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FD-7000
Ultrasonic Flowmeter

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WARNING: These products are not designed for use in, and should not be used for, human applications.

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BEFORE OPERATING THE FD-7000

Important Notice!

The FD-7000 flow meter is equipped with a Lead Acid Gel Cell battery. This battery will require charging before initial operation.

Apply AC power, utilizing the enclosed line power cord, to the FD-7000 for a period of 16-24 hours prior to using the product for the first time. The line cord connects to the socket connection located on the side of the enclosure.

The FD-7000 has an integral charging circuit that prevents overcharging. The instrument can be permanently connected to AC line power without damaging the flow meter or the battery.

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QUICK-START OPERATING INSTRUCTIONS

This manual contains detailed operating instructions for all aspects of the FD-7000 instrument. The following condensed instructions are provided to assist the operator in getting the instrument started up and running as quickly as possible. This pertains to basic operation only. If specific instrument features are to be used or if the installer is unfamiliar with this type of instrument, refer to the appropriate section in the manual for complete details.

Location

1. TRANSDUCER LOCATION

A. Determine the appropriate mounting location for the transducers by referring to **Figure 1**.

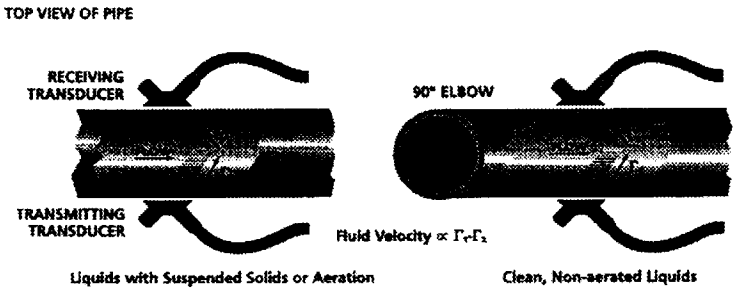

Figure 1 Transducer Locations

Pipe Preparation and Mounting

2. PIPE PREPARATION AND TRANSDUCER MOUNTING

A. The piping surface, where the transducers are to be mounted, needs to be clean and dry. Remove loose scale, rust and paint to ensure satisfactory acoustical bonds.

B. Connect the elastic mounting strap around the pipe. Leave the strap just loose enough to slip the transducers underneath.

C. Apply a liberal amount of silicone grease (enclosed) onto the transducer faces and the pre-

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QUICK-START OPERATING INSTRUCTIONS

pared areas of the pipe.

D. Place each transducer under the mounting strap, 180° apart on the pipe. Ensure that the transducer cables are facing the same direction. See **Figure 2**.

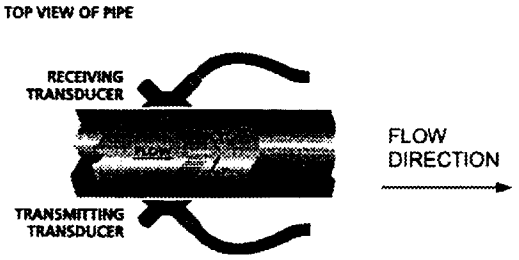

Figure 2 Transducer Cable Direction

Connections

E. Route the transducer cable back to the transmitter, avoiding locations near high voltage supply wires.

3. **TRANSDUCER CONNECTION**

A. Connect the transducer plug to the appropriate mating socket on the side the FD-7000 enclosure.

Startup

4. **INITIAL SETTINGS AND POWER UP**

A. Set the SENSITIVITY control to - 2.

B. Press the POWER button. The POWER indicator will illuminate.

C. **If the pipe is full of a flowing liquid,** the SIGNAL STRENGTH meter will indicate and the READ indicator will illuminate.

D. Adjust the SENSITIVITY control so that the right-most green LED just comes ON.

E. The default display indicates fluid velocity as either FPS or MPS. Refer to the appropriate place in this manual for specific features and options.

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PART 1 - INTRODUCTION

General

The FD-7000 ultrasonic flow meter is designed to measure the fluid velocity of liquid within closed conduit. The transducers are a non-contacting, clamp-on type, which will provide benefits of non-fouling operation and ease of installation.

The flow meter operates by transmitting an ultrasonic sound from its transmitting transducer through the pipe wall into the flowing liquid. The sound will be reflected by suspended particles or bubbles within the liquid and recorded by the receiving transducer. A frequency shift (Doppler effect) will occur that is directly related to the speed of the moving particle or bubble. This shift in frequency is interpreted by the instrument and converted to various user defined measuring units.

A unique feature of this product is that it employs a proprietary digital filtering system and recognition circuit. This feature allows the instrument to measure fluid velocities of clean liquids if the transducers are mounted downstream from a 90° elbow. The non-symmetrical hydraulic turbulence which occurs downstream of an elbow is captured, linearized and can be displayed as liquid velocity and volume. This capability is not available in conventional Doppler technology.

Application Versatility

The FD-7000 flow meter can be successfully applied on a wide range of metering applications. The simple to program transmitter allows the standard product to be used on pipe sizes ranging from 1 - 120 inch [25 - 3048 mm] pipe I.D. (With the small pipe transducer option, the pipe size range is 0.25 - 1 inch [6 - 25 mm]). A variety of liquid applications can be accommodated: raw sewage, reclaimed water, cooling water, river water, plant effluent, mining slurries, sludge, etc. Because the transducers are non-contacting and have no moving parts, the flow meter is not affected by system pressure, fouling or wear. Standard transducers are rated to 250°F [121°C]. Optional high temperature transducers are rated to operate to 400°F [204°C].

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PART 1 - INTRODUCTION

User Safety

The FD-7000 employs modular construction and provides electrical safety for the operator. The display face contains voltages no greater than 9 Vdc and the metal work is electrically connected to Earth Ground. All user connections are made through sealed bulk-head plugs located on the side of the FD-7000 enclosure.

Battery Backup

A rechargeable nickel-cadmium battery on the back of the display board retains all user-entered configuration values in memory for several years (at 25°C), even if power is lost or turned off. The ten year battery is continually trickle charged whenever line power is applied. A completely discharged battery recharges fully after 48 hours of instrument operation.

Product Identification

The serial number and complete model number of your FD-7000 is located on the inside of the transmitter's cover.

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PART 2 - PRE-INSTALLATION CHECKOUT

Unpacking

After unpacking, it is recommended to save the shipping carton and packing materials in case the instrument is stored or re-shipped. Inspect the equipment and carton for damage. If there is evidence of shipping damage, notify the carrier immediately.

Functional Test

The FD-7000 flow meter can be checked for basic fund tionality using the following **Bench Test** procedure. It is recommended that this operation be performed before each day of operation.

Procedure:

1. Open the FD-7000 transmitter cover.
2. Connect the transducer cable connector plug to the corresponding connector socket location on the side of the FD-7000 enclosure. See **Figure 3**.
3. Set the transmitter SENSITIVITY control [located on the front panel] to -2.
4. Apply power.
5. Hold the transducers, the flat sides facing each other, approximately 6-8 inches [150-200 mm] apart.
6. Move the transducers towards and away from each other 1 inch [25mm] for several cycles at approximately 1 second interval.
7. If unit is functioning properly, the READ LED will illuminate and the rate display will indicate flow readings.

Bench Test is Complete

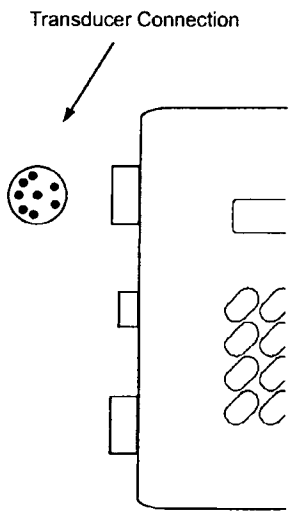

Figure 3

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PART 2 - TRANSDUCER INSTALLATION

Transducer Mounting Considerations

The transducers that are utilized by the FD-7000 contain piezo electric crystals for transmitting and receiving ultrasonic sound energy through the pipe wall.

The transducers can be mounted in three different configurations. The selection of the proper configuration is dependent on the liquid to be measured characteristics.

The three liquid characteristics, which will affect mounting location and orientation, are as follows:

Step A - Mounting Locations

CASE 1: Liquid that contains 25 to 10,000 PPM [1%] of 30 micron or larger suspended solids or aeration.

CASE 2: Liquid that contains greater than 10,000 PPM [1%] of 30 micron or larger suspended solids or aeration.

CASE 3: Liquid that contains fewer than 25 PPM of 30 micron or larger suspended solids or aeration and suspended solids and aeration content which is smaller than 30 microns.

CASE 1:

Liquid that contains 25 to 10,000 PPM [1%] of 30 micron or larger suspended solids or aeration.

Select a transducer mounting location with adequate straight runs of pipe, both upstream and downstream, to achieve stable readings. Examples of minimum upstream and downstream requirements are included in **Table 1**.

Mount the transducers 180° apart and facing each other on the pipe. If the pipe is horizontal, the preferred mounting orientation is 3 and 9 o'clock, with 12 o'clock being the top of the pipe. Orientation on vertical pipes does not matter. See **Figure 4**.

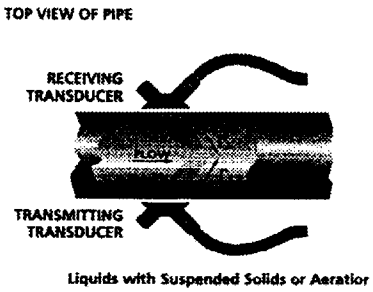

Figure 4

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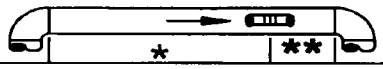
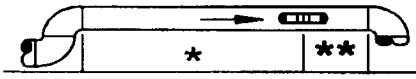
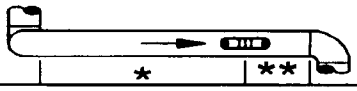
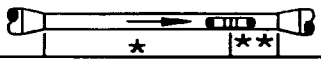
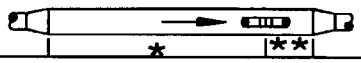
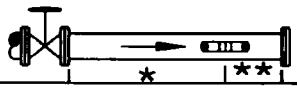
PART 2 - TRANSDUCER INSTALLATION

Table 1[1]

Piping Configuration and Transducer Position	Upstream Dimension: Pipe Diameters *	Downstream Dimension: Pipe Diameters **
	9	3
	14	3
	24	4
	8	3
	8	3
	24	4

[1] The FD-7000 system will provide repeatable measurements on piping systems that do not meet these requirements, but the accuracy of these readings may be influenced to various degrees.

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PART 2 - TRANSDUCER INSTALLATION

CASE 2:

Liquid that contains greater than 10,000 PPM [1%] of 30 micron or greater suspended solids or aeration.

The mounting location and straight pipe requirements for CASE 2 liquid characteristics are the same as those describe in CASE 1. The difference will be in the location of the transducers on the pipe. As the discontinuities (suspended solids or aeration) reach a level of approximately 1% or 10,000 PPM, sound can no longer be reliably transmitted through the liquid as it has a tendency to scatter and absorb into the high concentration of discontinuity. To compensate for this, the FD-7000 transducers can be located on the same region of the pipe. In a horizontal pipe, mount the transducers at 2 o'clock and 4 o'clock positions. (Assuming 12 o'clock as the top of the pipe.) See **Figure 5.**

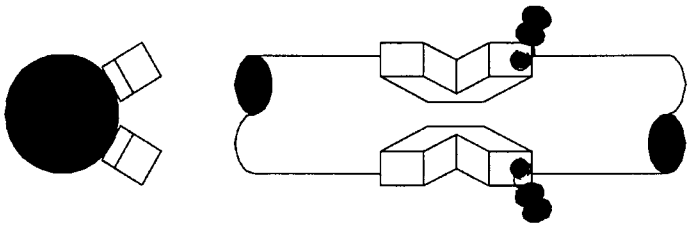

Figure 5

CASE 3:

Liquid that contains fewer than 25 PPM of 30 micron or larger suspended solids or aeration. Or, liquid that contains solids or aeration which is smaller than 30 microns.

The transducers will be mounted 1 to 3 pipe diameters downstream from a 90° elbow. The orientation of the transducers on the pipe will be 180° apart and facing each other and 90° out of the plane of the elbow. See **Figure 6**.

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PART 2 - TRANSDUCER INSTALLATION

STEP B - PIPE SURFACE PREPARATION

Before the transducer heads are bonded to the pipe surface, an area slightly larger than the flat surface of the transducer must be cleaned to bare metal on the pipe. (Plastic pipes do not require preparation beyond removal of paint.) Remove all scale, rust and paint. Thoroughly dry and degrease the mounting surfaces.

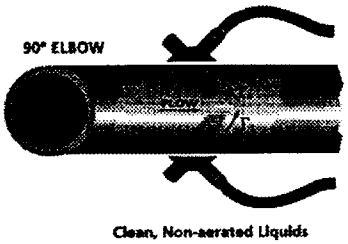

Figure 6

NOTE: Small pits in the piping surface typically do not significantly impact ultrasonic transmission or signal reception.

STEP C - TRANSDUCER MOUNTING

After selecting the applicable mounting location and preparing the piping surface as detailed in Steps A and B, the transducer can be mounted to the pipe.

Note: High Temperature transducer installations require specialized mounting hardware and instructions. Drawings detailing installation of this option is located in the Appendix of this manual.

Steps A and B, Mounting Locations and Pipe Preparation sections of this manual apply to the High Temperature option. Reference these sections as required.

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PART 2 - TRANSDUCER INSTALLATION

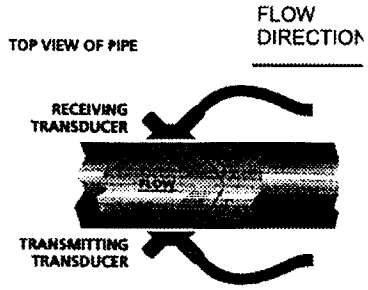

Figure 7

To assure an acoustically conductive path between the transducer face and the prepared piping surface, a coupling compound is employed. Enclosed with the FD-7000 system is tube of Dow Corning 111, silicone grease. This couplant is satisfactory for temporarily mounting the transducers to the pipe. If the installation is long-term (more than a few days), OMEGA recommends utilizing a silicone-based RTV such as Dow Corning RTV-732. If alternate couplants are utilized, the grease chosen must be rated to not flow at the temperature of the pipe.

1. Wrap the elastic strap (enclosed) around the pipe in the area where the transducers are to be mounted. Mount the strap snuggly, but leave the strap just loose enough to allow the transducers to be placed underneath.
2. Spread an even layer of coupling compound, approximately 1/8 inch [3mm] thick, to the prepared transducer mounting areas of the pipe. Utilize Dow 111 for temporary mounting or Dow 732 for permanent mounting.
3. Spread an even layer of the coupling compound, approximately 1/8 inch [3mm] thick, to the flat face of the two transducers.
4. Place each transducer under the strap with the flat face positioned towards the pipe. The notch on the back of the transducer will provide a mounting surface for the strap. The transducer cables must be facing in the same direction for proper operation. See **Figure 7**. NOTE: Large pipes may require two people for this procedure.
5. Tighten the strap tight enough to hold the transducers in place, but not so tight that all of the couplant squeezes out of the gap between the transducer face and pipe. Ensure that the transducers are squarely aligned on the pipe.
6. Route the transducer cable back to the transmitter mounting area avoiding high voltage cable trays and conduits. Do not attempt to add additional cable to the factory supplied transducer cable. The FD-7000 proc-

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PART 2 - TRANSDUCER INSTALLATION

esses very small signals, so the cable shield must be continuous.

7. If the transducers are to be permanently mounted using Dow 732, the RTV must be completely cured before proceeding to Instrument Start up. Ensure that no relative motion between the transducer and pipe occurs during the 24 hour curing process. If Dow 111 grease was used for temporary operation of the FD-7000 system, proceed with the Instrument Start-up procedures.

Transducer Installation is complete.

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PART 2 - ELECTRICAL CONNECTIONS

Transmitter Location

The FD-7000 enclosure should be located in an area that is convenient for observation of the LCD readout and keypad operations. To prolong the life of the keypad and controls, the enclosure cover should be left closed when the unit is unattended.

Place the FD-7000 transmitter in a location that is:

- Where little vibration exist.
- Protected from falling corrosive fluids.
- Within ambient temperature limits - 22 to 122°F [30 to 50°C]
- Out of direct sunlight. Direct sunlight may increase temperatures within the transmitter to above maximum limit.

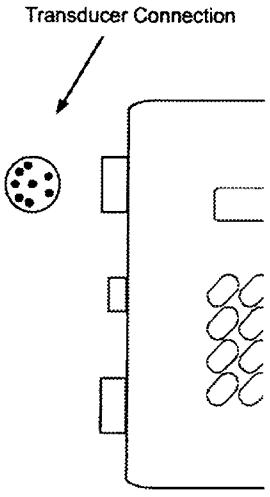

Figure 8

Connect the transducer plug to the socket connection located on the side of the FD-7000 enclosure. Refer to **Figure 8.** Ensure that tension on the retractable cables has not pulled either of the transducers out of position on the pipe. The transducers must be squarely mounted to achieve greatest accuracy.

NOTE: The transducer cable carries low level signals. Do not attempt to add additional cable to the factory supplied transducer cable.

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PART 2 - ELECTRICAL CONNECTIONS

4-20mA Output

The 4-20mA output is proportional to the flow rate measuring scale and can drive a load of up to 600 ohms. The output is isolated from earth ground and circuit low. Connect the load to the **4-20 mA** connection socket located on the side of the FD-7000 enclosure, matching polarity as indicated. **See Figure 9.** A mating plug for the connection socket has been included.

Battery Charging and AC Power Operation

To recharge the internal battery of the FD-7000 or to operate the meter for periods of time greater than 8 hours, connect the meter to AC line power. Line power is connected by plugging the enclosed line cord, to the appropriate connector socket located on the side of the FD-7000 enclosure. See **Figure 10**. Use wiring practices that conform to local codes (National Electric Code Hand book in the USA). Use only the standard three wire connection. The ground terminal grounds the instrument, which is mandatory for safe operation.

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

It is recommended not to run line power with other signal wires within the same wiring tray or conduit.

NOTE: This instrument requires clean electrical line power. Do not operate this unit on circuits with noisy components (i.e. Fluorescent lights, relays, compressors, variable frequency drives, etc.).

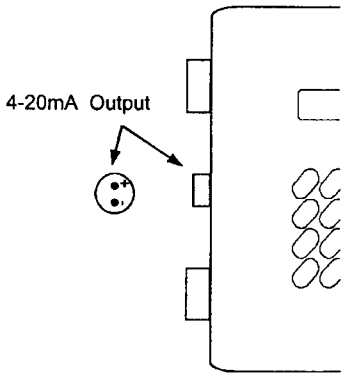

Figure 9

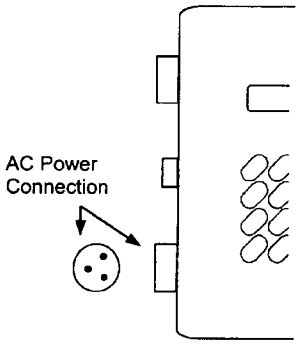

Figure 10

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PART 2 - SERVICE AND MAINTENANCE

Battery Care and Maintenance

The FD-7000 flow meter is equipped with a Lead Acid Gel Cell battery. This battery will require charging before initial operation. Apply AC power, utilizing the enclosed line power cord, to the FD-7000 for a period of 16-24 hours prior to using the product for the first time. The line cord connects to the socket connection located on the side of the enclosure.

The FD-7000 integral battery provides continuous operation for up to 8 hours on a full-charge. The battery is "maintenance free", but it still requires a certain amount of attention to prolong its useful life. To obtain the greatest capacity and longevity from the battery, the following practices are recommended:

- Do not allow the battery to completely discharge. (Discharging the battery to the point where the LOW BATTERY indicator illuminates will not damage the battery. Allowing the battery to stay discharged for long periods of time can degrade the storage capacity of the battery.) When not in use, continually charge the battery by keeping it plugged into line power. The FD-7000 battery management circuitry will not allow the battery to become "over-charged".

NOTE: The FD-7000 will automatically enter a low power consumption mode approximately 1-1/2 minutes after the LOW BATTERY indicator illuminates. This circuit prevents excessive discharge of the internal battery.

- If the FD-7000 is stored for prolonged periods of time, monthly charging is recommended.
- If the FD-7000 is stored for prolonged periods of time, store at a temperature below 70°F [21°C].

The CHARGING indicator will always be illuminated when the FD-7000 is connected to line power and the flow meter is turned ON. If the FD-7000 is turned OFF and line power is connected, the CHARGING indicator will illuminate only when the internal circuit is charging the battery. During storage, the CHARGING indicator will cycle as necessary.

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PART 2 - SERVICE AND MAINTENANCE

Desiccant Cartridge

The FD-7000 is equipped with a DESICCANT CARTRIDGE, which is located in the face plate of the meter. The purpose of the cartridge is to absorb the humidity that was present inside of the enclosure when the product was manufactured and to absorb moisture that may seep into the enclosure during field operation. Observing the color indicator of the DESICCANT CARTRIDGE and replacing it when it turns PINK will decrease the chance of corrosion and resulting failure of the internal components of the FD-7000:
Procedure

1. Obtain a new DESICCANT CARTRIDGE from OMEGA.
2. Replace the cartridge in a temperature and humidity controlled environment. Allow the meter to reach the same ambient temperature as the area in which the cartridge will be replaced. (Do not attempt to change the cartridge if the meter is below the Dew Point Temperature.)
3. Remove the old cartridge with a 1-3/8" open-end wrench or appropriate adjustable wrench.
4. Insert the new cartridge and tighten with the wrench.
5. Discard the used cartridge.

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PART 3 - STARTUP AND CONFIGURATION

Before Starting the Instrument

Note: The FD-7000 flow meter system **requires a full pipe of flowing liquid** before a successful startup can be completed. Do not attempt to make adjustments or change configurations until both a full pipe and liquid flow are verified.

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

Instrument Startup

Procedure:

1. Verify that all wiring is properly connected and routed.
2. Set the SENSITIVITY Control to -2. This control is located on the FD-7000 front panel.
3. Apply power. The POWER indicator will illuminate.
4. Adjust the SENSITIVITY control so that the right-most LED on the SIGNAL STRENGTH bar meter just illuminates or SIGNAL STRENGTH is at least in the yellow/green region.

Important!

Note: It is undesirable to adjust the SENSITIVITY control to a position higher than necessary, as ambient noise can also be amplified. This noise can cause false readings to occur.

5. If the pipe is full of a flowing liquid, the READ indicator will illuminate and the display will begin reading fluid velocity as FPS (Feet per Second) or MPS (Meters per Second). It is normal to have low SIGNAL STRENGTH and FAULT indication at ZERO flow.

6.If a SIGNAL STRENGTH reading in the green portion of the bar meter or a FLOW ANALYZER indication could not be obtained, refer to the troubleshooting section of this manual.

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PART 3 - STARTUP AND CONFIGURATION

Keypad Configurations

After a successful flow meter installation and startup (covered in the previous sections of this manual) the FD-7000 can be keypad configured to provide select engineering unit readings of flow and a scaled 4-20mA output. Configuration inputs are made via the keypad and are stored by the microprocessor. The entries are retained by the flow meter's backup battery in the event of power failure. If fluid velocity readings in FPS or MPS are the only required measurement, keypad configuration is not required.

Modes of Operation

The RUN/ENT key toggles the flow meter between the two modes of operation.

RUN Mode: This is the primary operating mode of the flow meter. The meter is in RUN mode when the readout is displaying flow as velocity (FPS, MPS) OR volume (GPM, LPM, LPS). In RUN mode the outputs are active and transmitting signals proportional to flow rate.

ENTRY Mode: This mode is used to view or change the configuration of the flow meter. When the FD-7000 ships from the OMEGA factory, it contains the following Default configuration:

Default Configuration

PARAMETER	US	METRIC
ID	1 Inch	25 mm
UNITS	1 [FPS]	1 [MPS]
DAMP	1 Sec	1 Sec
Volume/PLS	ϕ	ϕ
FULL SCALE	5 FPS	6.08 MPS
CAL	100%	100%

Each of these parameters may be viewed and/or modified in the ENTRY Mode. Changes are processed when the RUN/ENT is pressed and the meter returns to RUN MODE. In ENTRY Mode flow totalization is suspended and process outputs are frozen at the last value recorded.

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PART 3 - STARTUP AND CONFIGURATION

Pipe I.D. Input

The ID key allows the entry of a pipe's Internal Diameter. The FD-7000 utilizes the I.D. constant to process volumetric flow rates such as GPM (Gallons per Minute) or LPM (Liters per Minute). The entry is made as either inches or mm, dependent on whether the unit is configured as U.S. units or Metric units.

Press the I.D. key from the ENTRY MODE. The display will show

INSIDE DIAMETER

This is the present I.D. constant. Enter a new I.D. based on information obtained from the pipe manufacturer, a physical measurement or a pipe chart. Some common pipe sizes and dimensions are located on a series of charts located in the Appendix of this manual. The acceptable input range for the I.D. constant is shown in Table 3. FD-7000-SI

Table 3

I.D.	US	METRIC
Max	120 Inches	3300 mm
Min *	0.125 Inches	6 mm

* Pipe sizes less than 1 inch [25 mm] require a Small Pipe Transducer. FD-7000-SI

Note: If a decimal value of less than 1 is to be entered, enter 0 . X X X. The zero must precede the decimal value.

Note: If an entered value is out of the acceptable range of the instrument, an UNDER! or OVER! indication will be displayed. The meter will not allow any other entries to be made until a legitimate value is entered.

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PART 3 - STARTUP AND CONFIGURATION

Full Scale Input

The FULL SCALE key allows the entry of the highest anticipated fluid velocity. The entry is made as either FPS (Feet per Second) or MPS (Meters per Second) dependent on whether the unit is configured as US units or Metric units. The FULL SCALE input is used by the FD-7000 microprocessor to scale the 4-20mA output and adjust the resolution of the flow rate display.

Acceptable input range for the FULL SCALE constant is shown in **Table 4**.

Table 4

I.D.	US	METRIC
Max	20 FPS	8 MPS
Min *	n/a	n/a

Important!

* Note: FULL SCALE values below 1.5 FPS [0.5 MPS] are not recommended.

Note: If an entered value is out of the acceptable range of the instrument, a RANGE! indication will be displayed. The meter will not allow any additional entries to be made until a legitimate value is entered.

Volume to Velocity Conversion

Two useful equations which relate volumetric flow in round pipes to flow velocity are as follows:

$$FPS = \frac{U.S.\ GPM \times 0.409}{ID^2\ (inches)}$$

$$MPS = \frac{LPM \times 21.23}{ID^2\ (mm)}$$

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PART 3 - STARTUP AND CONFIGURATION

Totalizer Exponent Input

The VOL. PULSE key allows the entry of a totalizer exponent. This feature is useful for accommodating a very large accumulated flow. The exponent is a " X 10 " multiplier, which can be from 0 (no multiplier) to 2 (X 100). For example, to totalize in GAL X 100, a VOL. PULSE value of 2 would be used (10^2 or 100).

Acceptable input range for the VOL. PULSE constant is shown in **Table 5**.

Table 5

I.D.	US	METRIC
Max	2	2
Min *	0	0

* Note: If an entry greater than 2 is attempted, the meter will display OVER!. If a non- whole number value is attempted, the meter will display RANGE!. A legitimate value will need to be entered.

After a VOL. PULSE value is entered, the display will reflect the unit as $0=10^0$= X1, $1=10^1$=X10 and $2=10^2$=X100.

Table 6 illustrates various codes and their display results.

Table 6

VOL. PULSE CODE	ENG. NOTATION	DISPLAY MAXIMUM
0	10E0	999,999
1	10E1	999,999
2	10E2	999,999

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PART 3 - STARTUP AND CONFIGURATION

Engineering Units Input

The UNITS key allows the selection of measuring units. **Table 7** shows applicable codes for the engineering units available.

Table 7

UNITS CODE	U.S.	METRIC
1	FPS	MPS
2	GPM	LPM
3	MGD	LPS

Attempting to enter values other than 1, 2 or 3 will result in an UNDER! or OVER! to be displayed. Non-whole number values will result in a RANGE! display. A legitimate value must be entered.

Altering the CALibration of the FP-7000

A few factors can influence the readings of the FD-7000 flow meter. The CAL entry allows the user to compensate for flow discrepancies without affecting the factory calibration. Examples of situations that can cause reading discrepancies are:

- Operation on liquids with sonic velocity carrying properties that are different than water. Please refer to the Fluid Sound Speed correction chart located in the Appendix of this manual.
- Transducers mounted in non-recommended locations.
- Operation on fluids with a large amount of suspended solids.

By applying a CAL value other than 100%, the factory calibrated readings will be altered by the percentage entered. This CAL value will not be reflected in the 4-20mA output.

For example, if a reading of 175 GPM is displayed and the known flow rate is 160 GPM, a CAL value of

$$\frac{160\ \text{GPM}}{175\ \text{GPM}} \times 100 = 91.4\%$$

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PART 3 - STARTUP AND CONFIGURATION

The FD-7000 will not allow decimal values to be entered as a CAL constant, so round to the nearest whole number. In this case 91%.

Acceptable input ranges for the CAL constant are shown in **Table 8**. Values outside of this range will result in an OVER! or UNDER! Display. Non-whole number entries will result in a RANGE! Display. Enter an appropriate value.

Table 8

I.D.	US	METRIC
Max	200%	200%
Min	3%	3%

Display Damping

The DAMP key allows the selection of time duration between display updates. The value selected and entered will result in display updates of

n x 2 = seconds between updates

Acceptable input ranges for the DAMP constant are shown in **Table 9**. Values outside of this range will result in an OVER! or UNDER! display. Entry of an appropriate value is required.

Table 9

I.D.	US	METRIC
Max	5	5
Min	0.5	0.5

The TEST Diagnostic Key

The TEST key is used for diagnostic purposes. It displays the operand presently available at the analog to digital converter. This value will always be in the range of 0 to 255.

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PART 3 - STARTUP AND CONFIGURATION

System and Totalizer RESET

The RESET key is used for generating a system reset or to reset the accumulated flow. Press the RESET button from the ENTER Mode. A choice is then made to :

RESET	Reset the system
VOL. MULT	Press VOL PULSE to re-set the totalizer to zero.

If the RESET key is pressed again, all configuration constants will return to default values.

If the VOL. PULSE key is pressed, the accumulated flow will be erased and the display will return to zero.

Reset the Flow Totalizer

In RUN Mode, pressing the decimal point once will suspend totalizer accumulation. Pressing the decimal point again will clear the total. Pressing it a third time will restart the accumulation from zero.

Note: In RUN mode, the key presses are processed and displayed at the interval defined by the DAMP constant setting. (i.e. If the DAMP constant is set to 10, the key presses will be acknowledged only every 20 seconds.)

FLOW ANALYZER

The FLOW ANALYZER bar meter indicates the relative condition of the Doppler signal that is being processed by the FD-7000. When the instrument is utilized on liquids with suspended solids or aeration, the FLOW ANALYZER will indicate within the two right segments — an ideal Doppler condition. When the FD-7000 is used to measure cleaner liquids, the FLOW ANALYZER bar meter will search its discrete filter banks and adjust to match the particular liquid parameters that are present. The bar meter will indicate these changes when they occur. If no segments are illuminated on the FLOW ANALYZER, the level of liquid discontinuity or hydraulic turbulence is inadequate and the transducers will have to be relocated. Typically, moving the transducers closer to a 90° elbow will provide adequate liquid conditions.

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PART 4 - TROUBLE SHOOTING

CONDITION	POSSIBLE CAUSE
Unit does not turn "ON" when power is applied These procedures require the face plate to be removed from the enclosure.	• Verify that the battery is charged. Plug into an AC power source. • Test the fuse • Ensure the terminal block located in the upper left corner of the main PCB is secure • Verify that ribbon cables between PCBs are connected.
OVERRANGE light is ON	• Increase the value of the FULL SCALE constant. • Verify that fluid velocity is not greater than 20 FPS [6.08 MPS]
FAULT light is ON; low SIGNAL STRENGTH indication	• Ensure that the transducers are properly mounted to the pipe. • Verify that transducer connections are correct • Ensure that the pipe is full of moving liquid. • Increase SENSITIVITY so that right-most SIGNAL STRENGTH light just comes ON. • On cleaner liquids, move the transducers closer to a 90° pipe elbow. • On dirtier liquids, mount the transducers as described in CASE 3 of Part 2 of this manual. • If the pipe has a polyethylene liner, move the transducers to another area. The liner may contain an air void at this location. (continued)

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PART 4 - TROUBLE SHOOTING

FAULT light is ON; low SIGNAL STRENGTH indication (continued)	• If GND connection and pipe are at different potentials, ground FD-7000 to pipe potential. • If Variable Frequency Drives are being utilized, verify that the FD-7000 obtains a READ light when the pump turn OFF. If possible, increase the carrier frequency of the drive.
Stability of flow readings are unsatisfactory This procedure requires the face plate to be removed from the enclosure.	• Increase the DAMP constant from keypad. • Increase the system time constant by turning R17 (DAMP) clockwise till readings are satisfactory. • Move transducers to a location further from piping tees, elbows, valves, filters, etc.
Erroneous Reading	• Transducers mounted incorrectly. • Another local ultrasonic instrument is operating at about the same frequency [consult the Dynasonics factory]. • Presence of large amounts of suspended solids or aeration. Use CAL constant to compensate. • Sources of radiated interference are present. Apply appropriate shielding. • An electrically noisy power supply is powering the FD-7000. Power the meter with a circuit that does not power motors, ballasts or switching supplies.
The FD-7000 display indicates flow, when true fluid velocity is zero.	• Verify that residual leakage and flow is not present. [I.e. leaking check valves] • Verify that SENSITIVITY is not adjusted too high. With nominal flow running through the pipe, adjust SENSITIVITY control till the right-most bar meter light just comes ON.

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PART 5 - APPENDICES

Appendices

Spare Parts List
Mechanical Drawing
Fluid Sound Speed Conversion Chart
Clean Liquid Installation Guide
Pipe Dimension Chart: Cast Iron
Pipe Dimension Chart: Steel, SS, PVC
Velocity to Volumetric Conversion Chart
Statement of Warranty
Customer Service

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SPARE PARTS - FD-7000

PART NUMBER	DESCRIPTION
FD-7000-STD	FTD-7000 Std. Temp./Std. Pipe Transducer
FD-7000-HT	FTD-7000 High Temp./Std. Pipe Transducer
FD-7000-SI	FTD-7000 Std. Temp./Small Pipe Transducer
FD-7000-230VAC	FD-7000 Std. Temp./Std. Pipe Transducer - 230VAC
FD-7000-M	FD-7000 Std. Temp./Std Pipe Transducer - Metric
M-696	FTD-7000 Installation and Operations Manual
FD-7000-EXT	Two conductor, 20 AWG, unshielded cable
D003-0825-001	Stainless Steel Identification Tag
D005-9909-001	FTD-7000 Desiccant Cartridge
FD-7000-BATT	FTD-7000 Gel Cell Battery
D002-2011-002	Couplant, RTV (for permanent mounting)
D002-2011-001	Couplant, Silicone (for temporary mounting)
FD-7000-CHARGER	FD-7000 U.S. Line Cord (Two spades and ground)
FD-7000-CHARGER-UK	FD-7000 U.K. Line Cord (Three rectangular spades)
FD-7000-CHARGER-G	FD-7000 German Line Cord (Two round spades)
FD-7000-EXT	FD-7000 Transducer Extension Cable, 20 ft. [6 m]
D005-1301-002	Fuse, 0.125A Slow Blow, 250V
D005-1301-004	Fuse, 0.75A Slow Blow, 250V
D002-2009-046	Elastic Pipe Strap, 46" [1100 mm]
D002-2009-076	Elastic Pipe Strap, 76" [2000 mm]
D005-0904-001	4-20mA MIL Connector

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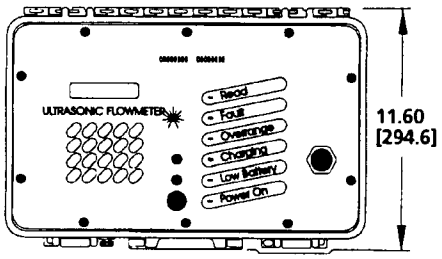
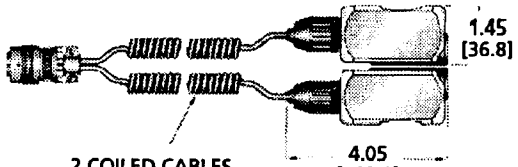
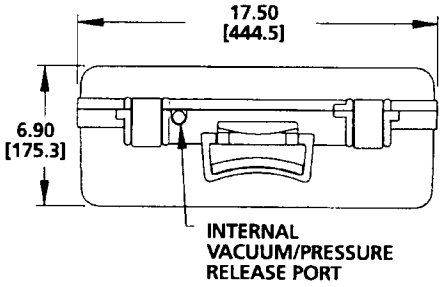
MECHANICAL DRAWING

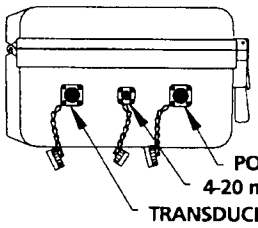
Inches
[mm]

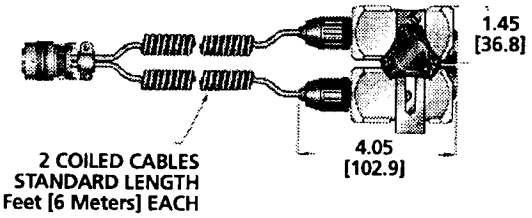


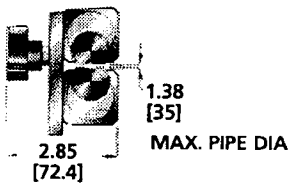
STANDARD CABLES & TRANSDUCERS CONFIGURATION











OPTIONAL SMALL PIPE TRANSDUCER AND CABLE ASSEMBLY

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Fluid Sound Speeds

Original Date: 7/30/99
Revision: none
Revision Date: none

Fluid	Specific Gravity 20 degrees C	Sound Speed m/s	Sound Speed ft/s	delta-v/degree C m/s/degree C	Kinematic Viscosity m^2/s
Acetate, Butyl (n)		1270	4163.9		
Acetate, Ethyl	0.901	1085	3559.7	4.4	0.489
Acetate, Methyl	0.934	1211	3973.1		0.407
Acetate, Propyl		1280	4196.7		
Acetone	0.79	1174	3851.7	4.5	0.399
Alcohol	0.79	1207	3960.0	4.0	1.396
Alcohol, Butyl (n)	0.83	1270	4163.9	3.3	3.239
Alcohol, Ethyl	0.83	1180	3868.9	4	1.396
Alcohol, Methyl	0.791	1120	3672.1	2.92	0.695
Alcohol, Propyl (I)		1170	3836.1		
Alcohol, Propyl (n)	0.78	1222	4009.2		2.549
Ammonia (35)	0.77	1729	5672.6	6.7	0.292
Anlline (41)	1.02	1639	5377.3	4.0	3.630
Benzene (29,40,41)	0.88	1306	4284.8	4.7	0.711
Benzol, Ethyl	0.867	1338	4389.8		0.797
Bromine (21)	2.93	889	2916.7	3.0	0.323
n-Butane (2)	0.60	1085	3559.7	5.8	
Butyrate, Ethyl		1170	3836.1		
Carbon dioxide (26)	1.10	839	2752.6	7.7	0.137
Carbon tetrachloride	1.60	926	3038.1	2.5	0.607
Chloro-benezene	1.11	1273	4176.5	3.6	0.722
Chloroform (47)	1.49	979	3211.9	3.4	0.550
Diethyl ether	0.71	985	3231.6	4.9	0.311
Diethyl Ketone		1310	4295.1		
Diethylene glycol	1.12	1586	5203.4	2.4	
Ethanol	0.79	1207	3960.0	4.0	1.390
Ethyl alcohol	0.79	1207	3960.0	4.0	1.396
Ether	0.71	985	3231.6	4.9	0.311
Ethyl ether	0.71	985	3231.6	4.9	0.311
Ethylene glycol	1.11	1658	5439.6	2.1	17.208
Freon R12		774.2	2540		
Gasoline	0.7	1250	4098.4		
Glycerin	1.26	1904	6246.7	2.2	757.100
Glycol	1.11	1658	5439.6	2.1	
Isobutanol	0.81	1212	3976.4		
Iso-Butane		1219.8	4002		
Isopentane (36)	0.62	980	3215.2	4.8	0.340
Isopropanol (46)	0.79	1170	3838.6		2.718
Isopropyl alcohol (46)	0.79	1170	3838.6		2.718
Kerosene	0.81	1324	4343.8	3.6	
Linalool		1400	4590.2		

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Linseed Oil	.925-.939	1770	5803.3		
Methanol (40,41)	0.79	1076	3530.2	2.92	0.695
Methyl alcohol (40,44)	0.79	1076	3530.2	2.92	0.695
Methylene chloride (3)	1.33	1070	3510.5	3.94	0.310
Methylethyl Ketone		1210	3967.2		
Motor Oil (SAE 20/30)	.88-.935	1487	4875.4		
Octane (23)	0.70	1172	3845.1	4.14	0.730
Oil, Castor	0.97	1477	4845.8	3.6	0.670
Oil, Diesel	0.80	1250	4101		
Oil (Lubricating X200)		1530	5019.9		
Oil (Olive)	0.91	1431	4694.9	2.75	100.000
Oil (Peanut)	0.94	1458	4783.5		
Paraffin Oil		1420	4655.7		
Pentane	0.626	1020	3346.5		0.363
Petroleum	0.876	1290	4229.5		
1-Propanol (46)	0.78	1222	4009.2		
Refrigerant 11 (3,4)	1.49	828.3	2717.5	3.56	
Refrigerant 12 (3)	1.52	774.1	2539.7	4.24	
Refrigerant 14 (14)	1.75	875.24	2871.5	6.61	
Refrigerant 21 (3)	1.43	891	2923.2	3.97	
Refrigerant 22 (3)	1.49	893.9	2932.7	4.79	
Refrigerant 113 (3)	1.56	783.7	2571.2	3.44	
Refrigerant 114 (3)	1.46	665.3	2182.7	3.73	
Refrigerant 115 (3)		656.4	2153.5	4.42	
Refrigerant C318 (3)	1.62	574	1883.2	3.88	
Silicone (30 cp)	0.99	990	3248		30.000
Toluene (16,52)	0.87	1328	4357	4.27	0.644
Transformer Oil		1390	4557.4		
Trichlorethylene		1050	3442.6		
1,1,1-Trichloro-ethane	1.33	985	3231.6		0.902
Turpentine	0.88	1255	4117.5		1.400
Water, distilled (49,50)	0.996	1498	4914.7	-2.4	1.000
Water, heavy	1	1400	4593		
Water, sea	1.025	1531	5023	-2.4	1.000
Wood Alcohol (40,41)	0.791	1076	3530.2	2.92	0.695
m-Xylene (46)	0.868	1343	4406.2		0.749
o-Xylene (29,46)	0.897	1331.5	4368.4	4.1	0.903
p-Xylene (46)		1334	4376.8		0.662

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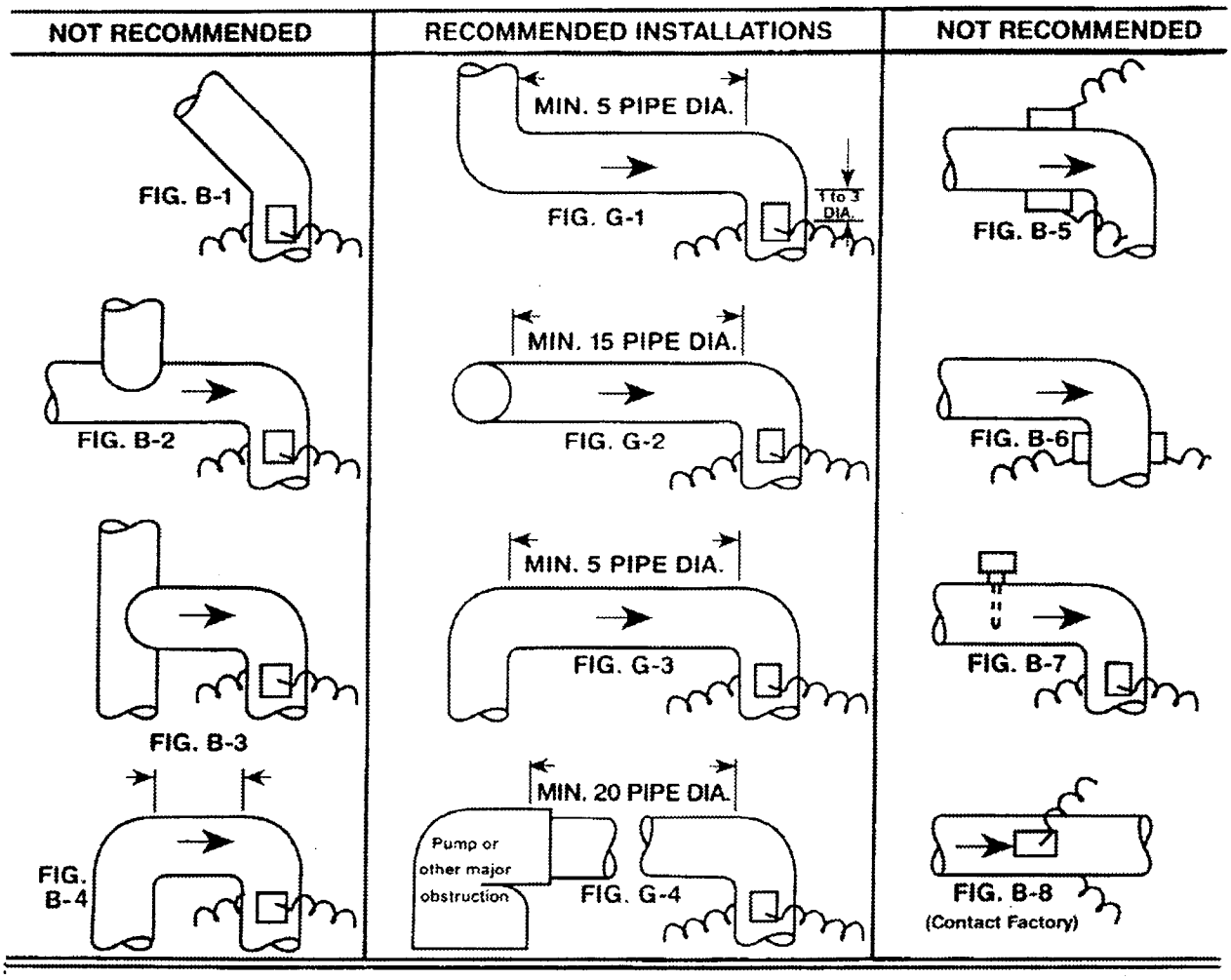
APPLICATION NOTE

FD-7000
ULTRASONIC FLOWMETER

MOUNTING LOCATIONS FOR CLEAN LIQUID APPLICATIONS
(Mount 1 to 3 Pipe Diameters Downstream from a 90° Elbow)



INFLUENCES THAT CAN CAUSE READING INSTABILITY

- Flow Rates less than 0.5 fps (0.15 MPS)
- Improper Piping Configurations will result in incorrect readings
- Extreme Pipe Vibration
- Extreme EMI, RFI, VFD
- Electrical Potential between Earth and Pipe
- Pipe Temperature exceeds Ratings (Std. 180° F (82°F) Otp. 400°F (240°C)

Cast Iron Pipe

Standard Classes

Size (Inches)	CLASS A			CLASS B			CLASS C			CLASS D			CLASS E			CLASS F			CLASS G			CLASS H		
	O.D. Inch	I.D. Inch	Wall	O.D. Inch	I.D. Inch	Wall	O.D. Inch	I.D. Inch	Wall	O.D. Inch	I.D. Inch	Wall	O.D. Inch	I.D. Inch	Wall	O.D. Inch	I.D. Inch	Wall	O.D. Inch	I.D. Inch	Wall	O.D. Inch	I.D. Inch	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	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	9.05	8.13	0.46	9.05	8.03	0.51	9.30	8.18	0.56	9.30	8.10	0.60	9.42	8.10	0.66	9.42	8.10	0.66	9.60	8.10	0.75	9.60	8.00	0.8
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	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	13.20	12.12	0.54	13.20	11.96	0.62	13.50	12.14	0.68	13.50	12.00	0.75	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	15.30	14.16	0.57	15.30	13.98	0.66	15.65	14.17	0.74	15.65	14.01	0.82	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	17.40	16.20	0.60	17.40	16.00	0.70	17.80	16.20	0.80	17.80	16.02	0.89	18.16	16.20	0.98	18.16	16.00	1.08	18.54	16.18	1.18	18.54	16.00	1.27
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	20.34	18.20	1.07	20.34	18.00	1.17	20.78	18.22	1.28	20.78	18.00	1.39
20	21.60	20.26	0.67	21.60	20.00	0.80	22.06	20.22	0.92	22.06	20.00	1.03	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	25.80	24.28	0.76	25.80	24.02	0.89	26.32	24.22	1.05	26.32	24.00	1.16	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	31.74	29.98	0.88	32.00	29.94	1.03	32.40	30.00	1.20	32.74	30.00	1.37	33.10	30.00	1.55	33.46	30.00	1.73						
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	39.60	36.00	1.80	40.04	36.00	2.02						
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	48.00	1.99												
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																		

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Steel, Stainless Steel, P.V.C.

Standard Schedules

Nominal Pipe Size Inches	OUTSIDE DIAMETER	SCH. 5		SCH. 10 (LTWALL)		SCH. 20		SCH. 30		STD.		SCH. 40		SCH. 60		X STG.		SCH. 80		SCH. 100		SCH. 120		SCH. 140		SCH. 180	
		ID	Wall	ID	Wall	ID	Wall	ID	Wall	ID	Wall	ID	Wall	ID	Wall	ID	Wall	ID	Wall	ID	Wall	ID	Wall	ID	Wall	ID	Wall
1	1.315	1.185	0.065	1.097	0.109					1.049		1.049	0.133			0.957	0.179	0.957	0.179							0.815	0.250
1.25	1.660	1.530	0.065	1.442	0.109					1.380		1.380	0.140			1.278	0.191	1.278	0.191							1.160	0.250
1.5	1.900	1.770	0.065	1.682	0.109					1.610		1.610	0.145			1.500	0.200	1.500	0.200							1.338	0.281
2	2.375	2.245	0.065	2.157	0.109					2.067		2.067	0.154			1.939	0.218	1.939	0.218							1.687	0.344
2.5	2.875	2.709	0.083	2.635	0.120					2.469		2.469	0.203			2.323	0.276	2.323	0.276							2.125	0.375
3	3.500	3.334	0.083	3.260	0.120					3.068		3.068	0.216			2.900	0.300	2.900	0.300							2.624	0.438
3.5	4.000	3.834	0.083	3.760	0.120					3.548		3.548	0.226			3.364	0.318	3.364	0.318								
4	4.500	4.334	0.083	4.260	0.120					4.026	0.237	4.026	0.237			3.826	0.337	3.826	0.337			3.624	0.438	3.624	0.438	3.438	0.531
5	5.563	5.345	0.109	5.295	0.134					5.047	0.258	5.047	0.258			4.813	0.375	4.813	0.375			4.563	0.500	4.563	0.500	4.313	0.625
6	6.625	6.407	0.109	6.357	0.134					6.065	0.280	6.065	0.280			5.761	0.432	5.761	0.432			5.501	0.562	5.501	0.562	5.187	0.719
8	8.625	8.407	0.109	8.329	0.148	8.125	0.250	8.071	0.277	7.981	0.322	7.981	0.322	7.813	0.406	7.625	0.500	7.625	0.500	7.437	0.594	7.187	0.719	7.187	0.719	6.183	1.221
10	10.750	10.482	0.134	10.42	0.165	10.25	0.250	10.13	0.310	10.02	0.365	10.020	0.365	9.750	0.500	9.750	0.500	9.562	0.594	9.312	0.719	9.062	0.844	9.062	0.844	8.500	1.125
12	12.750	12.420	0.165	12.39	0.180	12.25	0.250	12.09	0.330	12.00	0.375	11.938	0.406	11.626	0.562	11.750	0.500	11.370	0.690	11.060	0.845	10.750	1.000	10.750	1.000	10.120	1.315
14	14.000			13.50	0.250	13.37	0.315	13.25	0.375	13.25	0.375	13.124	0.438	12.814	0.593	13.000	0.500	12.500	0.750	12.310	0.845	11.810	1.095	11.810	1.095	11.180	1.410
16	16.000			15.50	0.250	15.37	0.315	15.25	0.375	15.25	0.375	15.000	0.500	14.688	0.656	15.000	0.500	14.310	0.845	13.930	1.035	13.560	1.220	13.560	1.220	12.810	1.595
18	18.000			17.50	0.250	17.37	0.315	17.12	0.440	17.25	0.375	16.876	0.562	16.564	0.718	17.000	0.500	16.120	0.940	15.680	1.160	15.250	1.375	15.250	1.375	14.430	1.785
20	20.000			19.50	0.250	19.25	0.375	19.25	0.375	19.25	0.375	18.814	0.593	18.376	0.812	19.000	0.500	17.930	1.035	17.430	1.285	17.000	1.500	17.000	1.500	16.060	1.970
24	24.000			23.50	0.250	23.25	0.375	23.25	0.375	23.25	0.375	22.626	0.687	22.126	0.937	23.000	0.500	21.560	1.220	20.930	1.535	20.930	1.535	20.930	1.535	19.310	2.345
30	30.000			29.37	0.315	29.00	0.500	29.00	0.500	29.25	0.375	29.250	0.375			29.000	0.500										
36	36.000			35.37	0.315	35.00	0.500	35.00	0.500	35.25	0.375	35.250	0.375			35.000	0.500										
42	42.000									41.25	0.375	41.250	0.375			41.000	0.500										
48	48.000									47.25	0.375	47.250	0.375			47.000	0.500										

Ductile Iron Pipe

Standard Classes

Pipe Size (inches)	Outside Diameter (inches)	Class 50		Class 51		Class 52		Class 53		Class 54		Class 55		Class 56		Cement Lining Std./Double Thickness
		ID	Wall	ID	Wall	ID	Wall	ID	Wall	ID	Wall	ID	Wall	ID	Wall	
3	3.96			3.46	0.25	3.40	0.28	3.34	0.31	3.28	0.34	3.22	0.37	3.14	0.41	
4	4.80			4.28	0.26	4.22	0.29	4.16	0.32	4.10	0.35	4.04	0.38	3.93	0.44	
6	6.90	6.40	0.25	6.34	0.28	6.28	0.31	6.22	0.34	6.16	0.37	6.10	0.40	6.04	0.43	.123/.250
8	9.05	8.51	0.27	8.45	0.30	8.39	0.33	8.33	0.36	8.27	0.39	8.21	0.42	8.15	0.45	
10	11.10	10.32	0.39	10.46	0.32	10.40	0.35	10.34	0.38	10.28	0.41	10.22	0.44	10.16	0.47	
12	13.20	12.58	0.31	12.52	0.34	12.46	0.37	12.40	0.40	12.34	0.43	12.28	0.46	12.22	0.49	
14	15.30	14.64	0.33	14.58	0.36	14.52	0.39	14.46	0.42	14.40	0.45	14.34	0.48	14.28	0.51	
16	17.40	16.72	0.34	16.66	0.37	16.60	0.40	16.54	0.43	16.48	0.46	16.42	0.49	16.36	0.52	
18	19.50	18.80	0.35	18.74	0.38	18.68	0.41	18.62	0.44	18.56	0.47	18.50	0.50	18.44	0.53	.1875/.375
20	21.60	20.88	0.36	20.82	0.39	20.76	0.42	20.70	0.45	20.64	0.48	20.58	0.51	20.52	0.54	
24	25.80	25.04	0.38	24.98	0.41	24.92	0.44	24.86	0.47	24.80	0.50	24.74	0.53	24.68	0.56	
30	32.00	31.22	0.39	31.14	0.43	31.06	0.47	30.98	0.51	30.90	0.55	30.82	0.59	30.74	0.63	
36	38.30	37.44	0.43	37.34	0.48	37.06	0.62	37.14	0.58	37.40	0.45	36.94	0.68	36.84	0.73	
42	44.50	43.56	0.47	43.44	0.53	43.32	0.59	43.20	0.65	43.08	0.71	42.96	0.77	42.84	0.83	.250/.500
48	50.80	49.78	0.51	49.64	0.58	49.50	0.65	49.36	0.72	49.22	0.79	49.08	0.86	48.94	0.93	
54	57.10	55.96	0.57	55.80	0.65	55.64	0.73	55.48	0.81	55.32	0.89	55.16	0.97	55.00	1.05	

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FPS TO GPM CROSS - REFERENCE (Schedule 40)

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

FPS TO GPM: GPM = (PIPE ID)² X VELOCITY IN FPS X 2.45

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

FPS X .3048 = MPS

GPM X .0007 = GPD

GPM X 3.7878 = LPM

FPS TO GPM CROSS - REFERENCE (Schedule 40)

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

FPS TO GPM: GPM = (PIPE ID)² X VELOCITY IN FPS X 2.45

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

FPS X .3048 = MPS

GPM X .0007 = GPD

GPM X 3.7878 = LPM

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NOTES:

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WARRANTY/DISCLAIMER

OMEGA ENGINEERING, INC. warrants this unit to be free of defects in materials and workmanship for a period of **13 months** from date of purchase. OMEGA's WARRANTY adds an additional one (1) month grace period to the normal **one (1) year product warranty** to cover handling and shipping time. This ensures that OMEGA's customers receive maximum coverage on each product.

If the unit malfunctions, it must be returned to the factory for evaluation. OMEGA's Customer Service Department will issue an Authorized Return (AR) number immediately upon phone or written request. Upon examination by OMEGA, if the unit is found to be defective, it will be repaired or replaced at no charge. OMEGA's WARRANTY does not apply to defects resulting from any action of the purchaser, including but not limited to mishandling, improper interfacing, operation outside of design limits, improper repair, or unauthorized modification. This WARRANTY is VOID if the unit shows evidence of having been tampered with or shows evidence of having been damaged as a result of excessive corrosion; or current, heat, moisture or vibration; improper specification; misapplication; misuse or other operating conditions outside of OMEGA's control. Components which wear are not warranted, including but not limited to contact points, fuses, and triacs.

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RETURN REQUESTS/INQUIRIES

Direct all warranty and repair requests/inquiries to the OMEGA Customer Service Department. BEFORE RETURNING ANY PRODUCT(S) TO OMEGA, PURCHASER MUST OBTAIN AN AUTHORIZED RETURN (AR) NUMBER FROM OMEGA'S CUSTOMER SERVICE DEPARTMENT (IN ORDER TO AVOID PROCESSING DELAYS). The assigned AR number should then be marked on the outside of the return package and on any correspondence.

The purchaser is responsible for shipping charges, freight, insurance and proper packaging to prevent breakage in transit.

FOR **WARRANTY** RETURNS, please have the following information available BEFORE contacting OMEGA:

1. Purchase Order number under which the product was PURCHASED,
2. Model and serial number of the product under warranty, and
3. Repair instructions and/or specific problems relative to the product.

FOR **NON-WARRANTY** REPAIRS, consult OMEGA for current repair charges. Have the following information available BEFORE contacting OMEGA:

1. Purchase Order number to cover the COST of the repair,
2. Model and serial number of the product, and
3. Repair instructions and/or specific problems relative to the product.

OMEGA's policy is to make running changes, not model changes, whenever an improvement is possible. This affords our customers the latest in technology and engineering.

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- Rotameters, Gas Mass Flowmeters & Flow Computers
- Air Velocity Indicators
- Turbine/Paddlewheel Systems
- Totalizers & Batch Controllers

pH/CONDUCTIVITY

- pH Electrodes, Testers & Accessories
- Benchtop/Laboratory Meters
- Controllers, Calibrators, Simulators & Pumps
- Industrial pH & Conductivity Equipment

DATA ACQUISITION

- Data Acquisition & Engineering Software
- Communications-Based Acquisition Systems
- Plug-in Cards for Apple, IBM & Compatibles
- Datalogging Systems
- Recorders, Printers & Plotters

HEATERS

- Heating Cable
- Cartridge & Strip Heaters
- Immersion & Band Heaters
- Flexible Heaters
- Laboratory Heaters

ENVIRONMENTAL MONITORING AND CONTROL

- Metering & Control Instrumentation
- Refractometers
- Pumps & Tubing
- Air, Soil & Water Monitors
- Industrial Water & Wastewater Treatment
- pH, Conductivity & Dissolved Oxygen Instruments

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