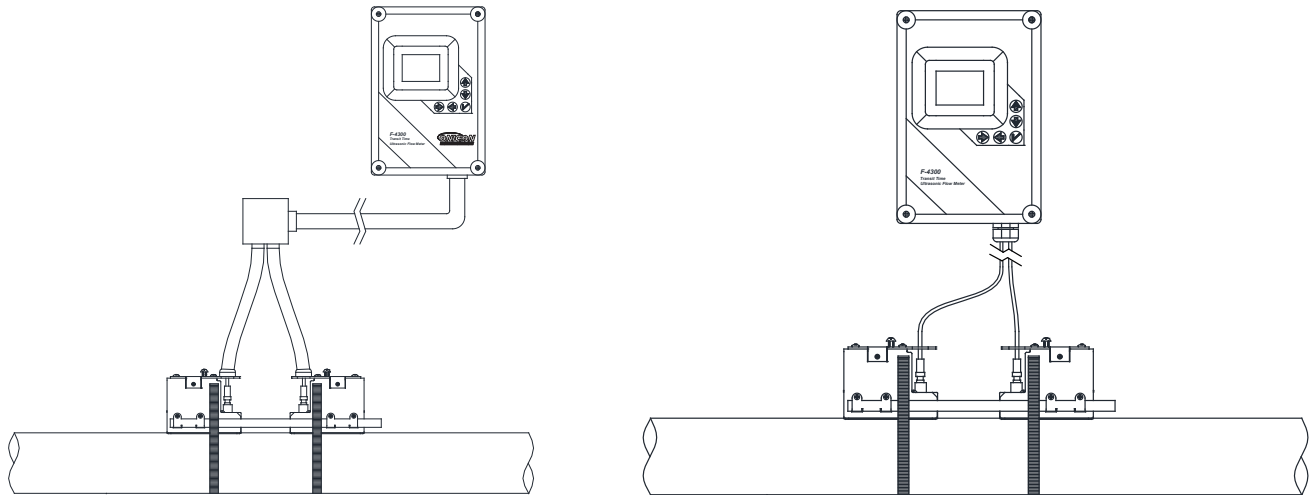
The transducer cables are provided with BNC connectors already installed at one end of the cable. Install this end of each cable at the transducers.

i

IMPORTANT NOTE

If using conduit, route cables from transducer through conduit to electronics enclosure.

!

WARNING

For proper operation, cables must not be bundled or run in conduit with any other signal or power cables. Do not cut or splice cables.

At the enclosure, the transducer cable should be landed as shown in figure to the right:

i

IMPORTANT NOTE

Route the upstream terminal to the upstream transducer locate in the terminal block. Repeat for the downstream terminal. If cables are discovered to be backwards after installation, simply reverse the cable installation inside the enclosure.

3.5   ELECTRICAL INSTALLATION

All user supplied conduit fittings, junction boxes, etc. must be installed in compliance with federal, state and local building codes.

3.5.1   Input Power Options

The F-4300 with MODBUS TCP/IP has only one input voltage option.

24 VDC, 10 Watts maximum

⚠

WARNING

Conduit openings in the F-4300 enclosure must be closed with UL listed fittings applicable to NEMA 4 enclosures.

⚠

WARNING

The protective earth connection must be made as shown in Section 3.5.2. Failure to do so will result in an increased risk of injury.

⚠

WARNING

All mains voltage connections must be made through the pre-drilled conduit/strain relief opening located at the bottom of the enclosure. Failure to do so will result in an increased risk of injury.

⚠

CAUTION

This product must be connected to earth ground for proper operation. Failure to do so may result in erratic operation.
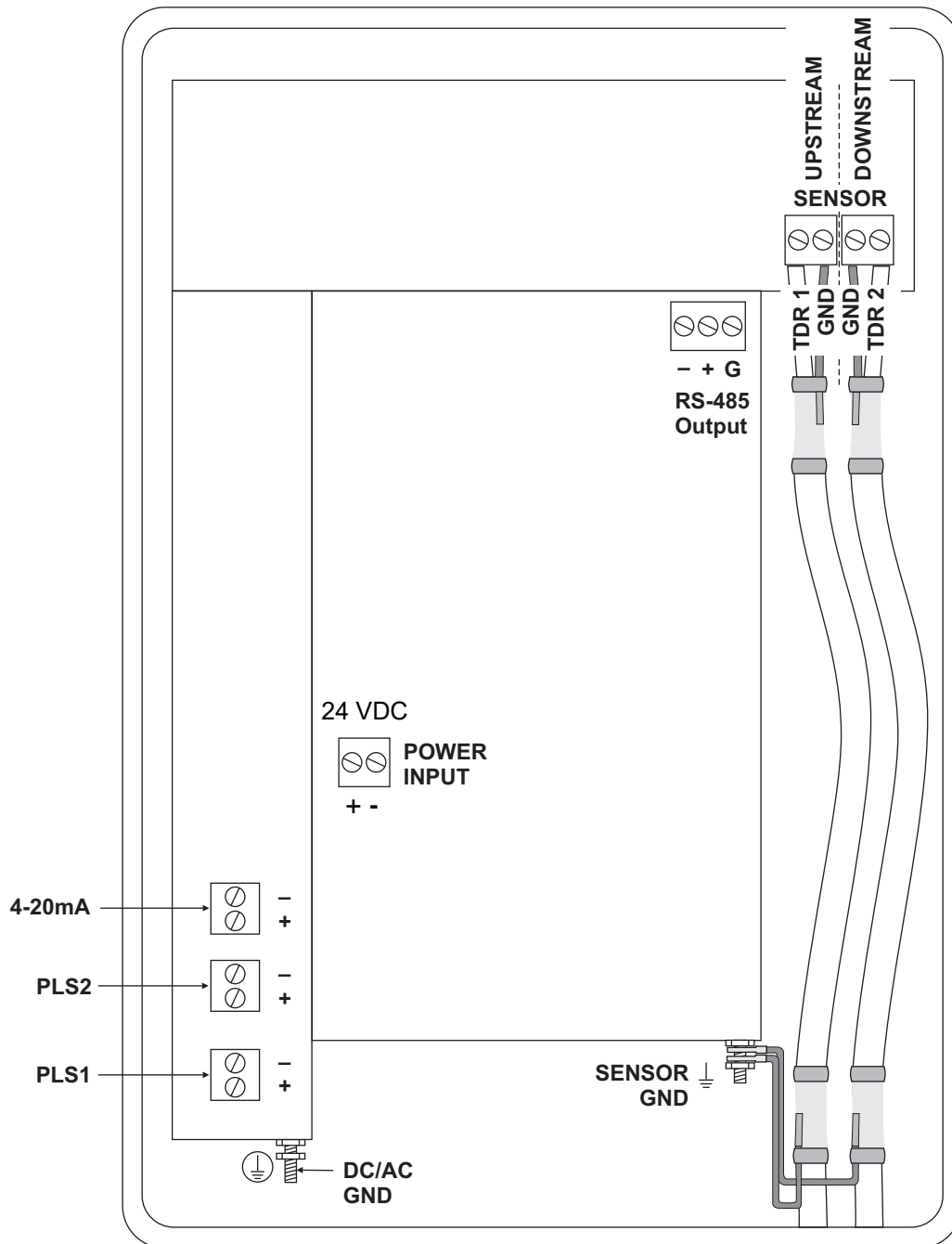

3.5.2 Electrical Connections

3.5.2.1 Connections for Meters

⚠️

WARNING

Turn off mains power at the source prior to making power connections to the F-4300. Contact with exposed live wiring may result in electric shock, burns and/or serious injury.

SECTION 4.0: START-UP

ONICON F-4300 flow meters are normally shipped with the intended installation parameters pre-programmed into the memory of the meter. This pre-programmed site is based on installation data provided to ONICON when the meter was ordered. The information programmed into the meter is also provided in a document that accompanies the installation hardware. It is titled, "Site Installation Details".

Confirm that the site installation details document matches the specific installation location. If there is any discrepancy between programmed parameters and actual site conditions, then the programming for the site must be edited before it is used. This manual contains information on programming the meter in the field, but if you require any assistance, please contact ONICON.

4.1	NAVIGATING THE RUN MODE & PROGRAMMING PAGES

The diagram on the next page shows the F-4300 menu system. Arrows show the four directions to navigate between menu boxes. Pressing a corresponding keypad arrow will move to the next item in the direction shown. Move the cursor (highlighted) under numerals with the and keys, and increase or decrease numerals with the and keys.
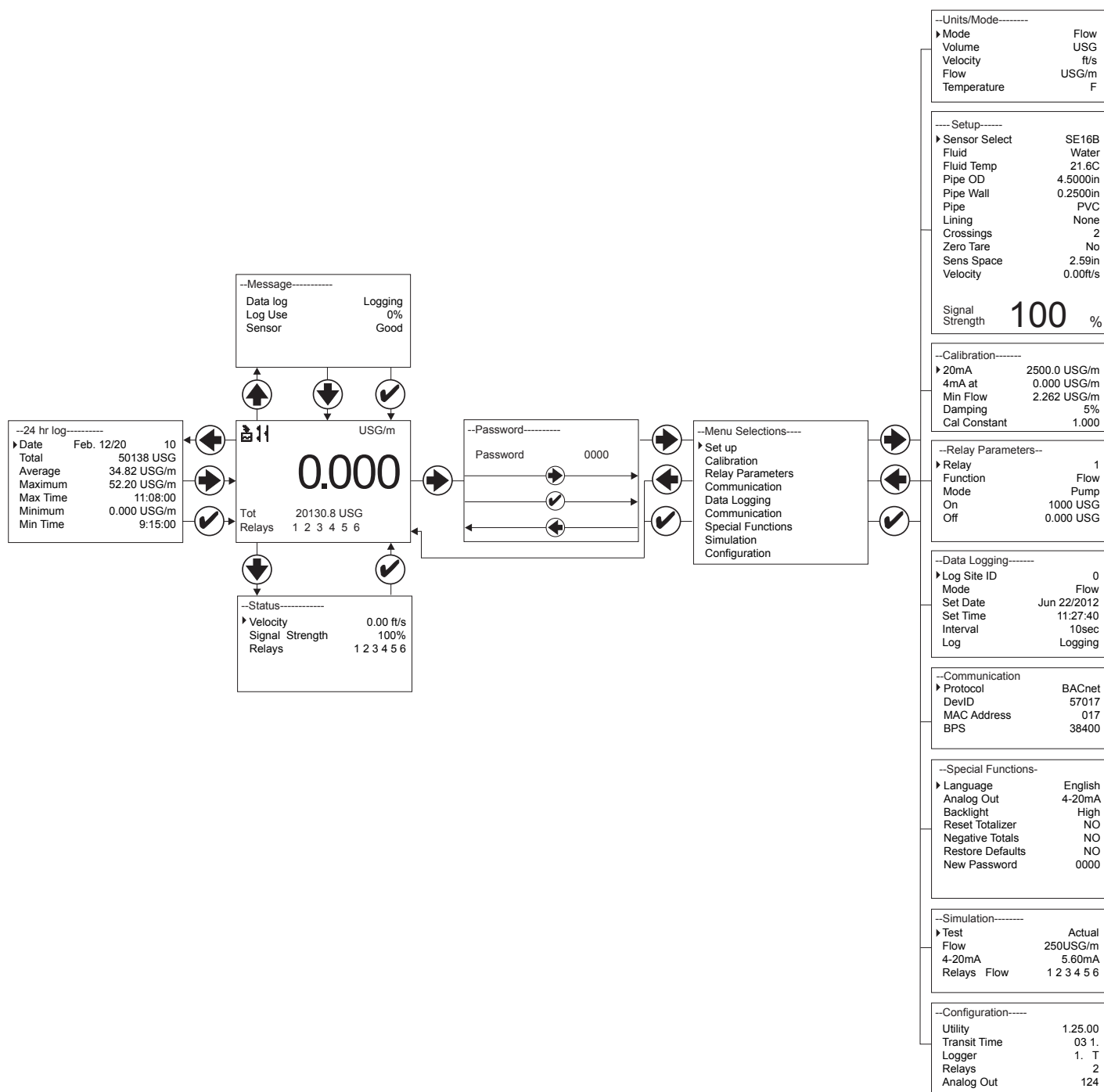
Programming values are stored permanently after pressing the .

Run Mode View

```
--Units/Mode--------
▸Mode                Flow
 Volume               USG
 Velocity            ft/s
 Flow               USG/m
 Temperature            F
```

```
---- Setup------
▸Sensor Select      SE16B
 Fluid              Water
 Fluid Temp         21.6C
 Pipe OD         4.5000in
 Pipe Wall       0.2500in
 Pipe                 PVC
 Lining              None
 Crossings              2
 Zero Tare             No
 Sens Space        2.59in
 Velocity        0.00ft/s

 Signal
 Strength      100      %
```

```
--Message-----------
Data log          Logging
Log Use                0%
Sensor               Good
```

```
--Calibration-------
▸20mA        2500.0 USG/m
 4mA at       0.000 USG/m
 Min Flow     2.262 USG/m
 Damping               5%
 Cal Constant       1.000
```

```
--24 hr log----------
▸Date      Feb. 12/20    10
 Total          50138 USG
 Average     34.82 USG/m
 Maximum     52.20 USG/m
 Max Time      11:08:00
 Minimum     0.000 USG/m
 Min Time       9:15:00
```

```
                   USG/m
🖥 ▮▮
     0.000
Tot       20130.8 USG
Relays    1 2 3 4 5 6
```

```
--Password----------

Password          0000
```

```
--Menu Selections----
▸Set up
 Calibration
 Relay Parameters
 Communication
 Data Logging
 Communication
 Special Functions
 Simulation
 Configuration
```

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

```
--Status------------
▸Velocity         0.00 ft/s
 Signal  Strength     100%
 Relays         1 2 3 4 5 6
```

```
--Data Logging-------
▸Log Site ID           0
 Mode               Flow
 Set Date     Jun 22/2012
 Set Time       11:27:40
 Interval          10sec
 Log             Logging
```

```
--Communication
▸Protocol         BACnet
 DevID            57017
 MAC Address        017
 BPS              38400
```

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

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

```
--Configuration-----
 Utility          1.25.00
 Transit Time       03 1.
 Logger             1.  T
 Relays                 2
 Analog Out           124
```

4.3   RUN MODE ICONS

ICONS

⊕ 1. ○ 2.	Message waiting. Press ⬆.
(data logging off icon)	Data logging off.
1. 2. (data logging on icons)	Data logging on.
1. 2. 3. 4. (USB icons)	USB file download.
(file with checkmark icon)	File download complete.
(crossed out icon)	Download Error.
1. 2. 3. (ultrasonic echo icons)	Ultrasonic Echo established.
(no echo icon)	No Echo, Empty Pipe.
(crossed sensors icon)	No Sensors Attached / Wrong Settings

4.4   RUN MODE PAGES

```
               USG/ m

   0.000

Tot          20130.8 USG
Relays       1 2 3 4 5 6
```

Main Display Page - The MAIN display shows the flow rate and totalizer in the units selected via the programming menu. You will see velocity instead of flow rate if you selected the velocity operating mode in the programming menu.

The bottom of the MAIN display shows the status of the pulse outputs. If any of the meter's pulse outputs are configured for volume totalization, the background of the specific pulse output programmed for this totalization will turn black, and then back to white after the pulse duration. If set for flow alarm, the background of the specific pulse output set for this alarm will turn black when latched on, and back to white when latched off.

The top-left corner of the MAIN display shows the status icons. Refer to the previous page for their descriptions.

```
┌─Messages─────────┐
│Data Log   Logging│
│Log Used        0 %│
│Sensor         Good│
│Sens.Up Temp 32.0 F│
│Sens.Dn Temp 32.0 F│
│                  │
│                  │
└──────────────────┘
```

Message Display Page - Pressing ⬆ from the MAIN display will navigate you to the MESSAGE page. On this page you can find the status of the logger, % log used, sensor status, and temperatures measured by both the upstream and downstream transducers.

```
┌─Status───────────┐
│Velocity  0.00 ft/s│
│Tot      0.000 USG│
│Signal Strength 100 %│
│Relays          1 2│
│                  │
│                  │
│                  │
└──────────────────┘
```

Status Display Page - Pressing ⬇ from the MAIN display will navigate you to the STATUS page. On this page you can see the flow velocity in units programmed in the meter, signal strength, and relay status again.

Signal strength is an important diagnostic tool. The value can be anywhere between 0-100%. 100% indicates that the meter is successfully transmitting between the upstream and downstream transducers.
If you have no flow, erratic flow, or inaccurate flow, this signal strength number should be noted. You will need to check transducer installation, pipe type and dimensions, and meter programming to resolve these potential issues.

```
┌─24 hr log────────┐
│>Date    Apr 21/2017│
│       No Data    │
│                  │
│                  │
│                  │
│                  │
└──────────────────┘
```

24 Hour Log Display Page - Pressing ⬅ from the MAIN display will navigate you to the 24 HOUR LOG display. By pressing the down arrow, you can view total flow, average flow, maximum flow, time maximum flow occurred, minimum flow, and time minimum flow occurred for any day after the meter has been deployed. Up to 365 days are stored, and after that date, the oldest data is removed to make room for the newest.

```
┌─Password─────────┐
│                  │
│                  │
│Password      0000│
│                  │
│                  │
│                  │
└──────────────────┘
```

Password Display Page - Pressing the ➡ from the MAIN display navigates you to the password entry page if the password has been changed from the default of 0000. This page comes directly before the programming menu, and is meant to allow you the ability to prevent malicious programming changes after deployment. The password can be changed at any time by navigating into the programming menu and changing it. See section 4.5 for instructions on changing this value. If the password has been changed from the default, use the directional buttons to change the digit values, then the ✓ to accept the password and move into the programming menu.

Any changes made in these menus are automatically saved, and take effect immediately. Your meter should have arrived pre-programmed by ONICON, so please use caution when changing any parameters which affect the setup the meter, such as the pipe material or pipe size.

For list selection options, press the ⬌ at any option to select it, and the ⬆ or ⬇ to change the selection. Press ✓ to accept the change. For numeric entry options, press the ⬌ to enter it, ➡ and ⬅ to navigate to different values, and then ⬆ or ⬇ to change the value selected. Press ✓ to accept the change.

Units/Mode Menu Page

The Units/Mode page allows the user to define whether the meter is configured to display velocity or flow rate, as well as define the engineering units seen on the MAIN display and programming menus.

```
--Units/Mode--------
▸Mode              Flow
 Volume            USG
 Velocity          ft/s
 Flow              USG/m
 Temperature       F
```

Mode – Select between "Flow" or "Velocity" for the MAIN display reading.

Options: Flow, Velocity

Volume – Select units for volume domain.

Options: USG (US gallons), ft3 (cubic feet), L (liters), m3 (cubic meters)

Velocity – Select units for flow velocity and fluid sonic velocity.

Options: ft/s (feet per second), m/s (meters per second)

Flow – Select units for volumetric flow rate.

Options: USG/m (gallons per minute), m3/h (cubic meters per hour), L/s (Liters per second), ft3/m (cubic feet per minute)

Temperature – Select units for temperature domain.

Options: F (Degrees Fahrenheit), C (Degrees Celsius)

Setup Menu Page

The Setup page allows the user to define the type of transducer used, and to define process conditions like pipe material & size, and fluid type & temperature. After these settings are defined, the spacing distance will be displayed on this page, and once the transducers are installed the meter will be ready to work.

All of these settings are pre-configured by ONICON before shipment. These settings should only be adjusted if the process conditions provided to ONICON at time of order were incorrect, or different transducers were supplied for field installation.

***Sensor Select* –** SE16B is the only option available at this time.

> ***Angle* –** Select the angle of the transducer. Contact ONICON for assistance defining what angle sensors you have.

***Fluid* –** Select between Water or Other. When Water is selected, the speed of sound of the fluid is determined based on the temperature entered later in this Setup menu.

***Vel@25C* –** Only appears if "Other" was selected at the **Fluid** option. Enter the speed of sound of the fluid at 25°C (77°F). Units are defined by what was selected in the Units/Mode menu.

dV/C – Only appears if "Other" was selected at the **Fluid** option. This defines how much the speed of sound varies per degree C. This should be left at 0 unless the speed of sound change of the fluid is linear with respect to temperature.

Temp Mode – Should be left at "Fixed"

> ***Temp –*** Temperature of the fluid. If "Water" was selected at **Fluid**, enter the water temperature. If "Other" was selected at **Fluid**, enter 25.0C or 77.0F for the fluid temperature, depending on units of measurement selected.

```
┌─Setup──────────────┐
│▶Sensor       SE16B │
│  Angle         41º │
│ Fluid        Water │
│ Temp Mode    Fixed │
│  Temp       77.0 F │
│ Pipe  Carbon Steel │
│ OD        4.5000 in│
└────────────────────┘
```

Pipe – Select the pipe material.

Carbon Steel, Brass, Aluminum, Acrylic, ABS, Other, Stainless 430, Stainless 410, Stainless 347, Stainless 316, Stainless 304, Stainless 303, Stainless 302, Mild Steel, PVC, Poly HD, Poly LD, Nylon, Iron, FRP, Ductile Iron, CPVC, Copper, Cast Iron.

> ***Vel –*** If "Other" pipe material was chosen, enter the sonic velocity of the pipe material here. Units of measurement are defined in the Setup menu.

> ***OD –*** Enter the pipe's outside diameter in units defined in the Setup menu. Charts with standard pipe sizes based on schedule are provided in the appendix of this manual.

> ***Wall –*** Enter the pipe's wall thickness in units defined in the Setup menu. Charts with standard pipe sizes based on schedule are provided in the appendix of this manual.

Lining – Select whether or not the pipe the meter is being mounted to has a liner.
Options: None, Tar Epoxy, Rubber, Mortar, Asb Cement, Other

> ***Thick -*** Enter the liner thickness in units defined in the **Setup** menu. Only appears if **Lining** is not "None"

Crossings – Defines the number of times the ultrasonic signal crosses the inside of the pipe. The first choice used should be 2 or 4 crosses.

1 crossing is a "Z" or "Direct" mode, 2 crossings is a "V" or "Reflect" mode, and 4 crossings is a "W" or "Double Reflect" mode. 1 crossing will provide the largest signal strength but more diligence is required to mount the transducers properly.

2 crossings provide the easiest means to mount the transducers, averages some of the flow distortions in the pipe, but attenuates the signal more than 1 cross. This is the default and ONICON recommended configuration.

4 crossings provide even more averaging than 2 crosses. 4 crosses will not be an option unless the transducers overlap in a 2 cross setup, which is dependent on pipe settings and fluid sonic velocity.

Zero Tare – Used to suppress readings or fluctuations at zero flow. Do not enable this function unless flow in the pipe has been valved to 0, and the pipe is full.

Sens Space – This function is not editable. This value will automatically calculate after the sensor type, angle, fluid type and temperature, pipe material and size, and number of crossings is defined. This distance is defined as the measurement between the inside of both transducers. Because the meter comes pre-programmed from ONICON, this number is already defined for you on the "Site Installation Details" sheet. However, if any of the factors listed above is changed in the field, you will need to change the transducer spacing to the new number provided here.
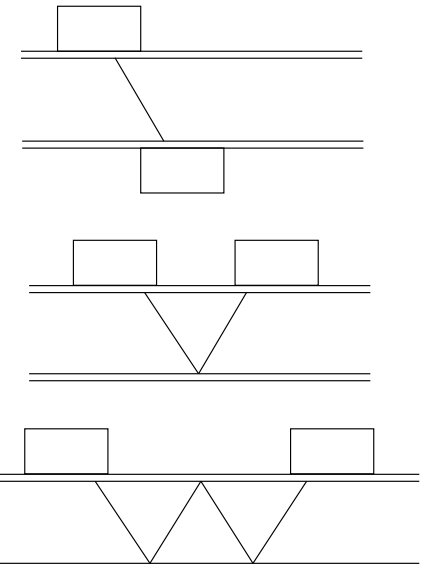
Velocity – After mounting the transducers and connecting the transducer cable, you will be able to see the flow velocity in real-time once flow is established.

Signal Strength – After mounting the transducers and connecting the transducer cable, you will be able to see the signal strength in real-time. The pipe must be full of water to get a valid signal strength reading.

```
┌─Setup──────────┐   ┌─Setup──────────┐
│Lining      None│   │Crossings      2│
│Crossings      2│   │Zero Tare     NO│
│Zero Tare     NO│   │Sens Space --- in│
│Sens Space --- in│  │Velocity 0.00 ft/s│
│Velocity 0.00 ft/s│ │                │
│            ▄▄▄▄│   │Signal     ▄▄▄▄ │
│>Signal   100   │   │>Strength 100 % │
└────────────────┘   └────────────────┘
```
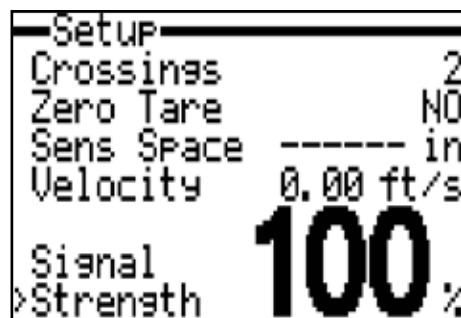
Calibration Menu Page

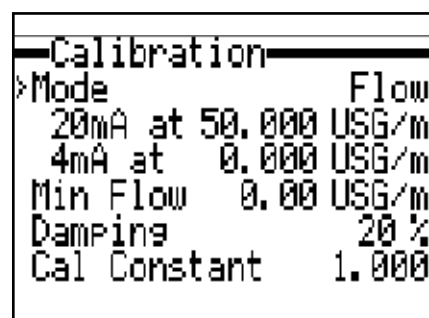The calibration menu defines the behavior of the flow measurement and its related outputs.

Mode – Shows the Mode which was selected in the Units/Mode menu. Could be "Flow" or "Velocity."

20 mA at or **5V at** – Enter the desired flow rate to be equal to 20 mA or 5V.

4 mA at or **0V at** – Enter the desired flow rate to be equal to 4 mA or 0V. Typically, 0 flow/velocity, but could be a negative value if you wanted the 4-20 mA/0-5V output to represent more than one direction.

```
┌─Calibration────┐
│>Mode       Flow│
│ 20mA at 50.000 USG/m│
│ 4mA at  0.000 USG/m│
│Min Flow  0.00 USG/m│
│Damping     20 %│
│Cal Constant 1.000│
└────────────────┘
```

Min Flow – Value which if the measured flow rate falls below, the meter will force the reading and outputs to 0. Units match those configured in the **Units/Mode** menu. The default and recommended value is the volumetric flow rate equivalent to 0.1 ft/sec in your pipe size.

Damping – The damping value stabilizes the flow rate on the display and analog output. For applications with poor straight run, use a higher dampening value to steady the flow reading. Lower dampening values should be used in applications where you want a faster response from the meter. The default dampening value is 20%.

Cal Constant – Calibration constant defined during calibration. This value shouldn't be changed unless ONICON support has requested to do so.

Relay Parameters Menu Page

The relay parameters page is where changes can be made to the pulse outputs available with the F-4300.

Relay – Defines which pulse output you are making changes to, either 1 or 2.

Function – Defines the behavior of the pulse output selected at the Relay option. Choices:

```
┌─Relay Parameters─┐
│Relay          1 │
│Function   Pulse │
│▶On   10.000 USG │
│                 │
│                 │
│                 │
└─────────────────┘
```

On – Pulse is always engaged

Off – Pulse is always disengaged

Pulse – Scaled pulse. Define how many gallons must be measured before a pulse occurs.
Pulse duration = 50 ms; max Hz = 10

Flow – Pulse output functions as a flow alarm. You will need to define when the alarm comes ON, and when the alarm will turn OFF again.

Examples:

High Flow Alarm: ON = 300 GPM, OFF = 250 GPM

Flow goes above 300 GPM and the pulse output latches ON. It will not turn OFF until flow goes below 250 GPM.

Direction Switch: ON = +0.1 GPM, OFF = -0.1 GPM

Any flow above 0.1 GPM will cause the pulse to turn ON, and it will turn off should flow reverse.

Data Logging Menu Page

The Data Logging page allows configuration of the data logger. Options include what is being logged, how often it is being logged, and the date settings.

> **ⓘ**
>
> **IMPORTANT NOTE**
>
> The logger must be configured in a specific order in order to function correctly:
> 1.   Set the Log Site ID, Mode, File Format, Date, Time, and Interval to the desired option.
> 2.   Under Data Log, select "Delete"
> 3.   Under Data Log, select "Start"
> Deploying the logger in any other order will compromise the settings you've chosen.

Log Site ID – Provide a number to the log site you're creating. Can be any number between 00-99.

Mode – Define what is being logged. Options: Flow, Velocity.

File Format – Define how you will want the data presented when downloaded. Choose .LG2 when you will be looking at the log data with the ONICON Logger Utility software. Choose .CSV when you will be loading the data directly into an Excel spreadsheet for manipulation and graphing.

Date – Configure today's date. Format: Month Day/Year.

Time – Configure the time. Format: hh:mm:ss. Range: 00:00:00-23:59:59.

```
--Data Logging-------
▶Log Site ID              0
 Mode               Flow
 Set Date      Jun 22/2012
 Set Time       11:27:40
 Interval         10sec
 Log             Logging
```

Interval – Define how often the unit selected under Mode will log. Options: 10 sec, 30 sec, 1 min, 2 min, 5 min, 10 min, 15 min, 30 min, and 60 min.

At the fastest interval, 10 sec, the logger will last 8.5 years before it is full. However, if you are curious about the % log used, it is available in

the Messages Menu accessible from the Run Screen by pressing the ⬆.

Although the logger storage capability is quite extensive, ONICON recommends not using an interval more resolute than required, as downloading a large log file could present data transfer problems and corrupted data.

Communications Menu Page

The communications menu provides the means to select the serial output of the meter, and the addressing and communication speed.

```
--Communication
▶Protocol          BACnet
 DevID            57017
 MAC Address        017
 BPS              38400
```

Protocol – Select the protocol for the serial communications. Options: OFF, MODBUS, BACnet

DevID – Only available if BACnet was the selected Protocol. This is the Device ID which must be unique for the device across the whole BACnet network. Range: 0-4,194,302.

MAC Address – Only available if BACnet was the selected Protocol. This is the RS485 bus address for the BACnet MS/TP communications. Range: 0-127 for master devices, 128-254 for slave devices.

BPS – BAUD Rate, or bits per second. Defines the speed of communication on the BUS. Must be the same for all devices on the BUS. Options: 9600, 19200, 38400, 76800.

Special Functions Menu Page

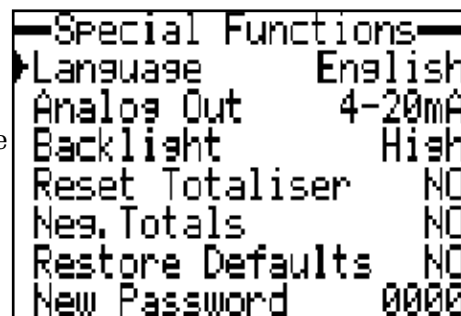*Language –* Select the language for the menus and display. Options: English, French, Spanish.

Analog Out – Defines the analog output type. Options: 4-20 mA, 0-5V.

Backlight – Raise or lower the brightness of the display backlight. Options: Off, High, Med, Low, Key Hi/Lo (Brightness goes to High after a keypress, then Low after 1 minute of no button presses), Key High, Key Med, and Key Low (Brightness goes to specified value after keypress, then OFF after 1 minute).

Reset Totalizer – Select YES to reset totalizer. YES will flash two times after pressing ✓ to indicate the action was accepted.

Neg. Totals – Selecting NO will cause the totalizer to ignore flow rates in the negative direction. Only positive flows will accumulate the totalizer. Selecting YES will cause negative flows to deduct from the totalizer. Totalizer values can achieve a negative value if negative totals are greater than positive totals.

```
┌──Special Functions──┐
▶Language        English
 Analog Out       4-20mA
 Backlight          High
 Reset Totaliser      NO
 Neg.Totals           NO
 Restore Defaults     NO
 New Password       0000
└─────────────────────┘
```

Restore Defaults – Selecting YES will cause all of the programming settings to revert to the factory default. These defaults are different than the programming ONICON performed at the factory before the meter was shipped.

New Password – This function allows a new password to be set. This password protects the programming menu access from the Main Display. The default value is 0000. Range: 0000-9999. Do not lose the password if changed, in case you need to return to the programming menu at a later date.

Simulation Menu Page

The simulation menu page is used to generate flow rates independent of the actual measurement in the system, in order to test output signals.

Any simulated flow rate is only active while the Simulation Menu is open. Once the menu is exited, the flow rate and output signal behavior will return to that actually measured by the meter.

Test – This function defines how the simulation mode will be tested. Options: Actual, Maximum, Minimum.

When Actual is selected, any flow rate which is currently present will be displayed on the screen, and the outputs associated with that flow rate is also displayed. Alternatively, you can move the cursor to the Flow option, press ⮕ to enter the option, and then set a flow rate manually. After ✅ is pressed, the analog output and pulse outputs will be driven by the set flow rate.

```
┌─Simulation──────────┐
│▶Test          Actual│
│ Flow     0.00 USG/m │
│ 4-20mA Flow     4.00│
│ Relays          1 2 │
└─────────────────────┘
```

When Maximum is selected, the flow rate will be driven to the 20 mA/5V value configured in the Calibration Menu Page.

When Minimum is selected, the flow rate will be driven to the 4 mA/0V value configured in the Calibration Menu Page.

Configuration Menu Page

The configuration menu page stores the serial number and electronics information for the F-4300. All of the values in this menu are read-only.

Serial # - Serial number of the F-4300. This value is also present on the outside of the enclosure, and inside the door.

Utility – Revision of the utility card. The utility card is the vertical card on the left hand side of the chassis. It connects to the LCD display, and has the analog and pulse outputs on it.

TransitTime – Revision of the transit time card. The Transit time card is the topmost horizontal card, with the two connectors attached to the Triax cable.

CommBoard – Revision of the communications card.

Relays – Lists the number of pulse outputs present on the meter. This should always be 2.

Analog Out – Lists the number of analog outputs present on the meter. This should always be 1.

```
┌─Configuration───────┐
│ Serial#        12345│
│ Utility   0.13.11.0 │
│ TransitTime         │
│ CommBoard           │
│ Relays             2│
│ Analog Out         1│
└─────────────────────┘
```

SECTION 5.0: MODBUS COMMUNICATIONS

5.1   MODBUS COMMUNICATIONS

The ONICON F-4000 Ultrasonic Flow meter is provided with a TCP/IP interface for connection to a MODBUS RTU network. Each meter is individually programmed at the factory with application specific data provided by the customer during the process of ordering the meter. This would normally include programming of all the settings necessary to allow the meter to communicate over the desired network.

MODBUS RTU Communications

The MODBUS RTU protocol is a data link protocol that uses the services of the TCP/IP physical layer. MODBUS is a master/slave protocol. Only one master device originates messages on the network. Slave devices on the network only communicate when responding to a data request from the master device. The ONICON F-4000 implementation of MODBUS RTU is as a slave device.

Word Order Settings for MODBUS

MODBUS master devices can be configured with differing data structures within MODBUS messages. The word order format of the slave device must match the requirements of the master. The ONICON F-4000 word order can be "Normal" or "Reversed". The default setting is "17".

TCP/IP Network Addressing

Before the F-4000 can communicate on the TCP/IP network:

1. The appropriate device address must be programmed into the meter. The valid address range is 1 — 254. The default address is 001.
2. An IP address must be assigned to the meter.

5.2   CONNECTIONS

MODBUS TCP. 10/100 Base-TX output connection are made as shown. Requires 10/100 Base-TX Cable and RJ45 connector. Port 502.
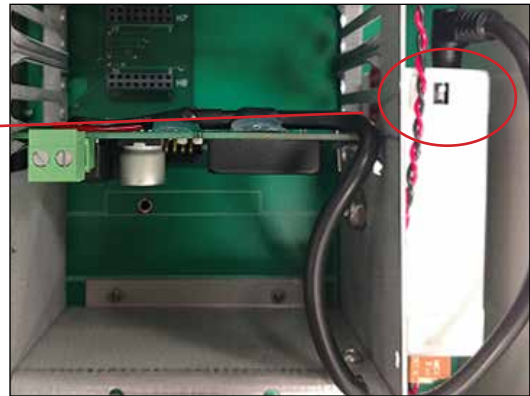
IMPORTANT NOTE

ⓘ The Protocol, BAUD rate, and Parity settings must not be changed, or the TCP/IP communications will not function correctly. The default settings are:

    Protocol – MODBUS
   BAUD – 38400
    Parity – None

5.2.1 IP Address Setting

Changing the IP address of the F-4300 requires the use of a PC with an Ethernet card and an available port. The default IP configuration of the F-4300 is as follows:

IP Address   192.168.255.1
Mask   255.255.0.0
Gateway   192.168.0.1

To change these IP address settings:
- Connect your Ethernet cable to the RJ45 jack on the MODBUS TCP/IP card
- Change the adapter settings in your PC as shown to the right:
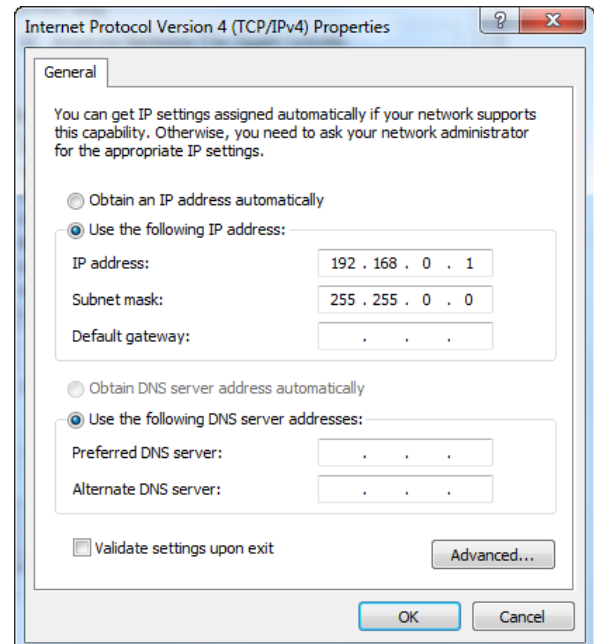
Next, open a web browser, and navigate to IP address 192.168.255.1.
The following page will appear:

The interface shown above is used to configure the IP settings on the F-4300. The Login Password is **admin** (case sensitive). Press Submit after entering the password, and the following page appears:

Seven pages are available from the main menu:

Home – The page you currently see. This page is not used to configure the IP address.
Port1 – Not used.
Network – This page allows you to change the IP address settings.
Filter – Not used.
Monitor – Not used.
Password – This page can be used to change the password from the default **admin**.
Logout – Press this button to logout of the F-4300 IP configurator.

Press the Network button to arrive at the following page:

Within the IP Address Selection section, you can configure the IP settings for the F-4300's MODBUS communications.

Address Type – Choose between Static IP, and DHCP. The Static IP Address, Subnet Mask, and Default Gateway will become un-editable if DHCP is selected.

After the configuration has been updated, press the Update Settings button to save the changes. Document the configuration chosen. After pressing the update button, if you need to access these settings again, you must go back into your PC's IP setting page and change the IP address and subnet to match the network the F-4300 is set for.

After you are done making configuration changes, you are ready to connect the F-4300 to the MODBUS TCP/IP network.

5.3 MODBUS MEMORY MAP

Register Address	Description	Register Type	Data Range	Over Range	Read/ Write	Comments
1	Reset Volume Total	Coil	NA	NA	Read/ Write	Turn coil ON (1) to reset total on F-4300. Turn coil to OFF (0) once reset is complete.

Register Address	Description	Register Type	Data Range	Over Range	Read/ Write	Comments
10001	Pulse Output 1 Status	Discreet Input	NA	NA	Read	(0) indicates pulse output is OFF or inactive. (1) indicates pulse output is ON or active.
10002	Pulse Output 2 Status	Discreet Input	NA	NA	Read	(0) indicates pulse output is OFF or inactive. (1) indicates pulse output is ON or active.

Register Address	Description	Register Type	Format Type	Comments
30001	Flow velocity – ft/s	Input Register	Floating Point (1 of 2)	
30002	Flow velocity – ft/s	Input Register	Floating Point (2 of 2)	
30003	Flow velocity – m/s	Input Register	Floating Point (1 of 2)	
30004	Flow velocity – m/s	Input Register	Floating Point (2 of 2)	
30101	Flow rate - GPM	Input Register	Floating Point (1 of 2)	
30102	Flow rate - GPM	Input Register	Floating Point (2 of 2)	
30103	Flow rate – L/s	Input Register	Floating Point (1 of 2)	
30104	Flow rate – L/s	Input Register	Floating Point (2 of 2)	
30105	Flow rate – ft³/min	Input Register	Floating Point (1 of 2)	
30106	Flow rate – ft³/min	Input Register	Floating Point (2 of 2)	
30107	Flow rate – m³/hr	Input Register	Floating Point (1 of 2)	
30108	Flow rate – m³/hr	Input Register	Floating Point (2 of 2)	
30165	Last 24 Hour Average Flow Rate - GPM	Input Register	Floating Point (1 of 2)	
30166	Last 24 Hour Average Flow Rate - GPM	Input Register	Floating Point (2 of 2)	
30167	Last 24 Hour Average Flow Rate - L/s	Input Register	Floating Point (1 of 2)	
30168	Last 24 Hour Average Flow Rate - L/s	Input Register	Floating Point (2 of 2)	
30169	Last 24 Hour Average Flow Rate - ft³/min	Input Register	Floating Point (1 of 2)	
30170	Last 24 Hour Average Flow Rate - ft³/min	Input Register	Floating Point (2 of 2)	
30171	Last 24 Hour Average Flow Rate - m³/hr	Input Register	Floating Point (1 of 2)	
30172	Last 24 Hour Average Flow Rate - m³/hr	Input Register	Floating Point (2 of 2)	
30301	Volume Total - Gal	Input Register	Floating Point (1 of 2)	
30302	Volume Total - Gal	Input Register	Floating Point (2 of 2)	

Register Address	Description	Register Type	Format Type	Comments
30303	Volume Total - Liters	Input Register	Floating Point (1 of 2)	
30304	Volume Total - Liters	Input Register	Floating Point (2 of 2)	
30305	Volume Total - ft³	Input Register	Floating Point (1 of 2)	
30306	Volume Total - ft³	Input Register	Floating Point (2 of 2)	
30307	Volume Total - m³	Input Register	Floating Point (1 of 2)	
30308	Volume Total - m³	Input Register	Floating Point (2 of 2)	
30317	Last 24 Hour Volume Total - Gal	Input Register	Floating Point (1 of 2)	
30318	Last 24 Hour Volume Total - Gal	Input Register	Floating Point (2 of 2)	
30319	Last 24 Hour Volume Total - Liters	Input Register	Floating Point (1 of 2)	
30320	Last 24 Hour Volume Total - Liters	Input Register	Floating Point (2 of 2)	
30321	Last 24 Hour Volume Total - ft³	Input Register	Floating Point (1 of 2)	
30322	Last 24 Hour Volume Total - ft³	Input Register	Floating Point (2 of 2)	
30323	Last 24 Hour Volume Total - m³	Input Register	Floating Point (1 of 2)	
30324	Last 24 Hour Volume Total - m³	Input Register	Floating Point (2 of 2)	
30901	Signal Strength - %	Input Register	Integer	0-100
30919	Adjusted Speed of Sound - ft/sec	Input Register	Floating Point (1 of 2)	
30920	Adjusted Speed of Sound - ft/sec	Input Register	Floating Point (2 of 2)	
30921	Adjusted Speed of Sound - m/sec	Input Register	Floating Point (1 of 2)	
30922	Adjusted Speed of Sound - m/sec	Input Register	Floating Point (2 of 2)	
30923	Sensor Status	Input Register	Index	0 = Sensor Good 4 = Sensor Open 5 = Sensor Short 7 = Low Signal
30925	Logging Status	Input Register	Index	0 = Stopped 1 = Active 2 = Full
30926	Logging Used - %	Input Register	Floating Point (1 of 2)	
30927	Logging Used - %	Input Register	Floating Point (2 of 2)	
30947	Velocity Units	Input Register	Index	0 = ft/s 1 = m/s
30948	Flow Units	Input Register	Index	0 = GPM 1 = L/s 2 = ft³/min 3 = m³/hr
30949	Linear Units	Input Register	Index	0 = Feet 1 = Inches 2 = Millimeters 3 = Meters
30950	Volume Units	Input Register	Index	0 = ft³ 1 = Gallons 5 = m³ 6 = Liters
30951	Time Units	Input Register	Index	0 = Second 1 = Minute 2 = Hour

SECTION 6.0: COMMISSIONING FOR ONICON CLAMP-ON ULTRASONIC FLOW METERS

Please read all installation instructions carefully before proceeding. Wiring diagrams are located in an earlier section of this manual. Use the meter certificate of calibration to verify that the specified installation & operating parameters match the actual conditions at the location where the meter is installed. A worksheet for checking off these steps and recording measured values is located in section 6.3.

6.1 HELPFUL HINTS FOR START-UP AND COMMISSIONING

Please read these helpful hints before proceeding with the commissioning procedure on the next page.

1. ONICON flow meters are individually calibrated for a particular application. Be sure to verify the pipe size and location.
2. The ultrasonic flow sensing systems will not work with an empty pipe.
3. When measuring analog output signals, remember that current (mA) must be measured in series, while voltage is measured in parallel. If the 4-20 mA signal is already connected to a control system, you must break the connection and measure the signal in series.

6.2 COMMISSIONING PROCEDURE

Please read the entire procedure before proceeding. A worksheet for checking off the following steps and recording measured values provided in Section 6.3.

1.	Confirm that the flow meter is being installed in accordance with Sections 1.8 and 3.2 of this manual.	Confirm that the installation location is removed from any sources of strong electrical interference and that the enclosure is mounted on a vibration-free surface. Confirm that the transducer signal cables are run in dedicated conduit without other signal or power cables.
2.	Confirm flow meter location.	Confirm adequate straight pipe run to achieve desired results. Is the meter located in the correct location as required by the plans? Compare actual straight pipe upstream and downstream of the meter location to recommended distances identified in this manual. Contact ONICON to discuss specifics of your application. If straight pipe run is very short, consult ONICON PRIOR to commissioning the meter.
3.	Confirm pipe size.	Confirm that the meter is tagged for the pipe size in which it is installed. When in doubt, measure the circumference of the pipe. Pipe O.D. = (Circumference / 3.14) – (insulation thickness x 2).
4.	Verify the type of fluid used in the piping system.	Confirm that the fluid specified on the flow meter certificate of calibration matches the fluid flowing in the piping system.
5.	Confirm control system programming.	Confirm that the control system input points are properly configured for the analog output range, pulse scale factor and/or relay output function identified on the calibration certificate & meter tag.
6.	Confirm connection to the correct ONICON display or Btu meter (if ordered).	Confirm that the flow meter serial number matches the ONICON display or Btu meter serial number (when ordered together).
7.	Verify output signal wiring.	Verify that the wiring is correct as shown in this manual and/or the additional wiring diagram provided with the ONICON display or Btu meter. If in doubt, contact ONICON for assistance before proceeding further.
8.	Confirm correct supply voltage.	Verify that the supply voltage is within specified limits. The F-4300 could have been ordered with a low voltage or high voltage board.
The following steps require flow in the pipe. Flow signal readings should be taken while holding the flow rate constant, if possible. Otherwise, take the various output readings as quickly as possible.		
9.	Record the information shown on the flow meter display.	Record readings shown for: Flow rate and Flow total

10.	Measure and record analog or pulse outputs.	Refer to flow meter wiring diagram for the various outputs based on your particular installation. Use the following formulas to calculate flow rate from measured analog signals:
	Current Output:	GPM = $\dfrac{\text{(measured current in mA - 4)}}{16}$ X Full Scale Analog Flow Rate or,
	Scaled Relay Output:	GPM = $\dfrac{\text{measured voltage}}{5}$ X Full Scale Analog Flow Rate Each contact closure = unit volume identified as "Scale Factor." (Measure and record time interval between contact closures.)
11.	Compare various output signals to each other and to the flow rate displayed by the control system.	Compare the flow rate calculated in step 10 to meter display and to the flow rate indicated by the control system. Refer to the troubleshooting section of this manual when readings are inconsistent.

End of standard commissioning. Please contact ONICON at (727) 447-6140 with any questions.

6.3   COMMISSIONING WORKSHEET

Please read all installation instructions carefully prior to proceeding with these steps. Use the following worksheet for checking off the commissioning steps and recording measured values. The following steps require flow in the pipe. Flow signal readings should be taken while holding the flow rate constant, if possible. Otherwise, take the various output readings as quickly as possible.

STEP	TEST/MEASUREMENT	S/N:	S/N:	S/N:	S/N:
1.	Site selection/location OK:				
2.	Straight run OK:				
3.	Measured pipe size:				
4.	Record fluid type:				
5.	Control system programming OK:				
6.	Record Btu meter /display S/N:				
7.	Signal & transducer wiring Ok:				
8.	Record measured supply voltage:				
9.	Record the displayed data:	Rate _____ Total _____ Signal Strength _____	Rate _____ Total _____ Signal Strength _____	Rate _____ Total _____ Signal Strength _____	Rate _____ Total _____ Signal Strength _____
10.	Analog or pulse output(s) 4-20 mA signal: Scaled output interval: Calculated flow rate:	_____mA _____VDC _____ _____GPM	_____mA _____VDC _____ _____GPM	_____mA _____VDC _____ _____GPM	_____mA _____VDC _____ _____GPM
11.	Flow rate displayed by control system.	_____GPM	_____GPM	_____GPM	_____GPM

Function Codes Supported:
01 - Read Coil(s)
02 - Read Discreet Input(s)
04 - Read Input Register(s)
05 - Write Single Coil
06 - Write Single Register
15 - Write Multiple Coils
16 - Write Multiple Registers
17 - Report Slave ID

Engineering Units	Abbreviation	Engineering Units	Abbreviation
Volume Rate (Flow)		Volume Total	
Gallons per minute	GPM	Gallons	Gal
Liters per second	L/s	Liters	Liters
Cubic feet per minute	ft3/min	Cubic Feet	ft3
Cubic meters per hour	m3/hr	Cubic Meters	m3
Velocity (Flow velocity, Fluid speed of sound)			
Feet per second	ft/s		
Meters per second	m/s		

SECTION 7.0: TROUBLESHOOTING

| POSSIBLE CAUSES:	CORRECTIVE ACTION:
METER READING WHEN THERE IS NO FLOW?	
Erratic measurement (set damping to 0% to check) due to electrical noise or poor signal quality.	• Set Calibration / Damping to 5% with zero flow use Setup / Tare function. • Ensure triax cable shield is properly connected to ground. • Ensure correct power input ground connection. • Double-check sensor separation distance and contact ONICON for further assistance. • Adjust Calibration Menu / Min Flow setting.
Variable Speed Drive interference	• Follow drive manufacturers wiring and grounding instructions • Relocate flow meter electronics, sensor and wiring away from VSD
Sensor cable connections incorrect or loose	• Refer to connections diagram. Disconnect and reconnect sensor cables ensuring that cable is properly inserted into terminals and tightened.
METER READING LOWER THAN EXPECTED?	
Calibration Error	• Review calibration menu. Pipe dimensions and fluid selection/fluid velocity.
Lower flow rate than expected	• Investigate pump/valves. Compare velocity with alternate instrument.
Erratic measurement (set damping to 0% to check) due to electrical noise or poor signal quality.	• Ensure triax cable sensor shield is properly grounded. • Ensure correct power input ground connection. • Double-check sensor separation distance and contact ONICON for further assistance.
NO ECHO INDICATION Icon: No Echo	
Sensor Connections	• Ensure triax cable sensor shield is properly grounded. • Ensure triax cable is connected to transducers.
Sensors not mounted to Pipe or mounted improperly	• Apply coupling compound and mount sensors to pipe with proper sensor spacing.
Empty pipe or partially filled	• Pipe must be fluid filled and acoustically transparent in order to obtain echoes.
Coupling compound washed out, or sensor loose on pipe.	• Remount sensor • Use acoustic coupling compound ultrasonic couplant.
METER READING HIGHER THAN EXPECTED?	
Calibration Error	• Review calibration menu. Pipe dimensions and fluid selection/fluid velocity.
Higher flow rate than expected	• Investigate pump/valves. Compare velocity with alternate instrument.
Erratic measurement (set damping to 0% to check) due to electrical noise or poor signal quality.	• Ensure triax cable sensor shield is properly grounded. • Ensure correct power input ground connection. • Double-check sensor separation distance and contact ONICON for further assistance.
Pipe not Full	• Verify pipe is full by mounting sensors at top of pipe and check echo icon. No echo if pipe is not full.

APPENDIX

SONIC VELOCITY RELATIVE TO TEMPERATURE OF PURE WATER

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

Pipe Charts
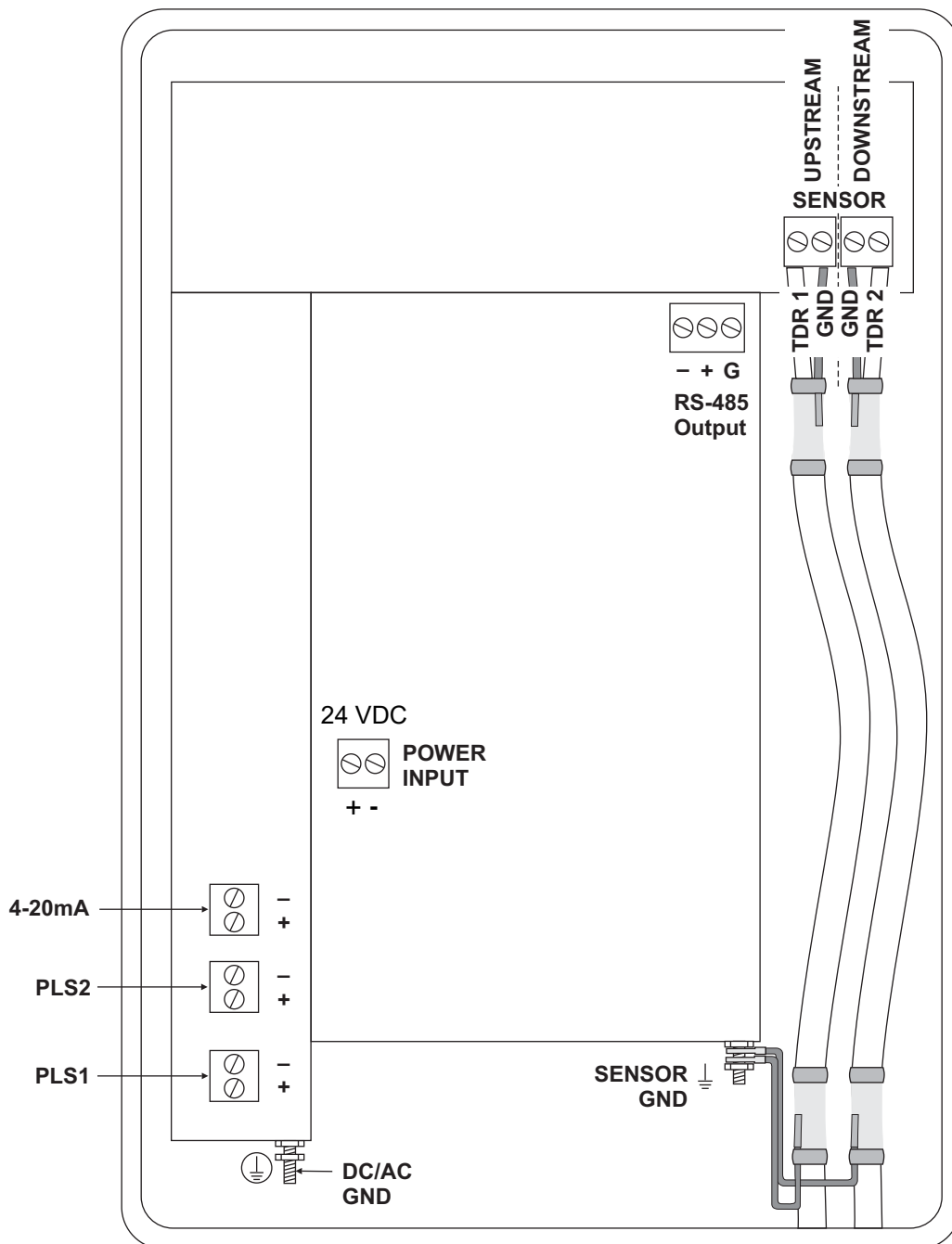
Carbon Steel & PVC Pipe

Pipe Size	Pipe O.D.	Standard Schedule 40		Extra Heavy Schedule 80		Dbl. Extra Heavy		Schedule 10		Schedule 20		Schedule 30		Schedule 40	
		I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL
½	.840	.622	.109	.546	.147	.252	.294							.622	.109
¼	1.050	.824	.113	.742	.154	.434	.308							.824	.113
1	1.315	1.049	.133	.957	.179	.599	.358							1.049	.133
1¼	1.660	1.380	.140	1.278	.191	.896	.382							1.380	.140
1½	1.900	1.610	.145	1.500	.200	1.100	.400							1.610	.145
2	2.375	2.067	.154	1.939	.218	1.503	.436							2.067	.154
2½	2.875	2.469	.203	2.323	.276	1.771	.552							2.469	.203
3	3.500	3.068	.216	2.900	.300	2.300	.600							3.068	.216
3½	4.000	3.548	.226	3.364	.318	2.728	.636							3.548	.226
4	4.500	4.026	.237	3.826	.337	3.152	.674							4.026	.237
5	5.563	5.047	.258	4.813	.375	4.063	.750							5.047	.258
6	6.625	6.065	.280	5.761	.432	4.897	.864							6.065	.280
8	8.625	7.981	.322	7.625	.500	6.875	.875			8.125	.250	8.071	.277	7.981	.322
10	10.750	10.020	.365	9.750	.500	8.750	1.000			10.250	.250	10.136	.307	10.020	.365
12	12.750	12.000	.375	11.750	.500	10.750	1.000			12.250	.250	12.090	.330	11.938	.406
14	14.000	13.250	.375	13.000	.500			13.500	.250	13.376	.312	13.250	.375	13.124	.438
16	16.000	15.250	.375	15.000	.500			15.500	.250	15.376	.312	15.250	.375	15.000	.500
18	18.000	17.250	.375	17.000	.500			17.500	.250	17.376	.312	17.124	.438	16.876	.562
20	20.000	19.250	.375	19.000	.500			19.500	.250	19.250	.375	19.000	.500	18.814	.593
22	22.000	21.250	.375	21.000	.500			21.500	.250	21.250	.375	21.000	.500		
24	24.000	23.250	.375	23.000	.500			23.500	.250	23.250	.375	22.876	.562	22.626	.687
26	26.000	25.250	.375	25.000	.500			25.376	.312	25.000	.500				
28	28.000	27.250	.375	27.000	.500			27.376	.312	27.000	.500	26.750	.625		
30	30.000	29.250	.375	29.000	.500			29.376	.312	29.000	.500	28.750	.625		
32	32.000	31.250	.375	31.000	.500			31.376	.312	31.000	.500	30.750	.625		
34	34.000	33.250	.375	33.000	.500			33.376	.312	33.000	.500	32.750	.625		
36	36.000	35.250	.375	35.000	.500			35.376	.312	35.000	.500	34.750	.625		
42	42.000	41.250	.375	41.000	.500					41.000	.500	40.750	.625		

Ductile Iron Pipe - Standard Classes

Size INCH	OUTSIDE DIA. INCH	Class 50		Class 51		Class 52		Class 53		Class 54		Class 55		Class 56		CEMENT LINING **STD THICKNESS	**DOUBLE THICKNESS
		WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.		
3	3.96			0.25	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	0.44	3.93		
6	6.90	0.25	6.40	0.28	6.34	0.31	6.28	0.34	6.22	0.37	6.16	0.40	6.10	0.43	6.04	.125	.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	0.39	10.32	0.32	10.46	0.35	10.40	0.38	10.34	0.41	10.28	0.44	10.22	0.47	10.16		
12	13.20	0.31	12.58	0.34	12.52	0.37	12.46	0.40	12.40	0.43	12.34	0.46	12.28	0.49	12.22		
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	.1875	.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	0.62	37.06	0.58	37.14	0.63	37.04	0.68	36.94	0.73	36.84		
42	44.50	0.47	43.56	0.53	43.44	0.59	43.32	0.65	43.20	0.71	43.08	0.77	42.96	0.83	42.84	.250	.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 I.D. BY DIMENSION SHOWN

Pipe Charts

Stainless Steel, Hastelloy "C" & Titanium Pipe

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

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

Pipe Charts

Cast Iron Pipe - ASA Standard

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

Cast Iron Pipe - AWWA Standard

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

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

Pipe Charts

Copper Tubing

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