APPENDIX C: MONITOR MANUFACTURER DOCUMENTATION

Time Delta S

Fixed Transit-Time Flow Meter System

Key Features

- Dynamic flow correction
- Simple configuration
- Digital outputs
- Enhanced anti-bubble measurement technology (ABM)
- Rugged and reliable
- Maintenance free

The Time Delta S is a fixed ultrasonic flow meter based on the transit-time measurement method for measuring flow rates of relatively clean homogeneous liquids utilizing clamp-on sensors. Thanks to microprocessor-based electronics, the flow meter can be easily configured from the front keyboard to particular applications. The Time Delta S is ideally suited for liquid flow measurement for pipe diameters from 0.50 to 235 inches. Systems are composed of a converter and sensor set. Applications include flow measurement of any fluid through which an ultrasonic signal may be transmitted, including those of unknown sound velocities. The flow meter is a compact and lightweight instrument incorporating the latest electronics and high speed digital signal processing technologies (32 bit MPU), resulting in high performance and easy operation.

Features

- **Dynamic flow correction** – system develops characteristic profiles to correct for optimal flow rates across the velocity range
- **Simple configuration** – complete setup from front keyboard and menu driven software interface
- **Digital outputs** – 2 outputs may be configured for totalizer pulse, flow switch, range limiting, overflow, memory alarm, and abnormal signal condition
- **Enhanced anti-bubble measurement technology (ABM)** – removes the effect of entrapped and suspended flow bubbles
- **Rugged and reliable** – NEMA-6 (IP67) enclosure makes Time Delta S well suited to most industrial environments
- **Maintenance free** – no moving parts provides long-term reliable operation
- **High accuracy** – ±0.5% to ±1.0% of velocity typical on calibrated system

Performance Specifications for the Converter

Fluid Conditions

Measured fluid Homogeneous liquids (water, sea water, hydrocarbons or fluid of unknown sound velocity) capable of ultrasonic wave propagation

Fluid turbidity 10000 deg. (mg/l) or less

State of flow Axis-symmetric flow in pipe totally filled with fluid

Fluid temperature Standard Temperature Sensor: -40 to 212°F (-40 to 100°C). High-Temperature Sensor: -40 to 390°F (-40 to 200°C)

Velocity range 0.06 to 105 ft/sec (0.018 to 32 m/sec) bi-directional flow

Piping Conditions

Pipe material Carbon steel, stainless steel, cast iron, copper, pvc, aluminum, ductile iron, asbestos, frp, peek, pvdf, acrylic and other. If other is selected, pipe materials with a sonic velocity range of 3280 to 12136 ft/sec (1000 to 3700 m/sec) can be selected via the keypad (sonic velocity information for several pipe materials is included in the Operator Manual)

Pipe size Small pipe range detector: 0.50 to 4.0 in (13 to 100mm), 2 to 16 in (50 to 400mm). Universal pipe range detector: 8 to 48 in (200 to 1200mm). Large pipe range detector: 8 to 235 in (200 to 6000mm)

Lining material Tar, epoxy, mortar, rubber, Teflon, Pyrex glass, other, or none. If other is selected, liner materials with a sonic velocity range of 3280 to 12136 ft/sec (1000 to 3700 m/sec) can be selected via the keypad. (Sonic velocity information for several liner materials is included in the Operator Manual.)

Fluid type Water, sea water or other. If other is selected, a sonic velocity range of 1640 to 8200 ft/sec (500 to 2500 m/sec) can be selected via the keypad. (Sonic velocity information for several fluids is included in the Operator Manual.)

Measurement Accuracy

Accuracy ±0.5% of velocity for velocities >1.0 ft/sec. typical on calibrated system; ±1.5% to ±2.0% of velocity for velocities <1.0 ft/sec. typical on calibrated system. *(Calibrated system conditions include a minimum of 10 inner pipe diameters of upstream straight pipe run and a minimum of 5 inner pipe diameters of downstream pipe run. Longer runs may be necessary due to pipe configurations.)*

Linearity 0.1% of scale

Repeatability 0.5% or better

Physical Specifications for the Converter

Ambient temperature -10 to 140°F (-23.0 to 60.0°C)

Ambient humidity less than 90% RH

Enclosure Copper aluminum alloy, coated with epoxy paint (blue/gray color)

Environmental rating NEMA-6 (IP67)
Dimensions 8.65H x 9.05W x 3.75D in. (220 x 230 x 95 mm)
Weight 9.9 lbs. (4.5kg)

Functional Specifications for the Converter

Power supply 100 to 240V AC ±10%, 50/60 Hz. Optional 20 to 30V DC
Power consumption Approx. 20 VA
LCD display 2 line, 16 character per line, 4.0W x 1.0H in. (102 x 25mm), high resolution Back-Lit LCD
Keypad 20 keys, tactile feedback
Power failure backup System data stored in non-volatile memory
Response time 0.5 sec. or less
Analog output signal 4 to 20mA DC (isolated), max. load resistance 1K Output can be configured to hold last value, force high, force low or force zero during fault condition, keypad selectable
Transmit output voltage X1, X2, X4 and X8 transmit voltage, keypad selectable
Alarm output signals Two open-collector digital transistor outputs (max., 30V DC, 200mA)
Analog output check Analog output values of -20% to +120% can be forced onto the analog loop via keypad for testing purposes
Alarm output function Open collector digital alarm outputs independently configurable from keypad for the following. Not Used: No output. Signal Error: ON at abnormal measurement. Flow SW high: ON when flow rate exceeds high limit. Flow SW low: ON when flow rate falls below low limit. F: Total alarm: ON when flow total exceeds forward integral switch. R: Total alarm: ON when flow total exceeds reverse integral switch. F: Total overflow: ON when forward integral value overflows. R: Total overflow: ON when reverse integral value overflows. R: Flow direction: ON when reverse flow direction is detected. F: Total Pulse: Forward flow integral pulse. R: Total Pulse: Reverse flow integral pulse *(Note: maximum totalizer pulse = 5 pulses/sec. Minimum totalizer pulse = 1 pulse/day. Totalizer pulse width 50 msec or 100 msec, keypad selectable)*
Communications Option RS-232 port standard
Display language English or Japanese (Katakana)

Measurement Display Screen

System units English or Metric, keypad selectable
LCD display Configurable from keypad to display flow rate and one of the following: forward totalizer value, reverse totalizer value, totalizer difference value, forward totalizer pulse count, reverse totalizer pulse count, flow velocity (ft/sec or m/sec) and output range %
Display Display of forward or reverse totalized flow, keypad selectable—maximum 9 digits, with rollover cycle counter
Totalizer English System Units: gal, Kgal, ft3, Kft3, Mft3, Mbbl, Kbbl, acre-ft (gal = U.S. gallons). Metric System Units: ml, l, m3, Km3, Mm3, Mbbl, bbl, Kbbl

We attempt to provide you with complete information in this catalog. Because of the specific nature of ultrasonic technology, we strongly recommend you contact us regarding application and availability before placing your order.

Ordering Information

Included in standard delivery: converter, manual

FLVS12	Time Delta S fixed transit-time flow meter converter, AC power input	$ 2,650
FLVS42	Time Delta S fixed transit-time flow meter converter, DC power input	3,250

Accessories

Each detector kit includes: Detector unit, 16 ft. signal cable, mounting straps, 3.5 oz tube of sonic coupling compound

	Description	Pipe diameter range	Temperature range	
FLD22	Small diameter sensor (2 MHz)	0.50 to 4.0 in	-40 to 212°F	$ 1,150
FLW12	Small diameter sensor (2 MHz)	2.0 to 16.0 in	-40 to 212°F	1,150
FLW41	Universal sensor (1 MHz)	8.0 to 48.0 in	-40 to 212°F	750
FLW50	Large diameter sensor (0.5 MHz)	8.0 to 235.0 in	-40 to 212°F	2,500
FLD32	High-temperature sensor (2 MHz)	2.0 to 16.0 in	-40 to 390°F	3,500
TKUSTTNIST	Calibration, NIST traceable (5 pt.)			450
TKUSTTPTG	FS-200 Ultrasonic thickness gauge			1,200
TKUSTTSG	Sonic coupling compound			15
TKUSTTSGN	Sonic coupling compound, silicone-free			35
TKUSTTPCSR	Pipe tape measure			30
TKUSTTPLSS	Line isolator/conditioner			359.95
TKUSTTRG58	Signal cable, 50 ohm (16 ft min)			2.50/ft.

Time Delta S

Specifications (continued)

Flow rate English System Units: gal/sec, gal/min, gal/hr, gal/day, ft3/sec, ft3/min, ft3/hr, Mft3/day, bbl/sec, bbl/min, bbl/hr, and Mbbl/day *(Note: gal refers to U.S. gallons; bottom line of LCD display configurable from keypad).* Metric System Units: l/sec, l/min, l/hr, Ml/day, m3/sec, m3/min, m3/hr, Mm3/day, bbl/sec, bbl/min, bbl/hr, and Mbbl/day *(Note: gal refers to U.S. gallons; bottom line of LCD display configurable from keypad)*

Display Maximum 8-digit display of flow velocity and rate with flow direction, keypad selectable *(Note: bottom line of LCD display configurable from keypad)*

Decimal point position Instantaneous flow rate is keypad selectable for the following: 00000000, 0000000.0, 000000.00, 00000.000, 0000.0000, 000.00000, 00.000000 and 0.0000000 *(Note: bottom line of LCD display configurable from keypad)*

Test mode Simulated flow values can be entered directly from the keypad for bench testing alarms, flow switches, totalizers, and the analog output

Damping 0 to 99 sec. (time constant), keypad selectable

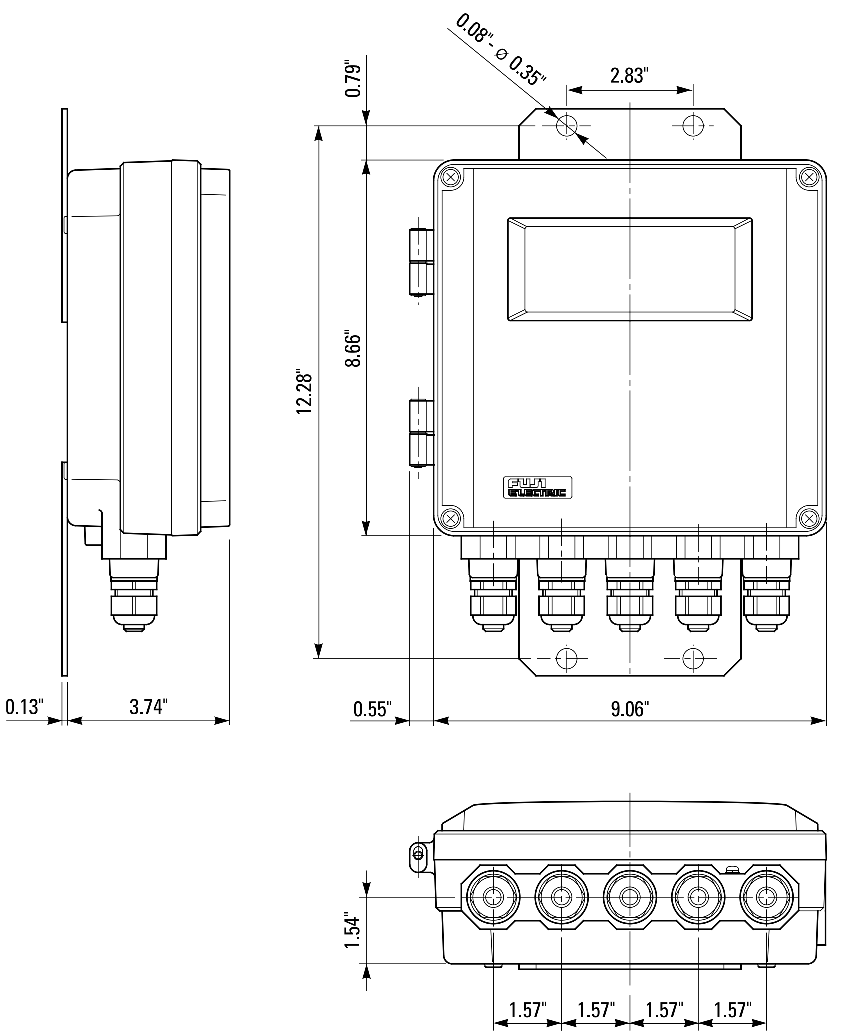
Low flow cutoff 0 to 16.0 ft/sec (0 to 5.0 m/sec), keypad selectable

Zero setting Zero Point Adjust: used when the flow can be stopped; zero point is manually set. Zero Point Clear: used when flow cannot be stopped; automatically sets zero point, keypad selectable

Analog output cal 4 mA and 20 mA (zero and span), keypad selectable

Analog output check Analog output values of -20% to +120% can be forced onto the analog loop via keypad for testing purposes

FLV Converter



Detector Models FLW and FLD

Mounting method V or Z method mounted to outside of pipe by means of steel bands, nylon belts or steel wire

Straight pipe length Upstream side—10d or more; downstream side—5d or more (d = inside pipe diameter)

Signal cable RG-58 or RG-58A/U, 50 ohm coaxial cable

Cable length Standard length 16 ft., maximum length 1000 ft. (300m)

Connection Converter: Internal screw. Detector Models FLW: internal terminal screw, strain-relieved, water-proofed. Detector Models FLD: BNC connector (female)

Pipe diameter range FLD22 (Small diam. pipe range): 0.50 to 4.0 in. (13 to 100mm). FLW12 (Small diam. pipe range): 2.0 to 16 in. (50 to 400mm). FLW41 (Universal pipe range): 8.0 to 48 in. (200 to 1200mm). FLW50 (Large diameter pipe range): 8.0 to 235 in. (200 to 6000mm). FLD32 (High-Temperature detector): 2.0 to 16 in. (50 to 400mm)

Operating temperature range FLD22, FLW12, FLW41, FLW50: -40 to 212°F (-40 to 100°C). FLD32 (High-Temperature): -40 to 390°F (-40 to 200°C)

Ambient temperature range All detector models: -4.0 to 140 °F (-20 to 60°C)

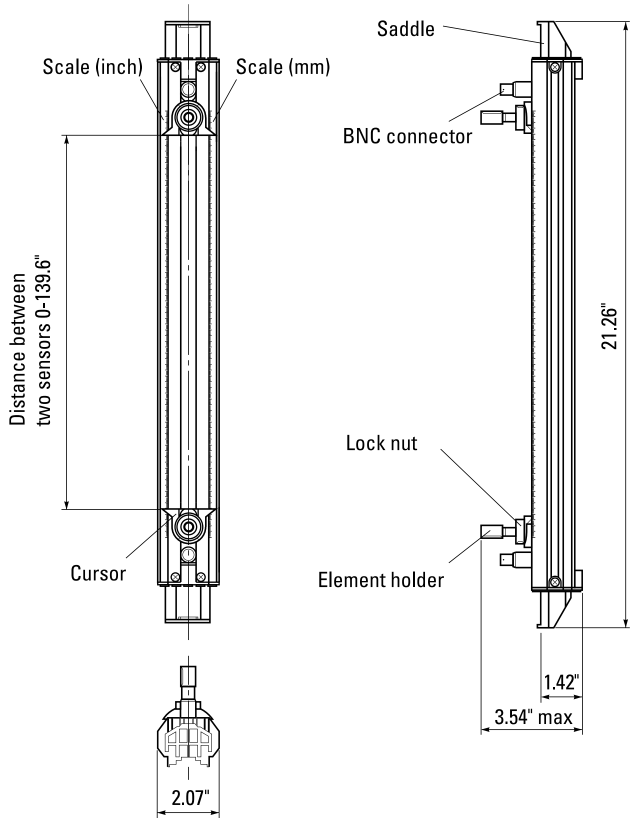
Ambient humidity All detector models: less than 100% RH

Environmental rating FLW Models: NEMA 6 (IP67). FLD22/FLD32 Models: NEMA3 (IP52)

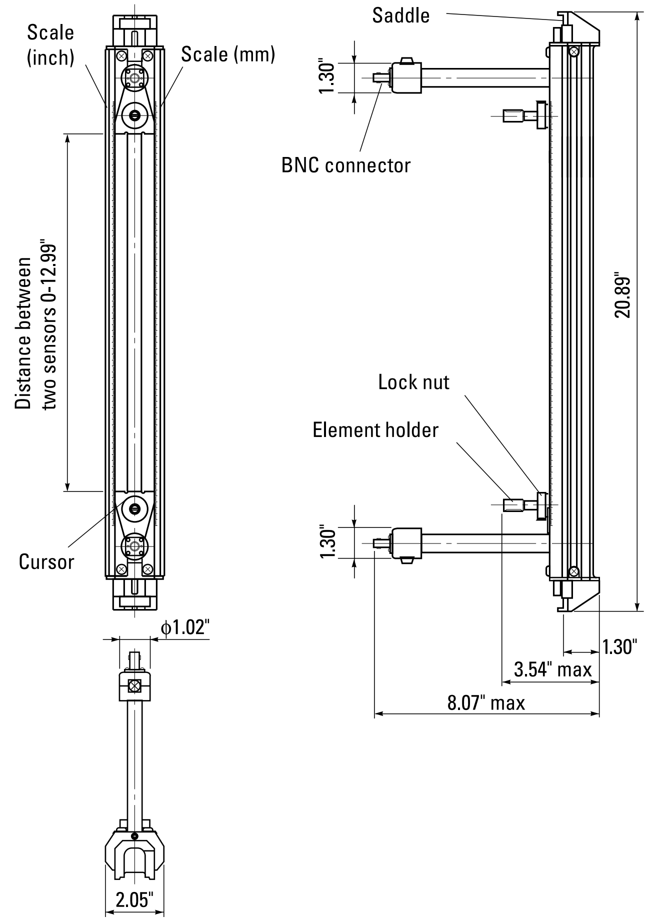
Material FLD22: High impact plastic housing, aluminum alloy/high impact plastic mounting bracket. FLD32: Stainless steel housing, aluminum alloy/high impact plastic mounting bracket. FLW12, FLW41, FLW50: Polyurethane/stainless steel cover plate. FLW12, FLW41, FLW50, FLD22: Epoxy resin crystal wedge. FLD32: Stainless steel crystal wedge

Dimension (WxHxD)/weight FLD22: 12.50 x 2.08 x 1.40 in./2.2 lbs. (540 x 53 x 36mm/1 kg). FLW12, FLW41 (each transducer): 2.83 x 2.36 x 1.57 in./0.9 lbs. (72 x 60 x 40mm/0.4 kg). FLW50 (each transducer): 4.10 x 3.66 x 2.44 in./3.0 lbs. (104 x 93 x 62mm1.4 kg). FLD32 (rail assembly including transducers): 20.86 x 2.05 x 1.30 in./3.53 lbs. (530 x 52 x 33mm/1.6 kg)

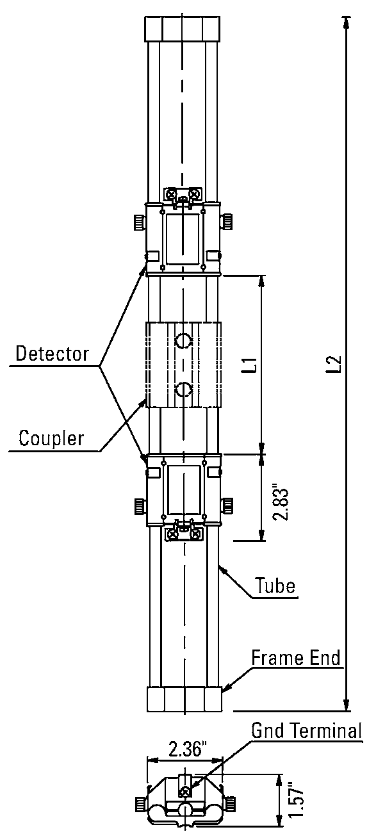
FLD22 Small Diameter Sensor Set



FLD32 High-Temperature Sensor Set



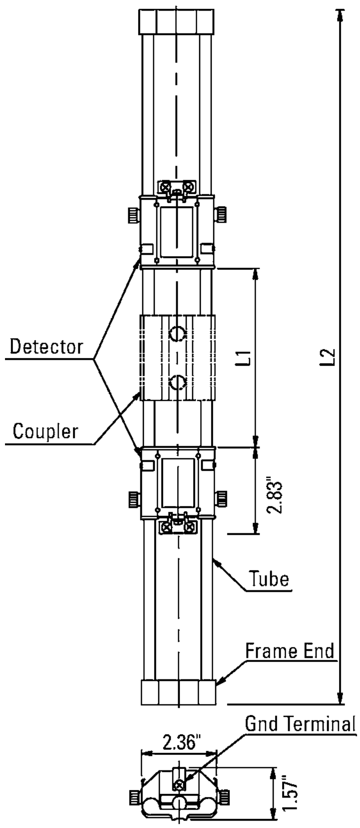
FLW12 Small Diameter Sensor Set



	L1	L2
Without Coupler	11.0"	18.75"
With Coupler	29.52"	37.50"

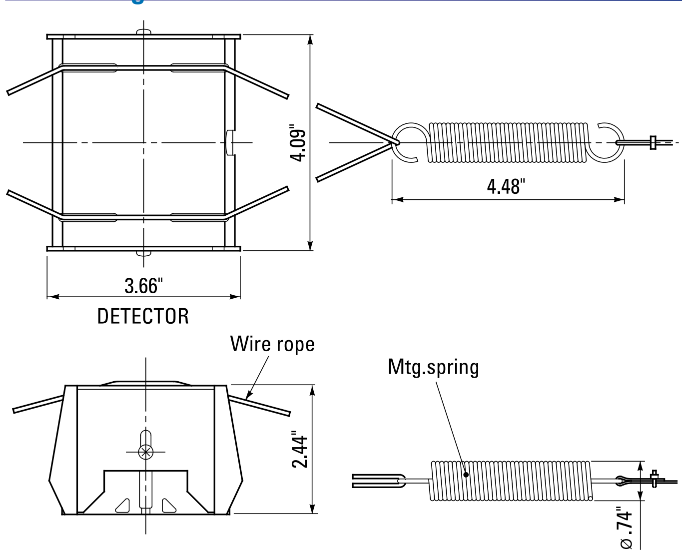
Specifications (continued)

FLW41 Universal Sensor Set



	L1	L2
Without Coupler	11.0"	18.75"
With Coupler	29.52"	37.50"

FLW50 Large Diameter Sensor Set

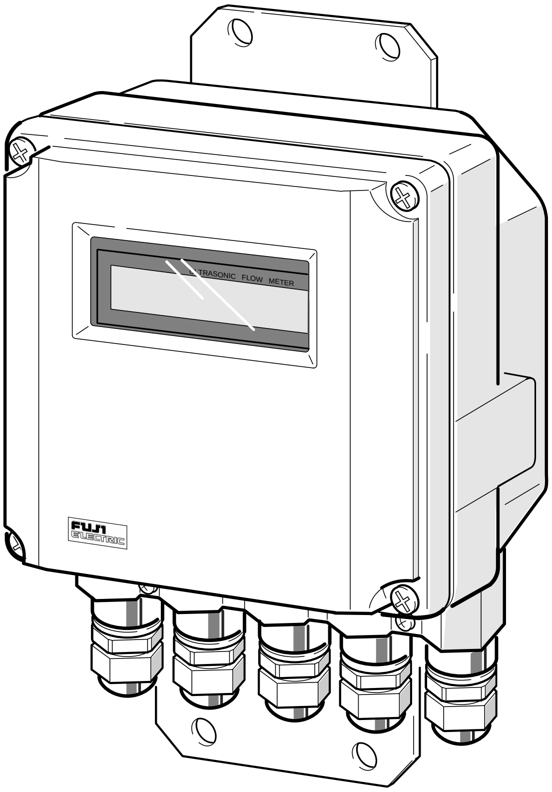


FUJI ELECTRIC

Instruction Manual

ULTRASONIC FLOW METER

TYPE: FLV
FLW



Fuji Electric Co.,Ltd.

INF-TN2FLVa-E

PREFACE

We are grateful for your purchase of Fuji Electric's Ultrasonic flowmeter.

- First read this instruction manual carefully until an adequate understanding is acquired, and then proceed to installation, operation and maintenance of the converter (sensor) of the ultrasonic flowmeter. Wrong handling may cause an accident or injury.
- The specifications of this flowmeter will be changed without prior notice for further product improvement.
- Modification of this flowmeter is strictly prohibited unless a written approval is obtained from the manufacturer. Fuji Electric will not bear any responsibility for a trouble caused by such a modification.
- This instruction manual shall be stored by the person who actually uses the flowmeter.
- After reading the manual, be sure to store it at a place easier to access.
- This instruction manual should be delivered to the end user without fail.

Manufacturer:	Fuji Electric Co., Ltd.
Type:	Described in Fuji Electric's company nameplate on main frame
Date of manufacture:	Described in Fuji Electric's company nameplate on main frame
Product nationality:	Japan

Request

- It is prohibited to transfer part or all of this manual without Fuji Electric's permission in written format.
- Description in this manual will be changed without prior notice for further improvement.

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Issued in July, 1998

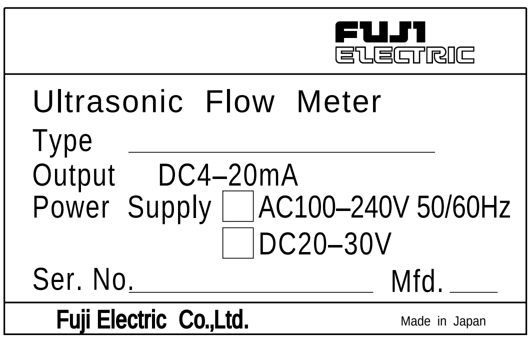
About ultrasonic flow meter

The ultrasonic flow meter in combination with the ultrasonic sensor mounted on the external wall of existing piping, is used to convert the amount of flow of a fluid flowing in the piping into a unified current signal and integrated pulse signal.

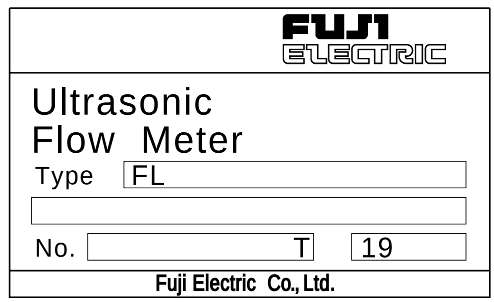
Check on type and specifications

The name of type is inscribed on the specification nameplate. Check the specification nameplate to make sure that type and specifications are correct as ordered (the nameplate is attached to the side of the converter, the upper side of the sensor cover (small type, large type) and the side of the frame (for high temperature).

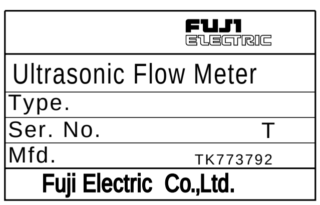
(1) Specification nameplate



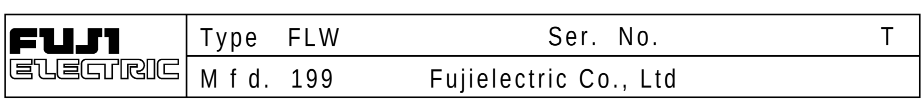
Converter



Large type sensor



Small type sensor



High temperature sensor

CAUTION ON SAFETY

• The cautionary descriptions listed here contain important information about safety, so they should always be observed. Those safety precautions are ranked 2 levels; DANGER and CAUTION.

DANGER	Wrong handling may cause a dangerous situation, in which there is a risk of death or heavy injury.
CAUTION	Wrong handling may invite a dangerous situation, in which there is a possibility of medium-level trouble or slight injury or only physical damage is predictable.

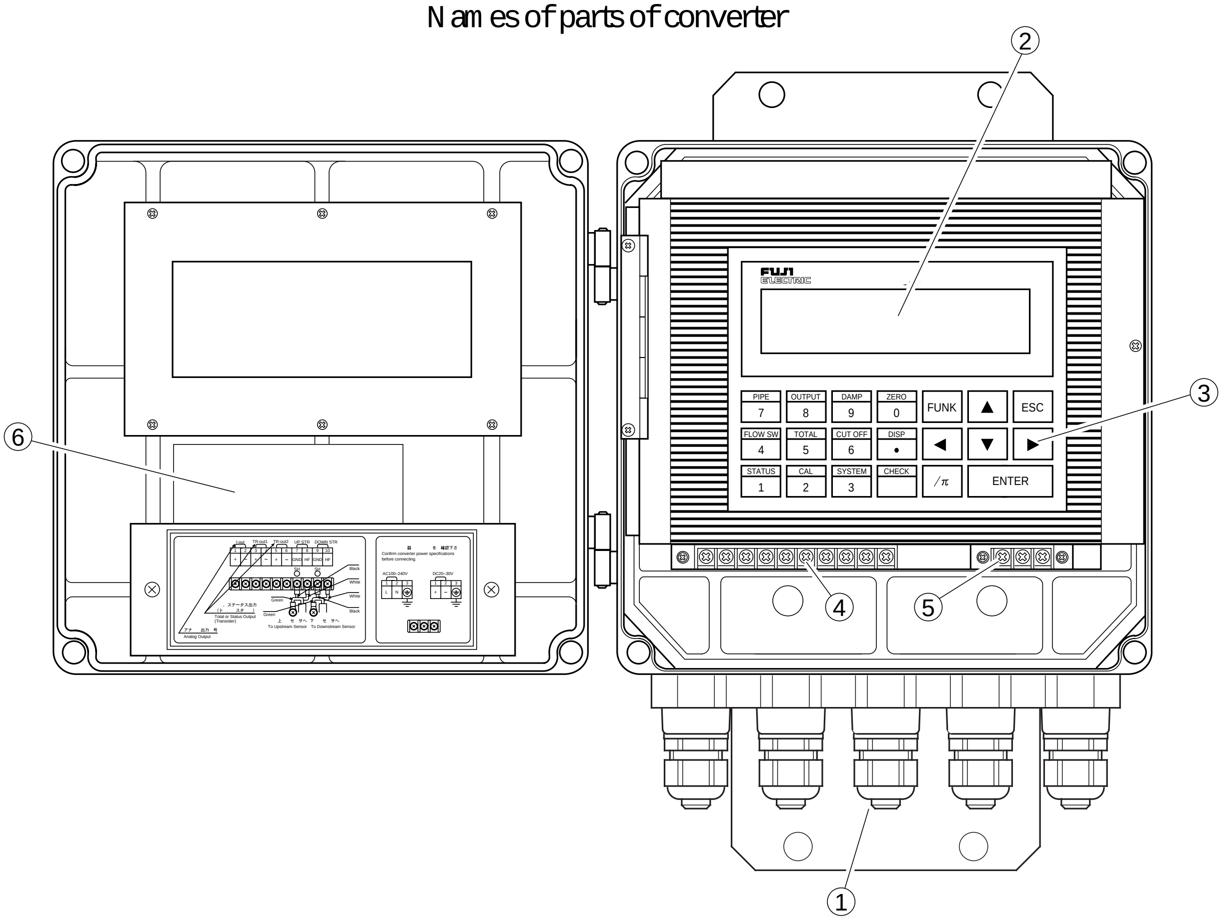
Caution on installation and wiring	
DANGER	• This unit is not explosion-proof type. Do not use it in a place with explosive gases to prevent explosion, fire or other serious accidents.
CAUTION	• The flowmeter should be installed in a place that meets the operating conditions shown in this instruction manual. Installation at an unsuited place may cause electric shock, fire or incorrect operation. • Install the flowmeter according to the instruction manual. Improper installation may lead to the cause of fall, trouble or incorrect operation. • When installing, make sure that the flowmeter interior is free from cable chips and other foreign objects to prevent fire, trouble, or incorrect operation. • Connect a power source of correct rating to prevent fire accidents. • Before making wiring work, be sure to turn OFF the power supply to prevent electric shocks. • Use wiring materials of correct rating to prevent fire accidents.

CONTENTS

1. OPERATING PARTS AND THEIR FUNCTIONS

The names and funcitons of parts of the converter are as follows.

Names of parts of converter



Item	Description
① Wiring port	Wiring port for power cable and signal cable
② Data indicator	Liquid crystal indicator for measurement data and set values
③ Key board	Used for setting the conditions of adjustments and measurements.
④ Main board terminal block	Used for connecting signal cables from sensor. Used for connection of signal cables for analog output and status output.
⑤ Power terminal block	Used for connecting power cable.
⑥ Parameter table	Used for entering setting data.

2. MOUNTING OF CONVERTER

2.1 Selection of mounting place

Install the converter at a place satisfying the following conditions.

1. Ambient temperature does not exceed a range of +14°F to +140°F. When installing outdoors, attach a shade or put the converter in an outdoor panel to protect it from direct sunlight.
2. Not exposed to moisture. Even an immersion-proof type is not protected against entry of water. Make arrangements so that water can be drained quickly.
3. Not exposed to dust or corrosive gases.
4. Free from vibrations and shocks.
5. Space shown in Fig.2-1 is available for easy inspection and adjustment.

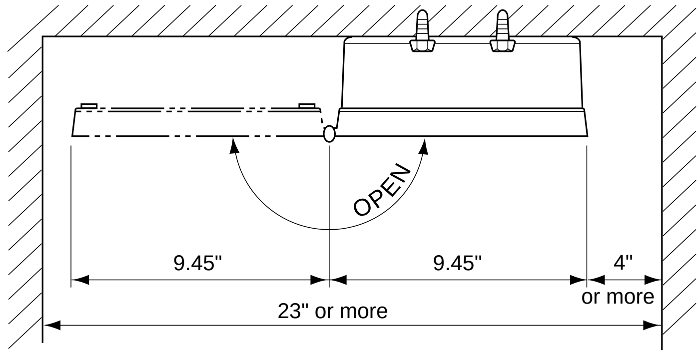


Fig.2-1 Installation space (top view)

2.2 Mounting method

Wall mounting or 2B bypass stand mounting is available for the converter.

For wall mounting, use 4-M8 bolts.

Be sure to mount the converter at correct position as shown in Fig.2-2.

Make a hole in the wall or the like according to the cutout dimensions shown in the diagram below, and mount the converter with M8 bolts.

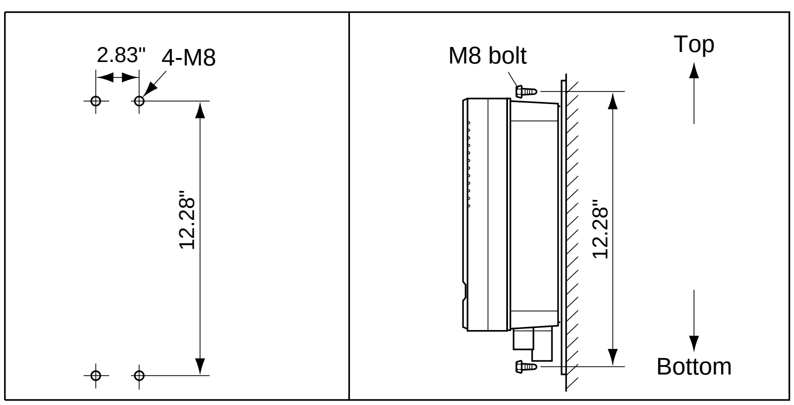
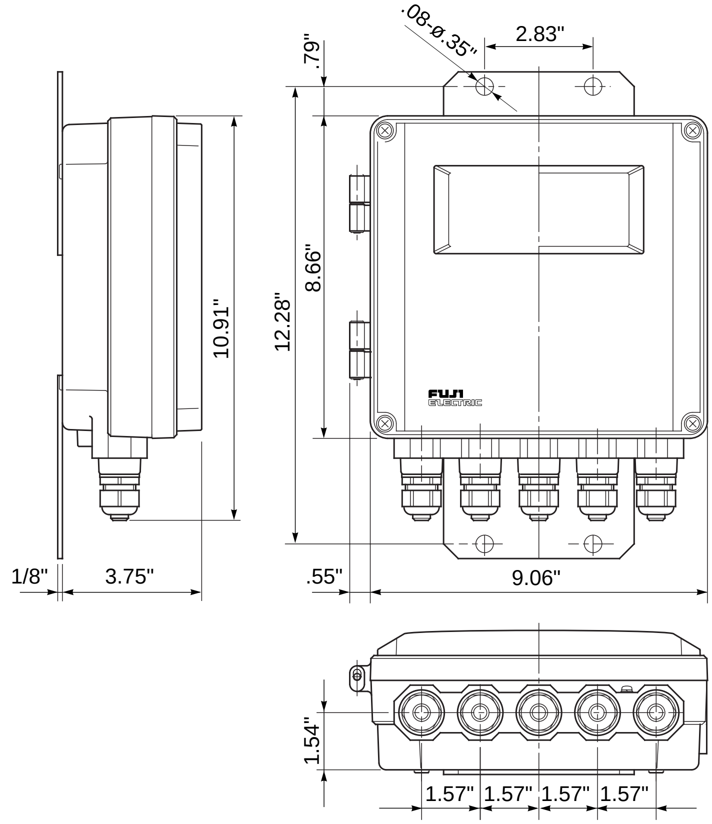


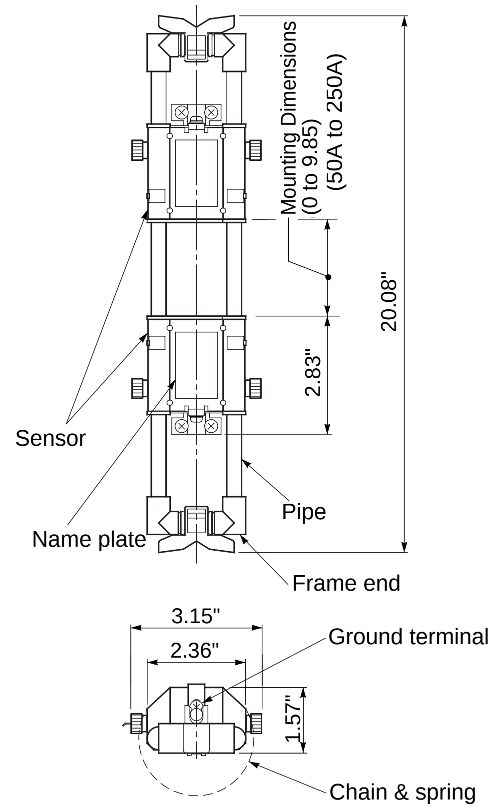
Fig.2-2 Mounting method

In case of 2B pipe standing type, use U bolts (M8) on the market.

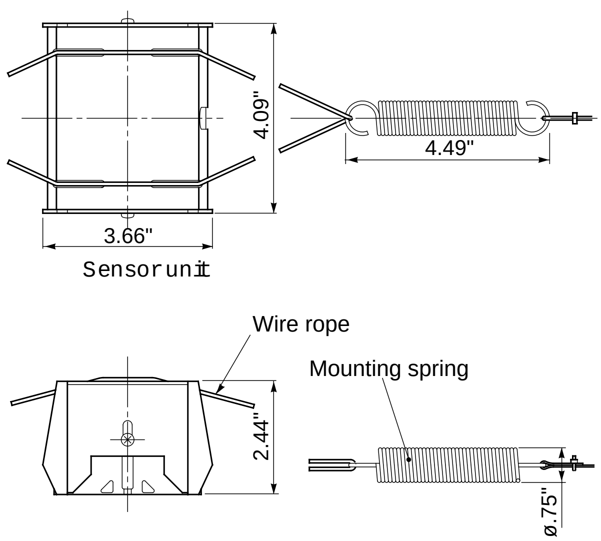
2.3 Outline diagram (unit: in.)



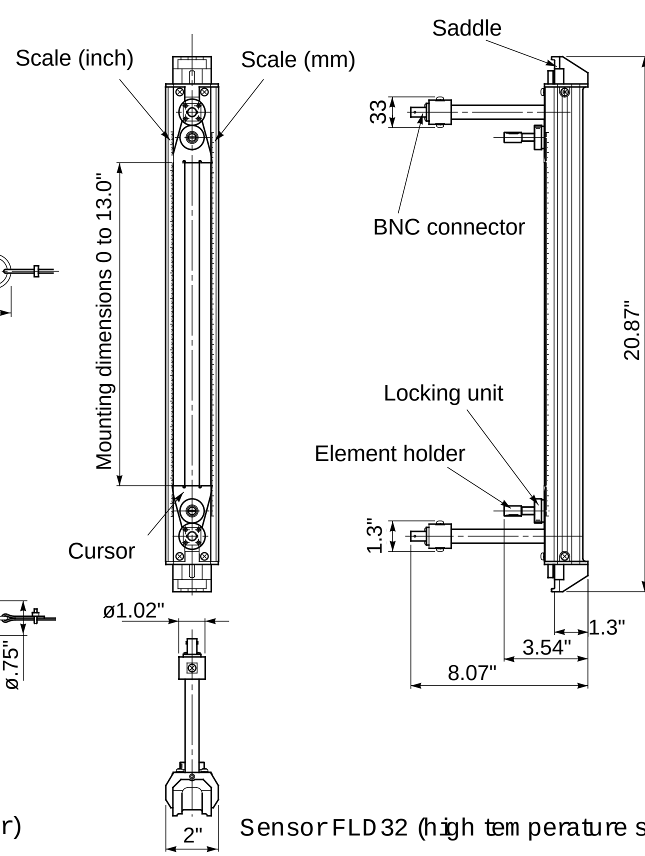
Converter FLV



Sensor FLW 1 (small type sensor)



Sensor FLW 5 (large type sensor)



Sensor FLD 32 (high temperature sensor)

3. WIRING OF THE CONVERTER

3.1 Before wiring

1. For signal cable between the sensor and converter, use double-shielded coaxial cables specified by Fuji Electric. The coaxial cable should be refrained from connecting midway.
2. The signal cable between the sensor and converter should be run in metallic conduits.
   To prevent the effects of induction noise, upstream and downstream signal cables should be wired as far away from power cable as possible.
3. An output signal cable should use shielded cable as much as possible.
4. To prevent the effects of noise, do not install signal cables together with power cable in the same duct.
5. A power cable is provided with earth wire, it should be connected to the ground.
6. As this instrument is not equipped with a power switch, be sure to mount a power switch on the instrument.
7. Wiring ports should be closed when they are not ready to use.

3.2 Wiring

Use the following cables:

- Power cable: 3 or 2 core cabtyre cable,
  Nominal sectional area : 0.30 in.^{2} or more,
  Finished outside diameter : ø.43 in.
- Output signal cable: 2 core cable or multi-core cabtyre cable as needed.
  Finished outside diameter : ø.43 in.
- Cable between sensor and converter:
  Signal cable specified by Code Symbols
  (High frequency coaxial cable with characteristic impedance of 50W)
  Finished outside diameter : ø.29 in.

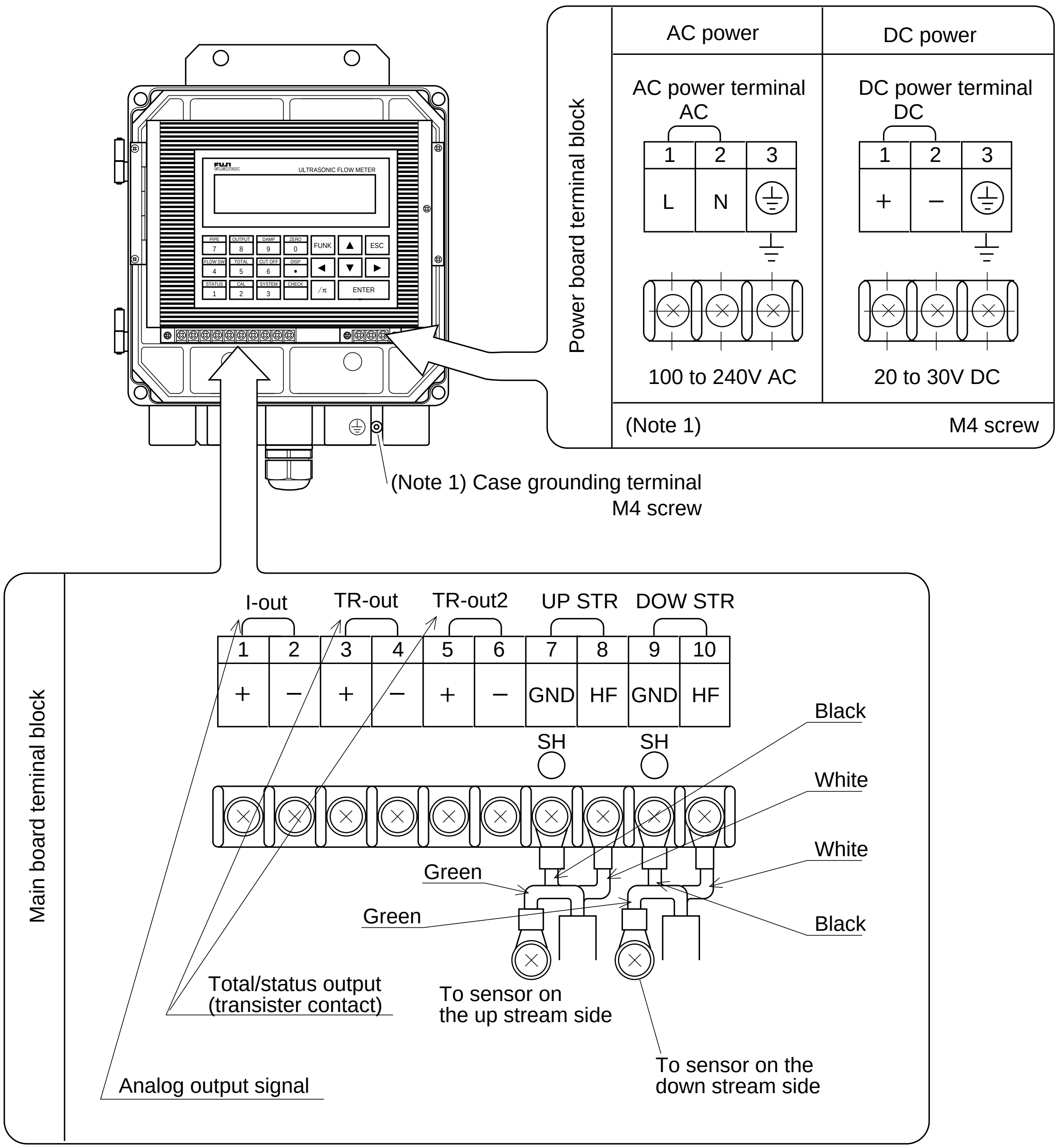
3.3 Treatment of the wiring port

The converter is an immersion-proof type specified by JIS C0920 "Rules for water-proof tests of electromechanical instruments and wiring materials". However, if the converter is to be installed in a pit, air tightness treatment should be provided for the wiring port to prevent possible entry of moisture, dew condensation or immersion of water.

Waterproof measures should be taken by using waterproof gland or plica tube gland furnished with this instrument. A gland, which is not ready to be used, should be sealed by supplied cover.

3.4 Wiring to terminals

Cables should be connected as shown in the following diagrams.



Note 1) Power board terminal block (for power) and case grounding terminals are available for grounding terminals.
Be sure to earth either of them. (Class D, wiring)

4. OPERATION AND WORKS

4.1 Before operation

Check the following before starting operation.

1. Power

   Power check — See Item 4.2 (1)

2. Wiring

   1) Check of main board terminal block
   2) Check of power board terminal block
   3) Check of grounding terminal

   See Item 3.4

3. Piping

   1) Check that a piping is filled with fluid.
   2) Check that there is no problem when water stops or flows.

4.2 Power ON and status

1. Power specification

1) AC power

Use power supply of 100 to 240VAC ±10% (50/60 Hz).

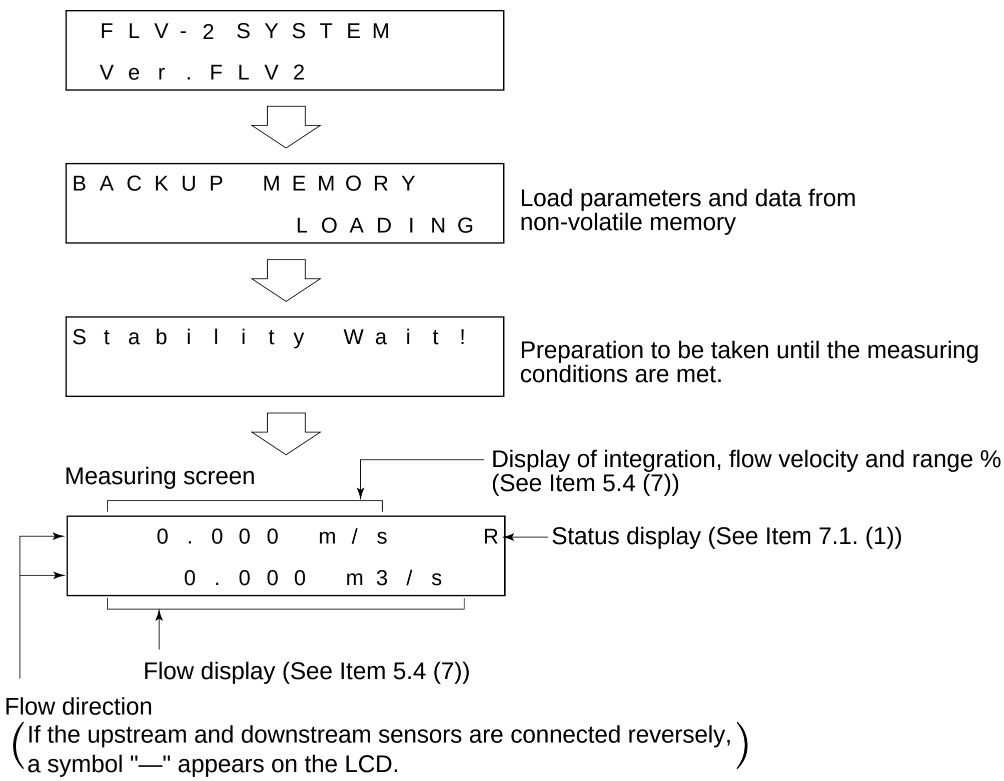
2) DC power

A power of 20V to 30V DC is available.

2. Power ON

When the instrument is turned on, the following data are displayed on the LCD after making a self-check of the devices.

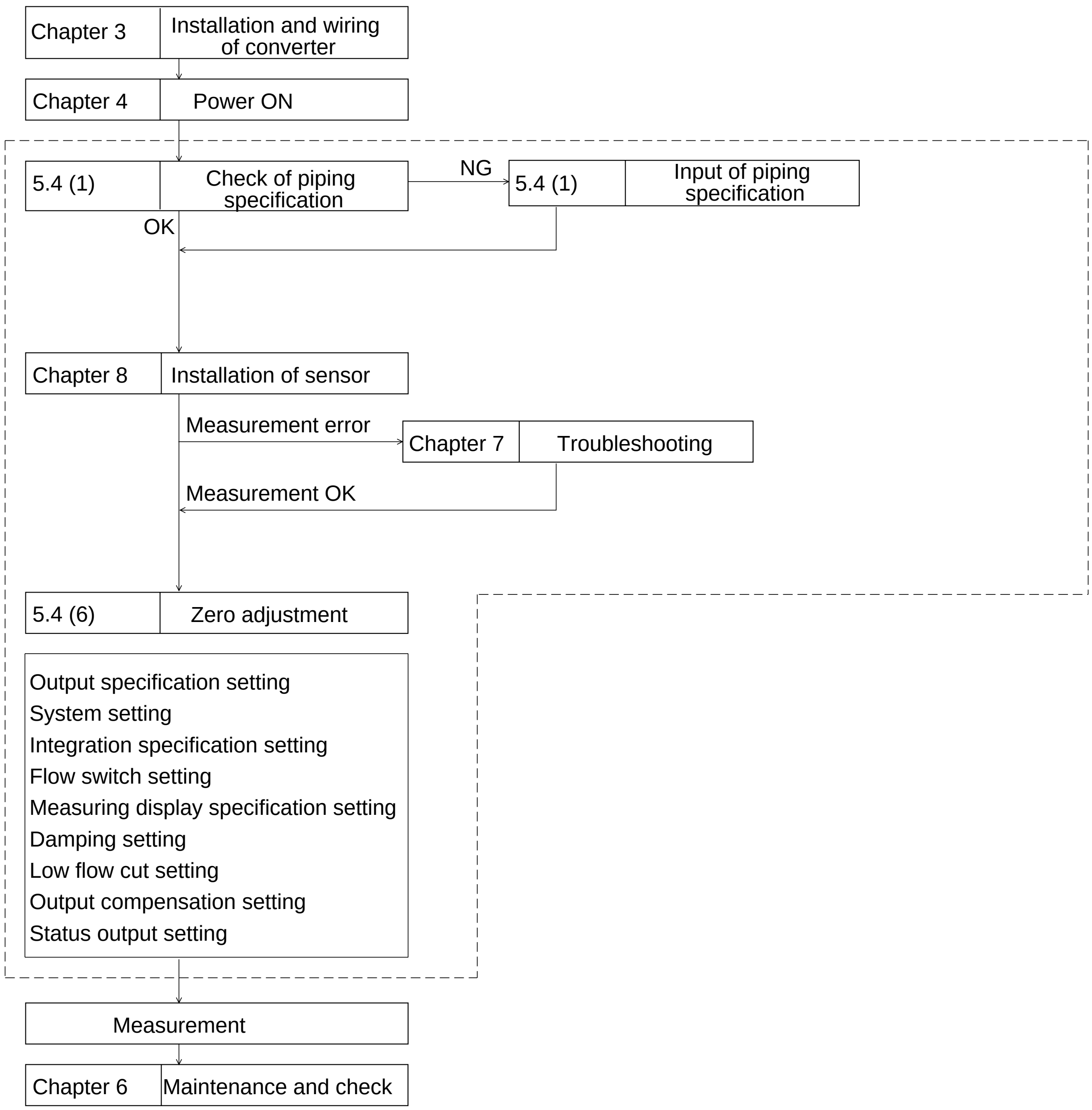
The numerical values and symbols being displayed are as described below :



5. SETTING OF PARAMETERS

5.1 Outline of operating procedures

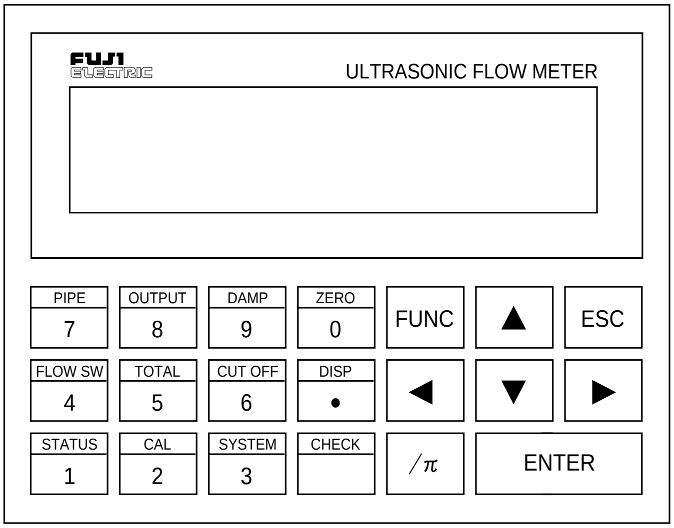
Proceed to the following procedure before starting measurements.



5.2 Description of key operation

Note) When adjustment is performed or setting is changed in this Chapter, be sure to enter parameters in the list attached to the converter.

Pressing the FUNC key enables you to perform the functions shown on the upper side of the ten-keys.



Description of key (1/2)

Name	Key display	Description
Ten-keys	0 to 9 , • , ±	To enter data and numeric values of piping specifications.
ENTER	ENTER	By pressing this key, numeric data and selected interactive items are set. In the interactive mode, questions are displayed.
◀ , ▶	◀ , ▶	To move the cursor to correct numeric values. Pressing the ◀ key allows the cursor to be moved the left. Pressing the ▶ key allows the cursor to be moved the right. Select the menu item display in an interactive message.
▲ , ▼	▲ , ▼	Pressing the ▲ key allows the menu page to advance. Pressing the ▼ key allows the menu page return.
ESCAPE (Stop)	ESC	To stop interactive operation.
FUNC. (Function)	FUNC	To perform the function inscribed on each ten-key.

Description of key (2/2)

Name	Key display	Description
/pi	/pi	By pressing this key, the circumstance of pipe, which has been entered, is converted into the outside diameter. (valid only when setting the outside diameter of pipe)
PIPE (Pipe)	FUNC PIPE	To enter the size and material of the sensor piping.
OUTPUT (Analog output)	FUNC OUTPUT	To set the condition of an analog output (units, range, limit, burn-out)
DAMPING (Damping)	FUNC DAMP	To set the damping.
ZERO (Zero)	FUNC ZERO	To use when zero adjustment is performed.
DISPLAY (Display panel)	FUNC DISP	Keys used to change items or unit system on the measurement display screen.
CUT OFF (Low flow cut)	FUNC CUT OFF	To set the low flow cut.
TOTAL (Integration)	FUNC TOTAL	To set condition required for integration of flow rate. (units, constant, preset value, integral switch, pulse width)
FLOW SW (Flow switch)	FUNC FLOW SW	To set the measured high/low value switch
STATUS (Status)	FUNC STATUS	To set condition of status output (integration pulse, measuring status)
CAL. (Calibration)	FUNC CAL	To compensate indication values of zero point and 100% point. (Current output is effected)
SYSTEM (System)	FUNC SYSTEM	To switch the measuring unit system and language, or confirm or calibrate analog output.
CHECK (Check)	FUNC CHECK	To display an error message and countermeasures when an error appears. (An error message is displayed on the upper-right of the LCD.)

5.3 List of setting items

Measurement screen

- Piping specifications ---------------------------------See Item 5.4 (1)
  (FUNC PIPE)
- Setting of output (FUNC OUTPUT)
  - Range ------------------------See Item 5.4 (2)
  - Output limit-----------------See Item 5.4 (3)
  - Burn-out---------------------See Item 5.4 (4)
- Damping --See Item 5.4 (5)
  (FUNC DAMP)
- Zero adjustment ---------------------------------------See Item 5.4 (6)
  (FUNC ZERO)
- Display setting ---See Item 5.4 (7)
  (FUNC DISP)
- Low flow cut---See Item 5.4 (8)
  (FUNC CUT OFF)
- Integration (FUNC TOTAL)
  - Integration unit and constant -----See Item 5.4 (9)
  - Integral preset --------------See Item 5.4 (10)
  - Integral switch -------------See Item 5.4 (11)
  - Integral pulse width -------See Item 5.4 (12)
- Flow switch ---See Item 5.4 (13)
  (FUNC FLOW SW)
- Status output ---See Item 5.4 (14)
  (FUNC STATUS)
- Output compensation ----------------------------------See Item 5.4 (15)
  (FUNC CAL)
- System (FUNC SYSTEM)
  - Measuring unit ------------See Item 5.4 (16)
  - Switch of language -------See Item 5.4 (17)
  - Confirmation analog output---See Item 5.4 (18)
  - Analog output calibration -----See Item 5.4 (19)
  - Status output check -------See Item 5.4 (20)
  - Test mode ------------------See Iitem 5.4 (21)

5.4 Setting of parameters

• Units are displayed in metric system.

5.4 (1) Setting of piping specifications

Description

Set the data of pipe required for measurement. The mounting dimension of the sensor is automatically calculated. Data of each item should be entered according to the display.

Item	Entry	Range or menu
Outside diameter of pipe	Numeric value	2 in. to 236 in.
Material of pipe	Selectable	CARBON STEEL, STAINLESS STEEL, PVC, COPPER, CAST IRON, ALUMINUM, FRP, ASBES-TOS, DUCTILE IRON, PEEK, PVDF, ACRYLIC, OTHERS*1
Pipe wall thickness	Numeric value	0.0039 in. to 3.937 in.
Lining (with/without) and material	Selectable	NO LINING, TAR EPOXY, MORTAR, RUBBER, TEFLON, PYREX GLASS, OTHERS *1
Type of fluid	Selectable	WATER, SEAWATER, OTHERS *1
Dynamic viscosity coefficient of fluid	Numeric value	0.001E−19.68 ft^2/s to 999.999E−19.68 ft^2/s *2
Mounting method of sensor	Selectable	V METHOD, Z METHOD
Type of sensor	Selectable	FLW 12, FLW 41, FLW 50
Transmission voltage of sensor	Selectable	1 TIME, 2 TIME, 4 TIME, 8 TIME

*1) Selection of "OTHERS"
Materials of piping and lining should be selected within the range of 3281 to 12,139 ft./sec. of sound velocity and 1640 to 8202 ft./sec. of flow velocity (see Appendix).

*2) Dynamic viscosity coefficient is expressed in water (68°F: 1.004E−19.68 ft^2/s)
When more accurate data need be obtained or fluid other than water is selected, enter an appropriate data as needed from Appendix.

Operation (example)	Outside diameter:114.3mm, pipe material:carbon steel, thickness:4.5mm, lining material:mortar, thickness:1.25mm, fluid:heavy water, sound velocity: 1388m/s, dynamic viscosity coefficient: 1.129 x 10^{-6} m^2/s, sensor mounting method:V method, type: FLW 12, Transmission voltage:8 times

Key operation	Description	Display
FUNC PIPE	The sensor mounting dimension is displayed.	SENSOR SPACING 0.00 mm V
▲ or ▼	Select "OUTER DIAMETER".	OUTER DIAMETER 114.3 mm
1 1 4 . 3, ENTER	Enter "114.3" with ten keys.	
◀ or ▶, ENTER	Select "CARBON STEEL".	PIPE MATERIAL CARBON STEEL
4 . 5, ENTER	Enter "4.5" with ten keys.	WALL THICKNESS 4.5 mm
◀ or ▶, ENTER	Select :MORTAR".	LINING MATERIAL MORTAR
1 . 2 5, ENTER	Enter "1.25" with ten keys.	LINING THICKNESS 1.25 mm
◀ or ▶, ENTER	Select "OTHERS".	KIND OF FLUID OTHERS
1 3 8 8, ENTER	Enter "1388" with ten keys.	FLUID S.V. 1388 m/s
1 . 1 2 9, ENTER	Enter "1.129" with ten keys.	VISCOSITY 1.129E − 6 m2/s
◀ or ▶, ENTER	Select "V METHOD".	SENSOR MOUNTING V METHOD
◀ or ▶, ENTER	Select "FLW 12".	SENSOR TYPE FLW 12
Note 3 ◀ or ▶, ENTER	SELECT "8 TIME".	TRANS.VOLTAGE 8 TIME
	The sonsor mounting dimension is displayed.	SENSOR SPACING 80.56 mm V
ESC ESC	Press the key twice.	(Measurement display)

Note 3) When selecting the transmission voltage, generally choose "4 TIME".

5.4 (2) Setting of analog output range

Description

An analog output range is set to provide an output of 4 to 20mA in the specified range of measured values (flow rate or flow velocity).

[Measurement items]

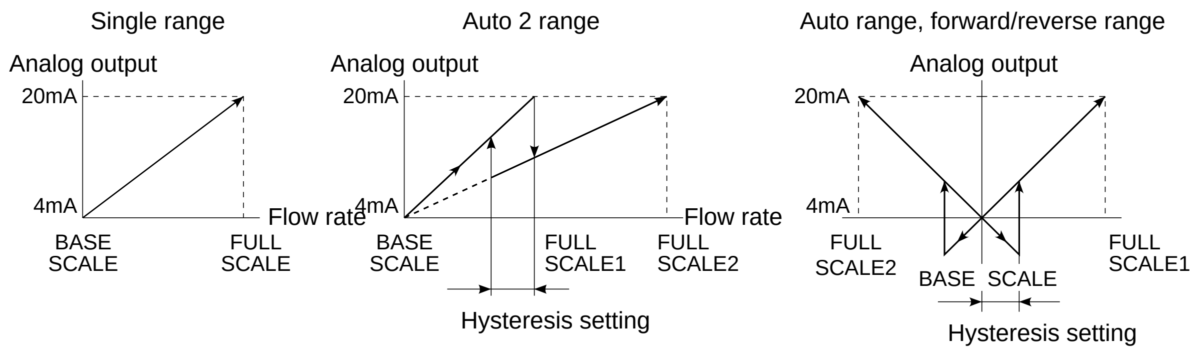
1. Selection of range unit ....m/s

Note 1) l/s, l/m l/h, Ml/d
m^3/s, m^3/m, m^3/h, Mm^3/d
BBL/s, BBL/m, BBL/h, MBBL/d

Choose any of the unit: METRIC system

2. Selection of range type

- SINGLE RANGE: Single range
- AUTO 2 RANGES: Auto 2 ranges
- BI-DIR RANGE: Auto forward/reverse range



3. Setting of range

- BASE SCALE: Set flow rate value or flow velocity value for 4mA output.
  Flow velocity value should be set within the range of 0 to ±32m/s.
- FULL SCALE: Set flow rate value or flow velocity value for 20mA output.
  Flow velocity value should be set within the range of ±0.3 to ±32m/s.

4. Setting of hysteresis

When selecting "AUTO 2 RANGES" or "BI-DIR RANGE" from the type of range, hysteresis is selectable.

Set the hysteresis within the range of 0 to 20% of full scale.

- In case of auto 2-range: Hysteresis of span size of full-scale 1 or full-scale 2, whichever is smaller
- In case of forward/reverse range: Hysteresis of span in action range

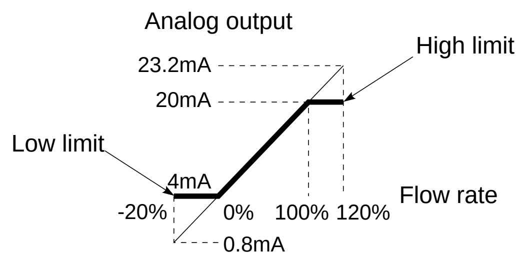
Note 1) Flow units of low flow cut, flow switch and output compensation flow units are changed with the selection of the range unit.

Operation (example)	When setting the base scale to 0m³/h, full scale 1 to 100m³/h, full scale 2 to –100m³/h and hysteresis to 5% in the forward/reverse range.	
Key operation	**Description**	**Display**
FUNC OUTPUT		
◀ or ▶, ENTER	Select "m3/h".	RANGE UNIT m3/h
◀ or ▶, ENTER	Select "Forward/reverse range".	RANGE TYPE BI-DIR.RANGE
0, ENTER	Enter "0" with ten keys.	BASE SCALE 0 m3/h
1 0 0, ENTER	Enter "100" with ten keys.	FULL SCALE 1 100 m3/h
± 1 0 0, ENTER	Enter "–100" with ten keys.	FULL SCALE 2 –100 m3/h
5, ENTER	Enter "5" with ten keys.	RANGE HYSTERESIS 5 %
ESC ESC	Press the key twice.	(Measurement display)

5.4 (3) Setting of analog output limit

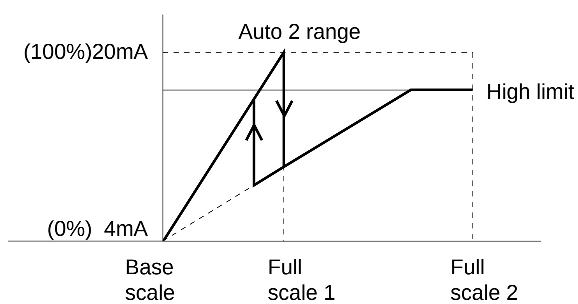
Description

Set the high/low limits within the range of analog output of 0.8 to 23.2mA (-20 to 120%).



Operation (example)	Low limit: -10% (2.4mA), high limit: 110% (21.6mA)	
Key operation	Description	Display
FUNC OUTPUT ▲ or ▼	Select "Output limitter".	OUTPUT LIMIT LOW –20%
± 1 0, ENTER	Enter "–10" with ten keys.	OUTPUT LIMIT LOW –10%
1 1 0, ENTER	Enter "110" with ten keys.	OUTPUT LIMIT HIGH 110%
ESC ESC	Press the key twice.	(Measurement display)

- In case of auto 2-range :
  Low limit is limited to the small range, and High limit is limited to the large range.
- In case of forward/reverse range :
  The low/high limits are limited to the range of action.



5.4 (4) Setting of burn-out

Description

When the pipe is empty of fluid or when air bubbles are contained in fluid, the flow rate can not be measured correctly. In such a case, the analog output needs to be set to "HOLD", "HIGH" limit or "LOW" limit. A burnout timer is used to set the time needed for burnout.

(Setting items)

- HOLD : Measured value is held
- HIGH : 120% t output (23.2mA) is obtained.
- LOW : -20% output (0.8mA) is obtained.
- Zero : 0% output (4.0mA) is obtained.
- NOT USED : Not used.
- Liquid crystal display : Measured value is held.
- Integrated pulse output : Output stops Note)
- Internal integration : Integration stops Note)

Note) Integrated pulse output and internal integration is integrated until the burnout timer is energized.

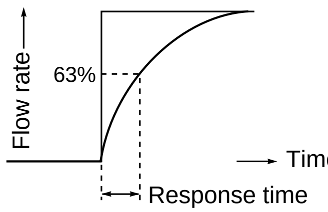
Operation (example)	When setting the burnout to the "LOW" limit and burnout timer to 15 seconds.	
Key operation	**Description**	**Display**
FUNC OUTPUT		
▲ or ▼	Select "Burn-out".	OUTPUT BURNOUT NOT USED
◀ or ▶, ENTER	Select "Low limit".	OUTPUT BURNOUT LOWER
1 5, ENTER	Enter "15" with ten keys.	BURNOUT TIMER 15 sec
ESC ESC	Press the key twice.	(Measurement display)

5.4 (5) Setting of damping

Description

Damping is used to suppress fluctuation of measured values.

The set value is a time constant (about 63% response time). (Setting range : 0 to 100 sec)



Unless otherwise specified in the order sheet, the setting time of damping is adjusted to 5 sec.

Operation (example)	Change of set value to 20 sec.	
Key operation	Description	Display
FUNC DAMP 2 0, ENTER	Enter "20" with ten keys.	DAMPING 20 sec (Measurement display)

5.4 (6) Zero adjustment

Description

Zero point of measured value is adjusted. (Setting items) • ZERO POINT ADJUST : Stop the flow of fluid and adjust zero point. The zero pont is the state of measurement at set point. • ZERO POINT CLEAR : This setting is used when fluid will not stop flowing. Adjusted zero point is cleared.

Operation (example)	Zero point adjustment when fluid is in stop mode.	
Key operation	Description	Display
FUNC ZERO ◀ or ▶ , ENTER	Select "Zero point adjustment".	ZERO MODE SET ZERO (Measurement display)

5.4 (7) Setting of measurement display specifications

Description

Select measured value from the following.

1. Setting of measurement display 1st line
   Select any one from the following 7 types for the 1st line display.

F:TOTAL	:Forward integral value
R:TOTAL	:Reverse integral value
TOTAL DIFF	:Forward/reverse difference between integral values
F:TOTAL PULSE	:Forward integral pulse counter
R:TOTAL PULSE	:Reverse integral pulse counter
FLOW VELOCITY	:Instantaneous flow velocity [m/s]
RANGE %	:Ratio of analog output to range

2. Setting of decimal measurement display on 2nd line
   On the second display is instantaneous flow rate displayed.
   Select one from the following 12 units of flow rate.

   l/s, l/m l/h, M l/d, m^3/s, m^3/m, m^3/h, M m^3/d
   BBL/s, BBL/m, BBL/h, M BBL/d } (metric system)

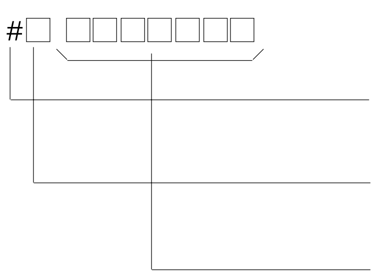
3. Setting of decimal point position of instantaneous flow rate display
   Setting of digit display after the decimal point is available.

   Select any one from the following.

Position of decimal point (digit)		Range of data display				
00000000.	:	-99999999.	to	0.	to	99999999.
0000000.0	:	-9999999.9	to	0.0	to	9999999.9
000000.00	:	-999999.99	to	0.00	to	999999.99
00000.000	:	-99999.999	to	0.000	to	99999.999
0000.0000	:	-9999.9999	to	0.0000	to	9999.9999
000.00000	:	-999.99999	to	0.00000	to	999.99999
00.000000	:	-99.999999	to	0.000000	to	99.999999
0.0000000	:	-9.9999999	to	0.0000000	to	9.9999999

Display of integral value

1. Display of forward/reverse integral values



Overflow mark
    When the integral value exceeds the overflow mark.
Overflow times
    0 to 9, # (exceeding 9)
Integral value
    0 to 9999999

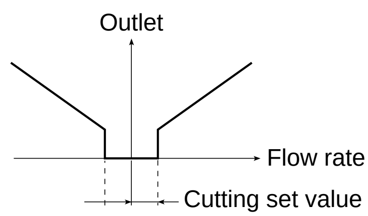
2. Display of forward/reverse difference between integral values
   Difference of integrated value = forward integral value − reverse integral value.
   Note: If any of integral values in the forward and reverse directions exceeds the over flow mark, ####### is displayed.

Operation (example)	Display instantaneous flow velocity and instantaneous flow unit in m3/h, and instantanous flow rate in 3 digits after decimal point.	
Key operation	**Description**	**Display**
FUNC DISP		
◀ or ▶, ENTER	Select "Flow velocity".	1:DISPLAY KIND VELOCITY
◀ or ▶, ENTER	Select m³/h".	2:FLOW UNIT m3/h
◀ or ▶, ENTER	Select "00000.000".	2:DECIMAL POINT 00000.000 m3/h
ESC ESC		(Measurement display)

5.4 (8) Low flow output cut

Description

A low flow output can be cut.
This flow meter will display the flow rate, when the fluid in the piping is moving with the valve closed due to a convection current. The cutting point should be set as needed.
(Setting range : 0 to 16.4 ft/s in terms of flow velocity value)



Operation (example)	Setting of cutting point to 0.05m/s.	
Key operation	**Description**	**Display**
FUNC CUT OFF		
0 . 0 5, ENTER	Enter "0.05" with ten keys.	CUT OFF 0.05 m/s
		(Measurement display)

5.4 (9) Setting of integrated output unit and constant

Description

Integrated output unit is set to integrate measurement value (flow rate)

Just after setting of measured value is completed, the pulse counter begins integration by clearing the previous integrated value.

1. Integrated unit……… Select one of the following 8 kinds of integral units.

   ml, l, m^3, km^3, Mm^3, mBBL, BBL, kBBL (metric system)

   Note : When changing the integrated unit, integral constant value and integral preset value are cleared.

2. Integral constant

   When the flow rate reaches the value set by the integral constant, integral pulse value is displayed on the measurement screen, and the integral pulse counter provides an output of 1 pulse.

   Setting range : 0 to 9999999

Operation (example) Integrated output of $100m^3$

Key operation	Description	Display
FUNC TOTAL ▲ or ▼, ENTER	Display "TOTAL MODE".	TOTAL MODE TOTAL STOP
◀ or ▶, ENTER	Select "m3".	TOTAL UNIT m3
1 0 0, ENTER	Enter "100" with ten keys.	TOTAL RATE 100 m3
ESC	Display "TOTAL MODE".	TOTAL MODE TOTAL STOP
◀ or ▶, ENTER	Select "START".	TOTAL MODE TOTAL RUN
ESC ESC	Press the key twice.	(Measurement display)

Integral mode

Stop: Integration is stopped.

Start: Integration is started (integral parameter can not be changed at a time of start).

Reset: Integral value is set to the integral preset value, and integration is stopped.

When the flowmeter is restored from power interruption, it will be operated in the integral mode that was set before power interruption.

[Note : If measurement is abnormal, refer to burnout setting for integration.]

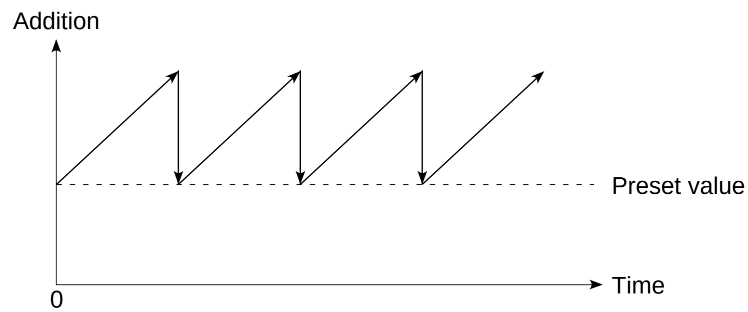
5.4 (10) Setting of integral preset value

Description

Set integrated preset value

F:TOTAL PRESET: Forward integral preset value
R:TOTAL PRESET: Reverse integral preset value

Setting range: 0 to 9999999



Note: In case of setting, please keep "TOTAL MODE" suspended.

Operation (example)	Forward direction: $1000m^3$, reverse direction: $2000m^3$	
Key operation	Description	Display
FUNC TOTAL		
▲ or ▼	Select "F:TOTAL PRESET".	F:TOTAL PRESET 0 m3
1 0 0 0, ENTER	Enter "1000" with ten keys.	F:TOTAL PRESET 1000 m3
ENTER	Select "R:TOTAL PRESET".	R:TOTAL PRESET 0 m3
2 0 0 0, ENTER	Enter "2000" with ten keys.	R:TOTAL PRESET 2000 m3
ESC ESC	Press the key twice.	(Measurement display)

5.4 (11) Setting of integration switch

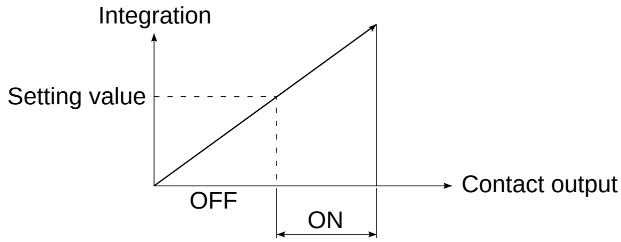
Description

When an integral value exceeds the set value, the status output is provided.

F:TOTAL SW : Forward integration switch
R:TOTAL SW : Reverse integration switch

Setting range: 0 to 9999999

Note) When setting the status output, integration switch is valid only when "F:TOTAL SW" or "R:TOTAL SW" is set.



Note: In case of setting, please keep "TOTAL MODE" suspended.

Operation (example)	Set value of forward integration switch : $50000 m^3$	
Key operation	Description	Display
FUNC TOTAL		
▲ or ▼	Select "TOTAL SW".	F:TOTAL SW 0 m3
5 0 0 0 0 , ENTER	Enter "50000" with ten keys.	F:TOTAL SW 50000 m3
ESC ESC	Press the key twice.	(Measurement display)

5.4 (12) Selection of integral pulse output pulse width

Description

The following 2 types can be selected according to the counter connected. When setting status output, set the pulse width to use "F:TOTAL" or "R:TOTAL". • 50msec • 100msec Note: In case of setting, please keep "TOTAL MODE" suspended.

Operation (example) Pulse width: 100msec.

Key operation	Description	Display
FUNC TOTAL		
▲ or ▼	Select "Pulse width".	PULSE WIDTH 50 msec
◀ or ▶, ENTER	Select "100msec".	PULSE WIDTH 100 msec
		(Measurement display)

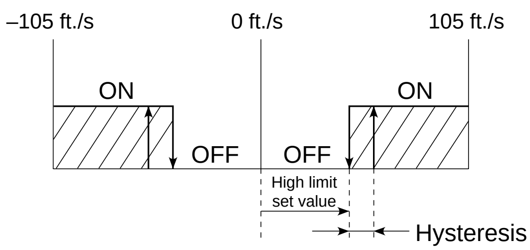
5.4 (13) Setting of measured value high and low limit switch

Description

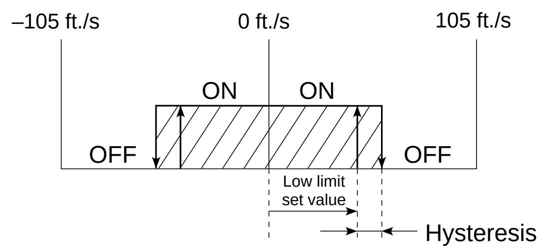
1. Set high limit and low limit of switching point when using high limit flow or low limit flow to set the status output.
   Setting range : 0 to ±105 ft./s of flow velocity

   [Relation between status output and set value]

   • High limit setting and high limit flow



   • Low limit setting and low limit flow



2. Setting of hysteresis
   Switching hysteresis can be held in the following range.
   Set hysteresis within 0 to 20% of the analog output range full scale (with auto 2 range, and forward and reverse auto range, effective for full scale 1 and 2, whichever small).

Operation (example)	Low limit flow velocity: 3.5m/s, high limit flow velocity value: 12m/s, hysteresis : 5%	
Key operation	Description	Display
FUNC FLOW SW		
3 . 5 , ENTER	Enter "3.5" with ten keys.	FLOW SW LOW 3.5 m/s
1 2 , ENTER	Enter "12" with ten keys.	FLOW SW HIGH 12 m/s
5 , ENTER	Enter "5" with ten keys.	FLOW SW HYS. 5 %
		(Measurement display)

5.4 (14) Setting of status output

Description

- When the status of setting or integral pulse is outputted, the contents of output is set.

1.	NOT USED	: No output
2.	SIGNAL ERROR	: ON at abnormal measurement
3.	F:TOTAL PULSE	: Forward flow integral pulse
4.	R:TOTAL PULSE	: Reverse flow integral pulse
5.	FLOW SW HIGH	: ON when the flow rate is over the high limit set by flow switch.
6.	FLOW SW LOW	: ON when the flow rate is below the low low limit set by flow switch.
7.	F:TOTAL ALARM	: ON when the flow rate is over the forward flow integration switch.
8.	R:TOTAL ALARM	: ON when the flow rate is below the reverse flow integration switch.
9.	F:TOTAL OVERFLOW	: ON when the forward flow integral value overflows.
10.	R:TOTAL OVERFLOW	: ON when reverse flow integral value overflows.
11.	FULL SCALE 2	: ON at FULL SCALE 2 RANGE in analog output range status.
12.	R:FLOW DIRECTION	: ON when the flow direction is reverse.
13.	RANGE OVER	: ON when the set value of the output span exceeds the range of -10 to 110%, or integral pulse output exceeds 5 pulse/sec.
14.	BACK UP ABNORMAL	: ON when the backup non-volatile memory is abnormal.

- Setting of status output pulse mode

Normal: effective when status output is ON.
Spot: effective when status output is OFF.

Operation (example)	When setting the forward integral pulse and contact output in the normal mode.

Key operation	Description	Display
FUNC STATUS		
◀ or ▶, ENTER	Select "CHANNEL 1".	STATUS CHANEL CHANNEL 1
◀ or ▶, ENTER	Select "F:TOTAL".	STATUS SEL :CH1 F :TOTAL
◀ or ▶, ENTER	Select "Normal".	STATUS MODE :CH1 NORMAL
ESC	(Continued on next page)	

Operation (example)	When setting the forward integral pulse and contact output in the normal mode.	
Key operation	**Description**	**Display**
◀ or ▶, ENTER	Select "CHANNEL 2".	STATUS CHANEL CHANNEL 2
◀ or ▶, ENTER	Select "F:TOTAL ALARM".	STATUS SEL : CH2 F :TOTAL ALARM
◀ or ▶, ENTER	Select "SPOT".	STATUS MODE : CH2 SPOT
ESC ESC	Press the key twice.	(Measurement display)

5.4 (15) Calibration of measured value

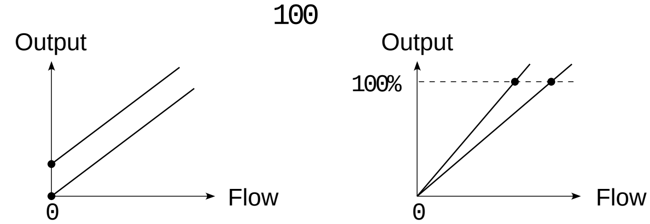
Description

Measured value (zero and span points) can be calibrated, if required.
Zero point and span point can be calibrated.

Calibration range: Zero point: ±16.4 ft/s of flow velocity
Span: ±200%

Measured value and analog output value are calculated by the following formula.

$$\text{Output} = \frac{\text{Measured value} \times [\text{span set value }\%]}{100} + \text{Zero point}$$



Movement of zero point   Movement of span

Operation (example)	Calibration of zero point to −0.5m/s and span point 105%	
Key operation	**Description**	**Display**
FUNC CAL		
± 0 . 5 ,ENTER	Enter "−0.5" with ten keys.	CALIBRATION ZERO −0.5 m/s
1 0 5 ,ENTER	Enter "105" with ten keys.	CALIBRATION SPAN 105 %
ESC ESC	Press the key twice.	(Measurement display)

5.4 (16) Switch of measurement unit system

Description

Measurement units can be set in the two systems, metric system and inch system.

(Setting contents)

• Metric system

Pipe dimension ------------mm

Flow velocity unit---------m/s

Flow rate unit--------------l/s, l/m l/h Ml/d
m^3/s, m^3/m, m^3/h, Mm^3/d
BBL/s, BBL/m, BBL/h, MBBL/d

Integration unit------------ml, l, m^3, km^3, Mm^3, mBBL, BBL, kBBL

• English system

Pipe dimension ------------inch

Flow velocity unit---------ft/s

Flow rate unit--------------gal/s, gal/m, gal/h, gal/d
ft^3/s, ft^3/m, ft^3/h, Mft^3/d
BBL/s, BBL/m, BBL/h, MBBL/d

Integration unit------------gal, kgal, ft^3, kft^3, Mft^3, mBBL, BBL, kBBL

Operation (example)	Change of measurement unit to inch system	
Key operation	Description	Display
FUNC SYSTEM		
◀ or ▶, ENTER	Select "Inch system".	SYSTEM OF UNITS ENGLISH
ESC ESC	Press the key twice.	(Measurement display)

5.4 (17) Selection of language (English/Japanese)

Description

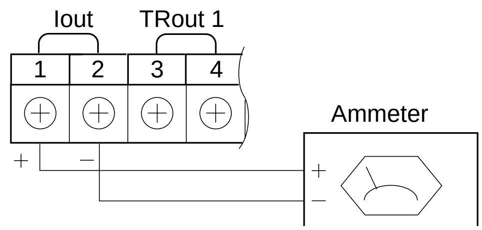
2 kinds of language, English and Japanese (Katakana) can be selected on this display, at the time of setting.

Operation (example)	Selection of English display	
Key operation	Description	Display
FUNC SYSTEM		
▲ or ▼	Select "Language".	LANGUAGE JAPANESE
◀ or ▶ , ENTER	Select "English".	LANGUAGE ENGLISH
ESC ESC	Press the key twice.	(Measurement display)

5.4 (18) Analog output check

Description

Check the analog output circuit.
Check to make sure that the output values at –20% to 120% are 0.8mA to 23.2mA.
Connect an ammeter to the Iout terminal as shown below.



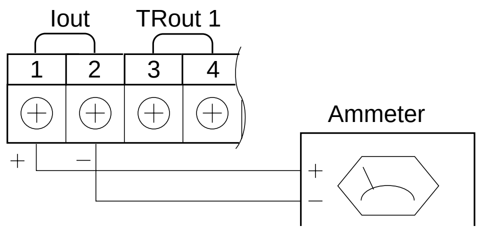
Operation (example)	Check of analog output of 4mA, 8mA, 12mA, 16mA, 20mA	
Key operation	Description	Display
FUNC SYSTEM		
▲ or ▼	Select "Analog output check".	OUTPUT CHECK 0%
0, ENTER	Enter "0" with ten keys. [0% (4mA) check]	OUTPUT CHECK 0%
2 5, ENTER	Enter "25" with ten keys. [25% (8mA) check]	OUTPUT CHECK 25%
5 0, ENTER	Enter "50" with ten keys. [50% (12mA) check]	OUTPUT CHECK 50%
7 5, ENTER	Enter "75" with ten keys. [75% (16mA) check]	OUTPUT CHECK 75%
1 0 0, ENTER	Enter "100" with ten keys. [100% (20mA) check]	OUTPUT CHECK 100%
ESC ESC	Press the key twice.	(Measurement display)

5.4 (19) Analog output calibration

Description

The analog output circuit is calibrated so that the measured flow rate is set to provide an output of 4mA in the base scale and 20mA in the full scale.

Calibration should be performed by connecting an ammeter to Iout terminal as shown below.



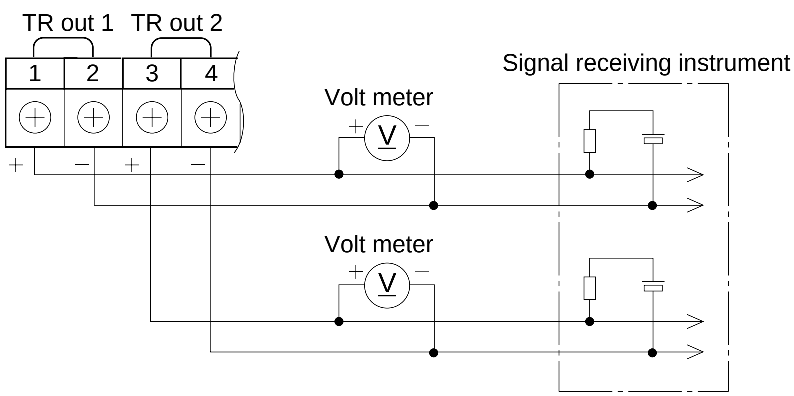
Operation (example)	Calibration of output of 4mA, 20mA	
Key operation	Description	Display
FUNC SYSTEM		
▲ or ▼	Select "Analog output calibration".	OUTPUT ADJUST SKIP
◀ or ▶, ENTER	Select "Setting".	OUTPUT ADJUST SETTING
▲ (up) or ▼ (down)	Fine calibration } Ammeter should indicate 4mA.	OUTPUT ADJUST 4mA
◀ (down) or ▶ (up) ,ENTER	Coarse calibration	
▲ (up) or ▼ (down)	Fine calibration } Ammeter should indicate 20mA.	OUTPUT ADJUST 20mA
◀ (down) or ▶ (up) ,ENTER	Coarse calibration	
ESC ESC	Press the key twice.	(Measurement display)

Note: After calibration is completed, set the calibration mode to Skip.

5.4 (20) Status output check

Description

Perform check of status output for ON-OFF operation. Status output is an open collector. A check is performed by connecting a voltmeter to terminals, TRout1 and TRout2 as shown below.

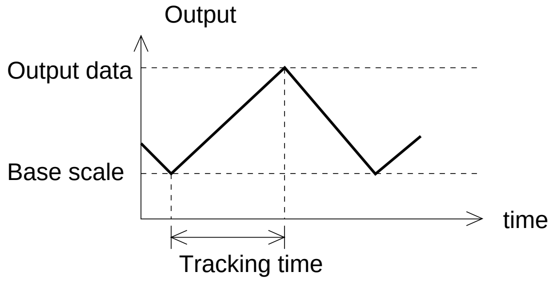


Operation (example)	Check of status channel1.	
Key operation	Description	Display
FUNC SYSTEM		
▲ or ▼	Select "Status check".	STATUS CHECK Channel*
◀ or ▶, ENTER	Select "Channel1".	STATUS CHECK Channel1
◀ or ▶	Select "ON or OFF".	STATUS CHECK ON
ESC ESC ESC	Press the key 3 times.	(Measurement display)

Note: Status output changes depending upon "normal" or "Reverse" specified under the status mode conditions.

5.4 (21) Test mode

Description

> The test mode is used to check for integrated conditions and action of the flow switch, etc. by entering measuring flow rate simulately.
>
> With base scale set to 0% and full scale to 100%, an arrival time from previous value to target value can be set as shown below:
>
> Data setting range: 0 to ±120%
>
> Tracking time setting range: 0 to 900sec
>
> 
>
>
> Note: During measurement, set the test mode to "NOT USED".

Operation (example)	To set the tracking time to 15 seconds so that the target value reach from 0 to 100%.

Key operation	Description	Display
FUNC SYSTEM		
▲ or ▼	Select "Test mode".	TEST MODE NOT USED
◀ or ▶, ENTER	Select "Setting".	TEST MODE SETTING
0, ENTER	Enter "0" with ten keys.	OUTPUT DATA 0%
2, 5, ENTER	Enter "15" with ten keys.	TRACKING TIME 15 sec
1, 0, 0, ENTER	Enter "100" with ten keys.	OUTPUT DATA 100%
ESC ESC	Press the key twice.	(Measurement display)

6. MAINTENANCE AND INSPECTION

6.1 Maintenance

(1) LCD display unit

Expected service life of LCD is 7 years. It is recommended that LCD should be replaced with new one in about 5 years since it is put into operation, or it may offer deteriorated contrast.

[Replacement procedure]

1) Power OFF
2) Remove the connector from the key panel and replace the LCD display unit (see parts list).
3) Assembly
4) Power ON
5) Check for normal operation

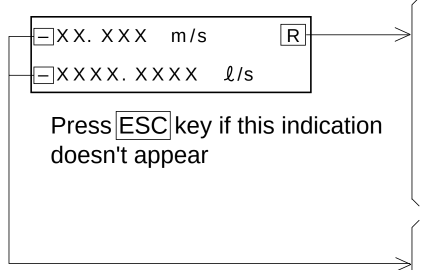
6.2 Inspection

(1) Daily check

Confirm the converter is operating normally by using the LCD display unit in accordance with Item "7.1 How to confirm normal operation".

7.1 How to confirm normal operation

7.1 (1) When checking by LCD indicator



Press ESC key if this indication doesn't appear

Indication symbol	Operation status	
R	Normal	
E	Range over	
C, H, W, O, I	Ab-normal	• Ultrasonic wave not transmitted normally inside pipe.
B	Ab-normal	Backup error
No indication	Forward flow of fluid	
—	Reverse flow of fluid	

7.1 (2) LCD indication when power turned ON

In case of no indication

System abnormal (CPU stopped)

└ Contact Fuji Electric.

7.1 (3) Detail check for abnormal status

Description

Status display at the upper right of the measurement screen is detailed as follows:

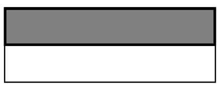
(Status display)		(Contents of display)	(Detailed Contents)
R	:	NORMAL	
C	:	CAL.ERROR	• Check for piping input data. • Turn ON/OFF the power.
H	:	RECEIVED SIGNAL ERROR	• Check for air bubbles in pipe • Check for particles in pipe
W	:	WINDOW ERROR	• Check for piping input data.
O	:	RECEIVED SIGNAL OVERFLOW	• Check for the sensor mounting method.
I	:	NO RECEIVED SIGNAL	• Check for piping input data. • Check for sensor installation. • Check for cable connections. • Check for type of sensor.
E	:	RANGE OVER	• Check for output setting. • Check for integral constant.
B	:	BACKUP ERROR	• Non-volatile memory fault.

Operation (example) I appears at the upper right of the measurement screen.

Key operation	Description	Display
FUNC CHECK	(Contens of display)	I:NO RECEIVED SIGNAL
ENTER	(Detailed contents)	CHECK INPUT PIPE DATA
▼	(Detailed contents)	CHECK SENSOR MOUNT
▼	(Detailed contents)	CHECK CABLE CONNECT
		CHECK SENSOR TYPE
▼	(Detailed contents)	
ESC ESC	Press the key twice.	(Measurement display)

7.2 Faults and remedies

7.2 (1) LCD display abnormal

Status	Cause
 No indication appears.	• Power is not turned ON. • Power voltage is low. • Fuse is burnout. • LCD is abnormal. ➡ Take remedy in "7.2 (5) Remedy for hardware fault" • DC power supply polarity is connected reversely.
 Dark indication on upper side.	• Power voltage is low. • LCD is abnormal. ➡ Take remedy in "7.2 (5) Remedy for hardware fault" • DC power supply polarity is connected reversely.
 Random indication	• Hardware fault. ➡ Take remedy in "7.2 (5) Remedy for hardware fault"
 Unclear display	• Ambient temperature low. (less than -10℃) ➡ Increase the temperature. • LCD indicator is worn out. ➡ Replace the LCD.
 Whole is dark	• Ambient temperature is high. (60℃ or more) ➡ Decrease the temperature.

7.2 (2) Key abnormal

Status	Cause
No response at press of input key	• Hardware fault. ➡ Take remedy in "7.2 (5) Remedy for hardware fault"
Specific keys can not be operated. Key operation is different from that defined.	

7.2 (3) Measured value abnormal

Status	Cause	Remedy
Minus (–) symbol indicated on measured value	• Connection between transmitter and sensor is reversed. (Upstream and down stream detectors should be connected reversely)	➡ Connect correctly.
	• Flow of fluid is reversed.	
Measured value fluctuates though flow rate is constant.	• Straight pipe length is inadequate.	➡ Move instrument to a place where 10D can be maintained on upstream and 5D on downstream.
	• Pump, valve etc. which disturbs flow is located nearby.	➡ Attach instrument at least 30D away
	• There is pulsation in the flow	➡ Set the damping to increase the response time.
Measured value is not changed with change in flow rate.	Ultrasonic wave is not transmitted inside pipe but measured value remains unchanged (HOLD). 1. Installation is improper • Error in piping specifications • Sensor attached to welded part • Error in sensor mounting dimensions • Error in silicon appliance at the time of mounting the sensor • Error in connection of the sensor cable.	➡ After confirming the cause, remove the sensor and apply sufficient amount of silicone to the sensor. Then, mount the sensor again at a position slightly away from previous position.
	2. Problem with piping, fluid ◎ Pipe not filled with fluid	➡ Fluid out a pipe filled with fluid on the same pipeline, and relocate the sensor to the pipe. • Attach the sensor to the lowest place on the pipeline.
	◎ Bubbles included in the fluid If measured value becomes normal when flow has stopped, it indicates that bubbles are contained in the fluid. When the sensor is mounted right after the valve, cavitation may occur in the pipe, resulting in entry of air bubbles. (Contined)	➡ Eliminate the bubbles. • Raise the level of the pump well. • Check the shaft seal of the pump. • Retighten the flange of negative pressure pipe. • Arrange so that fluid doesn't fall into the pump well Move the sensor to a place where no bubbles are contained. • Pump inlet side • Upstream side of valve

Status	Cause	Remedy
(Continued)	◎ Turbidity is high. Turbidity is higher than inflow water contamination or return sludge. ➡ ◎ Scale deposits on the inside of old pipe ➡ ◎ Thick lining Mortar lininig is several ten millimeters thick ➡ ◎ Separation of lining This is gap between lining and pipe. ➡	• Change sensor mounting from V method to Z method. • Move sensor to a place of smaller diameter on the same pipeline. • Relocate sensor to another place or pipe line.
	◎ Sensor is mounted on bent or tapered pipe. ➡	Mount sensor on a straight pipe.
	3. Effect of external noise • There is a radio broadcast station nearby. • Measurement conducted near a passage of vehicles or electric cars. ➡	• Keep the cable between converter and sensor as short as possible. • Ground the converter and piping.
	• Mounting of sensor incorrect • Mounting dimensions • Sensor is separated from pipe ➡	• Mount sensor parallel with pipe at the correct position. • Press sensor so it is securely mounted on the pipe.
	4. Hardware fault ➡	Refer to Item "7.2(5) Remedy for hardware fault".
Measured value not zero when fluid stops flowing.	• Fluid forms a convection inside the pipe. ➡	This is normal.
	• Zero point adjustment ➡	• Readjust the zero point after fluid has stopped flowing.
	• Pipe is not full of water or it is empty of water when water stops flowing. ➡	This is normal. • The value may vary at Item "5.4(4) Setting of output at abnormal measurement".

Status	Cause	Remedy
Error in measured value	• Input piping specifications differ from the actual ones. → • Scale deposits on old pipe →	Error of about 3% occurs when inner diameter differs by 1%. • Input the correct specifications • Input scale as a lining.
	• Length of straight pipe is inadequate. (should be at least 10D upstream and 5D downstream.) →	Change the sensor to another mounting position (upstream of disturbing objects) No disturbing objects in flow within 30D upstream without pump, valve, combined pipe, etc. • Try mounting the sensor at various angles versus the pipe section, and mount it where average value is obtained.
	• Pipe is not filled with fluid or sludge is deposited in the pipe. →	Occurs particularly where sectional area is small. • Move sensor to a vertical pipe.

7.2 (4) Analog output abnormal

Status	Cause		Remedy
Current output is not matched though indication value is not 0.	Range setting is not performed.	➡	• Set.
Output is 0mA.	Cable is disconnected.		
Output is below 4mA when indication is 0.	Zero adjustment of analog output has deviated.	➡	Adjust the analog output.
Output is greater than 20mA.	E is displayed on LCD indicator. Note)	➡	Range over: • Reset analog output range data.
	Span adjustment is incorrect.	➡	• Adjust the analog output.
Indication is changed but analog output remains the same.	Output load is greater than 1kW.	➡	• Reduce the load to 1kW or less.
Indication does not agree with analog output.	Zero or span of analog output has deviated.	➡	Adjust the analog output.
Analog output doesn't change even after it has been adjusted.	Hardware falut	➡	Contact Fuji Electric.

Note: When the base scale is not set to 0 within the range of an analog output, the flow display may not be matched with the analog output.

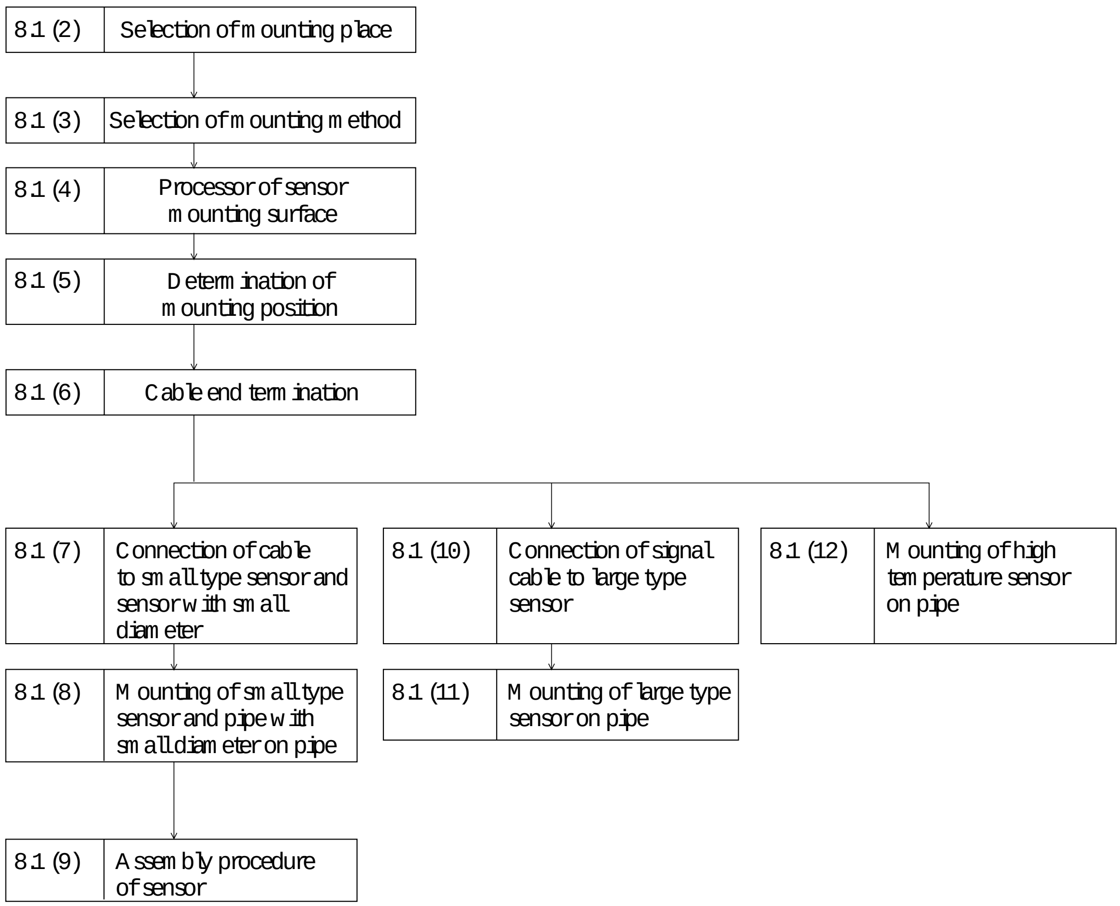
7.2 (5) Remedy for hardware fault

When hardware is in trouble after following "6. Maintenance and inspection" and "7. Troubleshooting", details of trouble and self-check should be notified to Fuji Electric.

8.1 Mounting of sensor

8.1 (1) Mounting procedure of sensor

Mount the sensor on the pipe, and perform the following works in order before making measurement.



8.1 (2) Selection of mounting place

Mounting place for the sensor, i.e. conditions of piping where flow rate is measured, has considerable influence on measurement accuracy.

A place satisfying the following conditions should be selected.

1) A place where there is a straight pipe portion of 10D or more on upstream side and of 5D or more on the downstream side.
2) A place where there are no factors which disturb the flow (pumps, valves, etc.) within 30D on upstream side.
3) Pipe must be filled up with fluid. No bubbles should be contained.
4) Make sure that a maintenance space is provided around the piping where the sensor is mounted. (See Fig. 8-1.)

   Note) A space should be provided so that maintenance work can be made with workers standing on both sides of the piping.

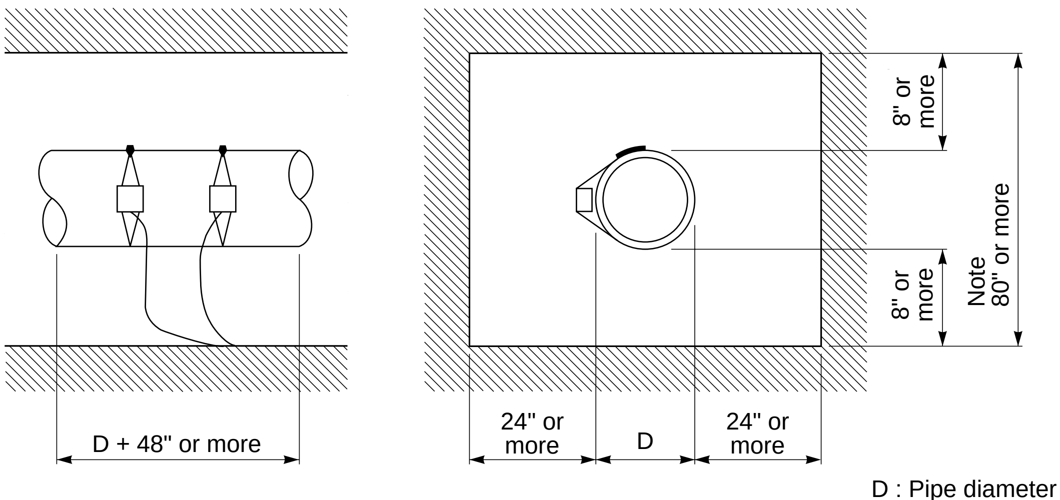
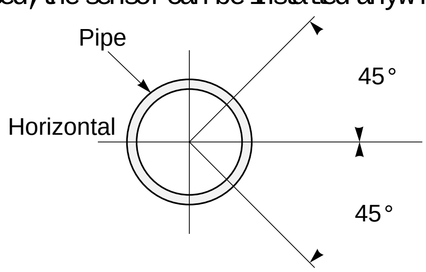


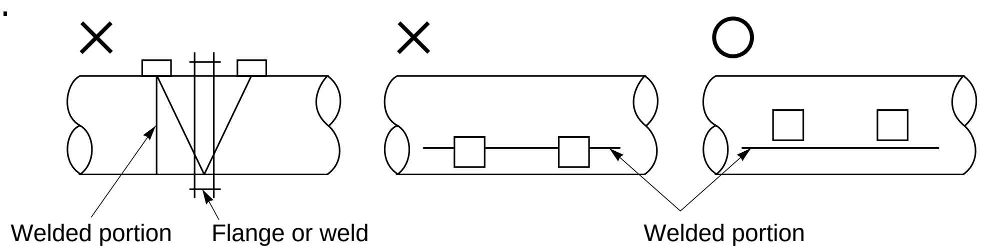
Fig. 8-1 Space required for mounting sensor

⚠ CAUTION

1. Where a horizontal pipe is used, install the sensor within ±45° from the horizontal plane.
   Where a vertical pipe is used, the sensor can be installed anywhere.



2. Avoid installing the sensor on a deformed portion of pipe or welded portion of pipe, or on flange.



8.1 (3) Selection of mounting method

There are two ways for mounting the sensor, the V method and the Z method (See Fig.8-2).

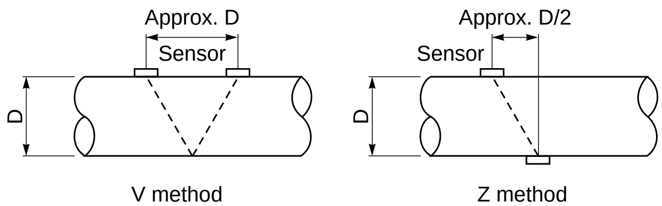


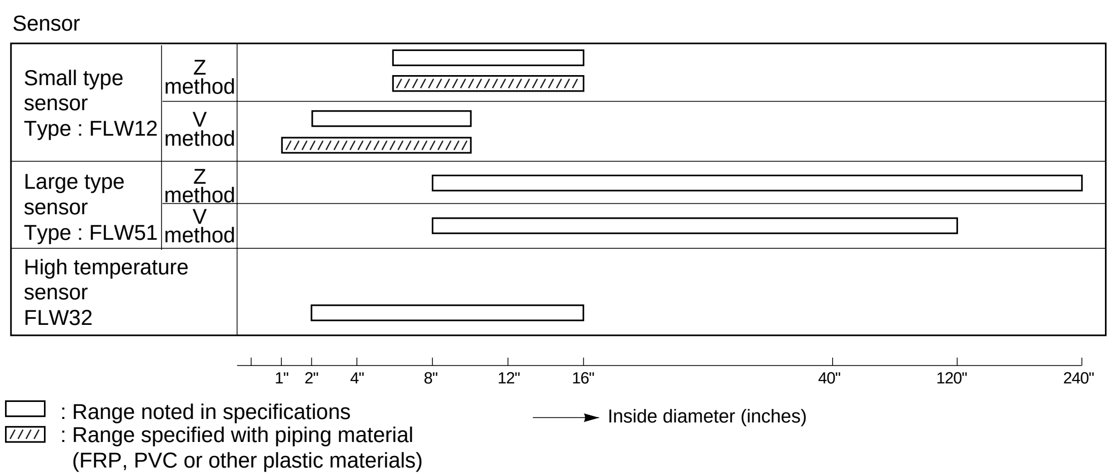
Fig.8-2 Mounting method

The Z method should be used in the following cases.

- Where a mounting space is not available. (As shown in the figure above, the mounting dimension with the Z method is about half of that with the V method).
- When measuring fluid of high turbidity such as sewage.
- When the pipe has a mortar lining.
- When the pipe is old and has a thick accumulation of scale on its inner wall.

Selection standard

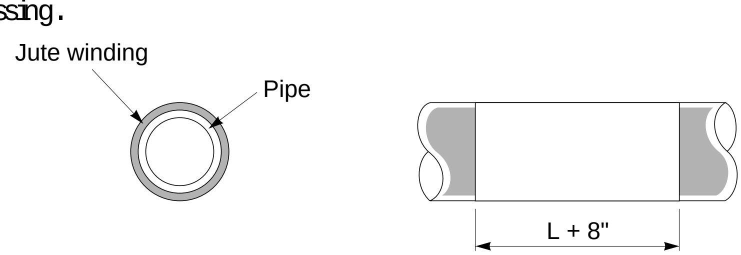
For a large size sensor with inside diameter of more than 12 in., the Z method is recommended for mounting.



8.1 (4) Processing of sensor mounting surface

Using thinner and/or sandpaper, remove pitch, rust and unevenness over a width of (L) + 8 in. on the pipe circumference where the sensor is mounted.

Note) If there is a jute winding on the pipe circumference, remove it and carry out the above processing.

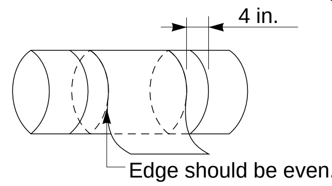


8.1 (5) Determination of mounting position (with Z method for large and small types)

Carry out the following to determine the mounting position.

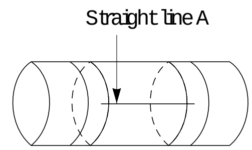
Gauge paper is necessary for this work. (Refer to Appendix 1. "How to make gauge paper".)

1. Align the edge of gauge paper with a point about 4 in. from one end of the processed section, and wrap the paper around the pipe so that the line drawn on the paper is parallel with the pipe shaft. (The paper should be taped to prevent slipping.) At this time, make sure that the paper edge is even.



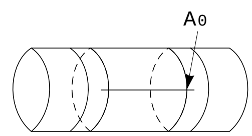
⬇

2. Extended the line drawn on the paper and mark a straight line A on the pipe.



⬇

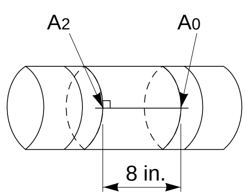
3. Mark a line along on edge of the paper. Assume the intersection of the line and the straight line A is A_0.



V method

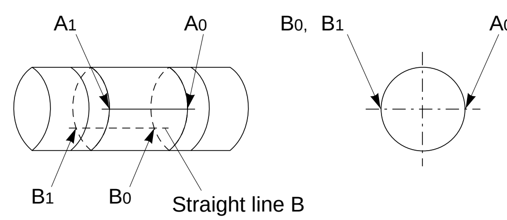
Z method

Example) L = 8 in.



4. Remove the gauge paper and measure the mounting dimension from A_0. Then, draw a line which crosses the straight line A (determine the position A_2).

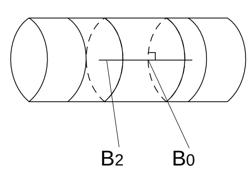
$\boxed{A_0 \text{ and } A_2 \text{ are the mounting position.}}$

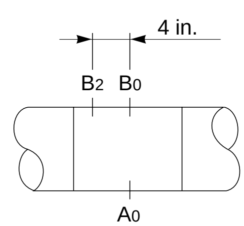


4. Measure the circumference of the pipe from the point A_0, and mark a line (straight line B) between the point B_0 and B_1 obtained at 1/2 of the circumference.

⬇

Example) L = 4 in.



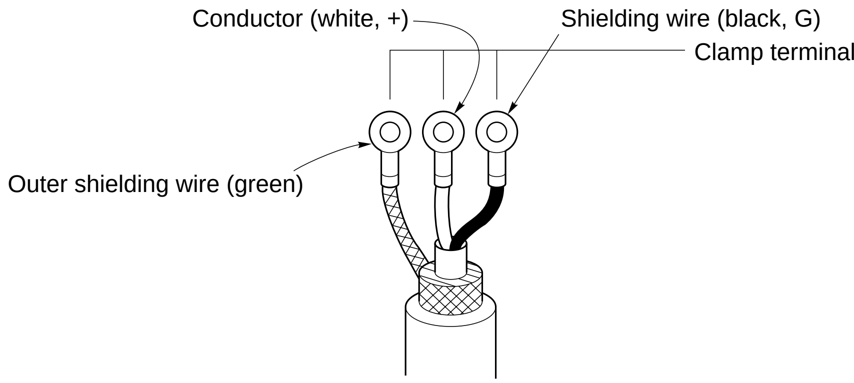


5. Put a mark at point B_0 and remove the gauge paper.
Measure the mounting dimension from B_0 and mark a line crossing the straight line B (determine the position B_2).
In this way, the mounting position is determined.

$\boxed{A_0 \text{ and } B_2 \text{ are the mounting position.}}$

8.1 (6) Cable end treatment

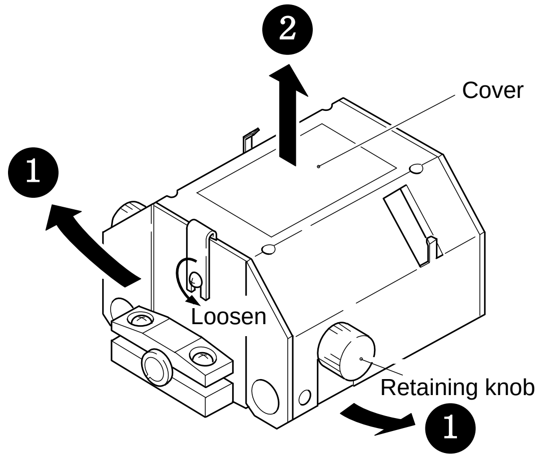
The end of coaxial cable is treated at the factory prior to delivery. If the cable needs to be cut before use, the conductor and the shielding wires should be treated using clamp terminals.



Note) When cutting the coaxial cable, make sure that the upstream side and the downstream side are the same in length.

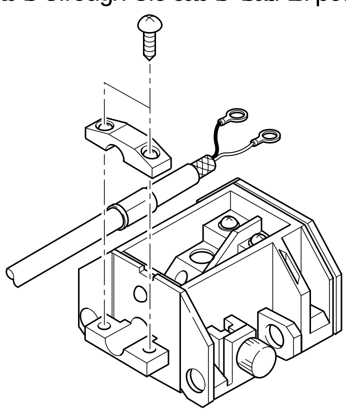
8.1 (7) Connection of cable to small type sensor

1. Loosen the earth screw and the retaining knob on the sensor using a screw driver, then remove the cover from the sensor.



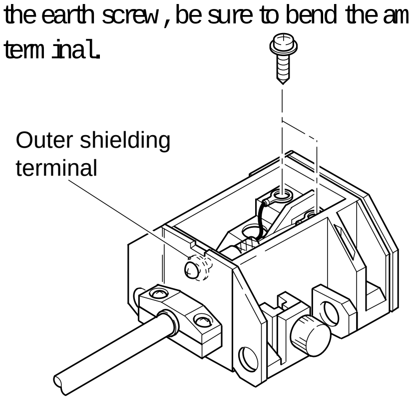
2. Select a mounting position on the pipe.

Note) Mount the sensors so that the upstream and downstream sensors can be distinguished with each other.
Remove the cable clamp and insert the coaxial cable through the cable lead-in port.

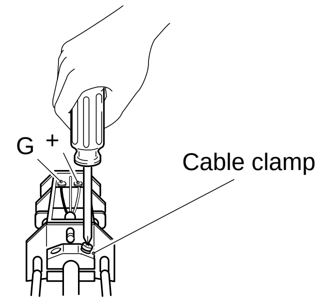


3. Connect the cable to the terminal (G, +) and the earth screw.

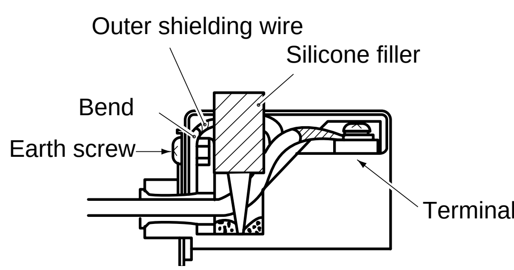
Note) After connecting the outer shielding wire to the earth screw, be sure to bend the amplifier terminal.



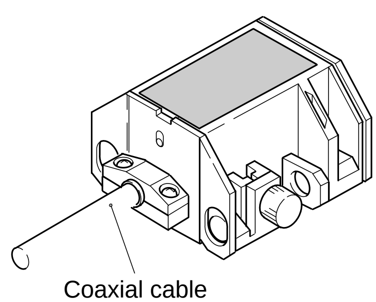
4. Secure the coaxial cable with the cable clamp.



5. Remove foreign matters from the terminals, and mold the while terminal block with silicone filler.
   - Cut off the tip of the silicone filler tube.
     Apply silicone to the terminal block while pressing the head of the tube against the bottom of terminals.
     At this time, care should be taken to prevent entry of air bubbles.



6. Put the cover on the sensor.

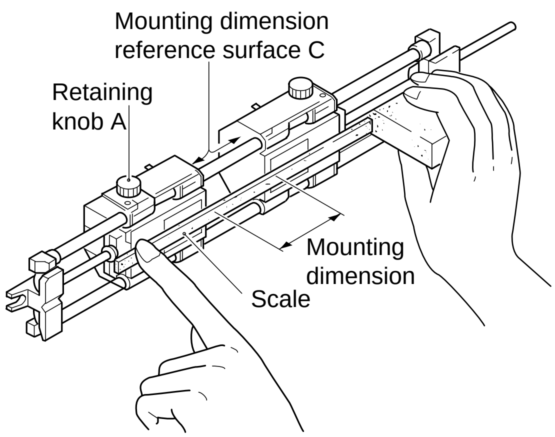


8.1 (8) Mounting of small type sensor on pipe

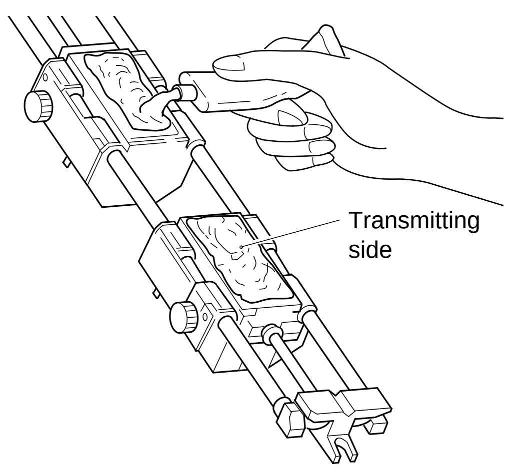
The small type sensor is mounted on pipe with a diameter of ø50 to 250 (V method) or ø150 to 400 (Z method) for measurements.

1. Mounting of sensor (V method)
   Mounting the sensor using the following procedure.
   For mounting, prepare a scale or a slide calipers.

1. Loosen the retaining knob A (4 places), slide the sensor so as to match the mounting dimension, place a scale on the mounting dimension reference surface C and adjust the dimension, then tighten the retaining knob A.

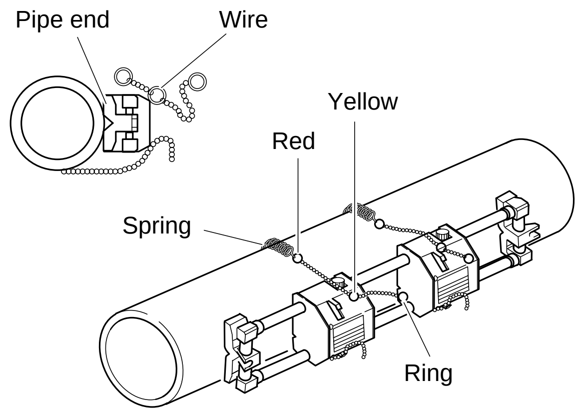


2. Spread silicone filler over the whole transmitting side of the sensor. Care should be taken to prevent entry of air bubbles.



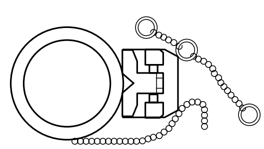
Clean the surface of the pipe and mount the sensor.

3. Raise the end of the pipe fitted with the sensor, and attach the yellow ring on the chain to the hook.

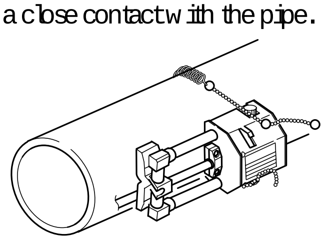


Attach the other chain to the other hook of sensor, and secure it loosely.

4. Pull the red ring and attach it to the hook.
   Use the same procedure for the other sensor.



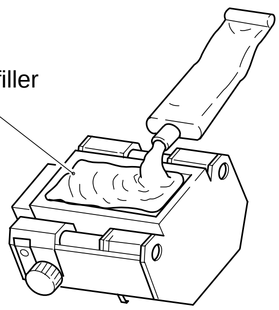
Turn over the frame end so that the sensor makes a close contact with the pipe.



Press the sensor firmly against the pipe.
Ensure that the sensor makes a close contact with the pipe.

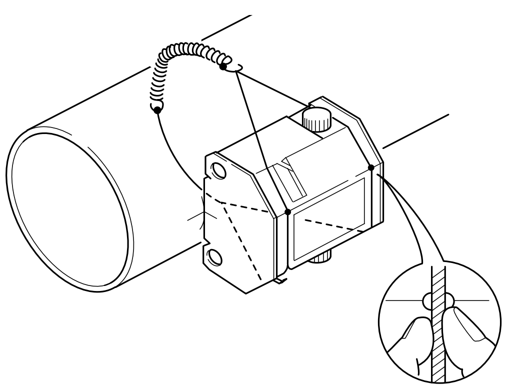
2. Mounting of sensor (Z method)
Mounting the sensor using the following procedure

1. Spread silicone filler over the whole transmitting side of the sensor. Care should be taken to prevent entry of air bubbles.

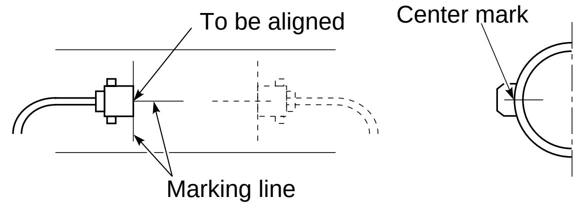


Clean the surface of the pipe, then mount the sensor.

2. Press the sensor against the pipe. Align the center of the sensor with the intersection of the marking line, and the mounting dimension reference surface with the marking line.



3. Make sure that the center mark on the sensor is aligned with the marking line. Then, connect the coaxial cable to the transmitter.



Note) Do not pull the coaxial cable. If it is pulled, the sensor is shifted which results in incorrect measurements due to poor contact with the pipe.

8.1 (9) Assembling procedure of the sensor

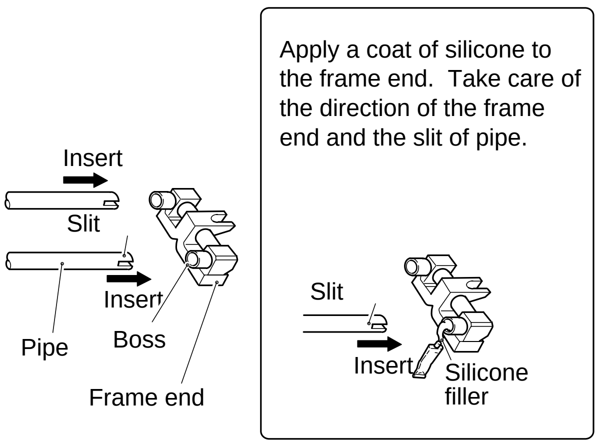
When the small type sensor (FLW 1) is shipped with cables of more than 32.8 ft. in length, it is delivered, disassembled since cable weight is applied to the stand or piping of the sensor during shipment.

Follow the procedure given below.

Assemble of parts

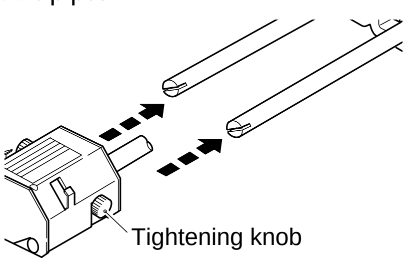
1. Be sure to read the "Cautions" before assembling the parts.

Insert the frame end onto one side of 2 pipes.



After inserting the pipes, tap the frame end with a plastic hammer or the like.

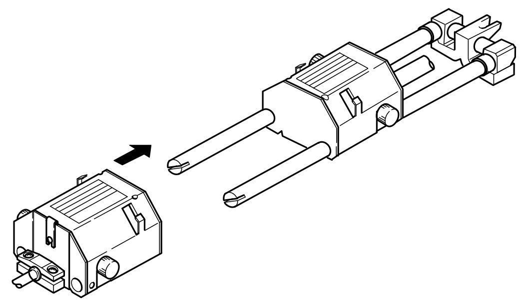
2. Loosen the tightening knob on the sensor and insert the pipes.



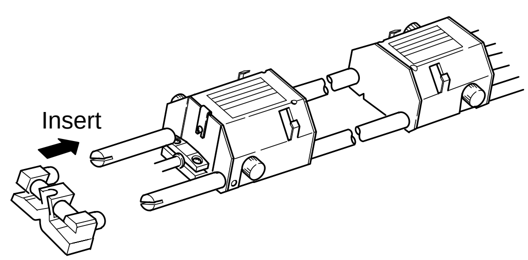
The sensor should be inserted in the correct direction.

3. Insert another sensor onto the pipes.

Insert it in the correct direction.



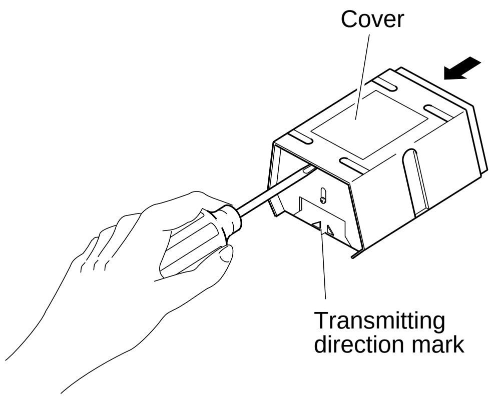
4. Insert the frame end onto the other side of pipes. Assembling method is the same as 1.



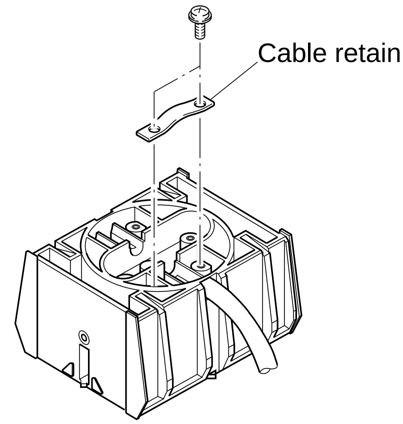
Note) After assembling the sensor, leave it at room temperature for a day to harden the filler (to obtain the required assembling strength).

8.1 (10) Connection of cable to large type sensor

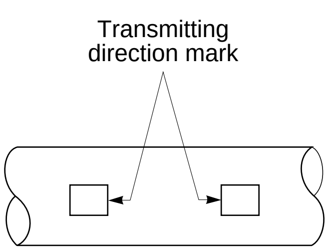
1. Slightly move the sensor cover and remove it using an screw driver or the like.



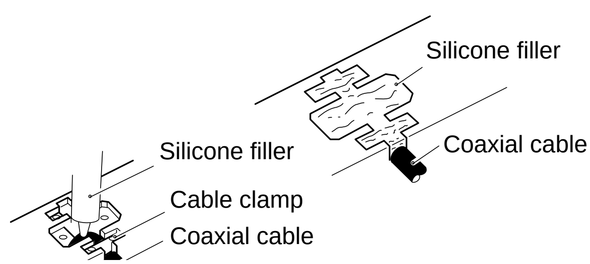
3. Connect the coaxial cable to the terminals (G,+) and secure the cable with the cable clamp.



3. Confirm the mounting position on the pipe.
   - Align the transmitting direction marks so that they are facing with each other.



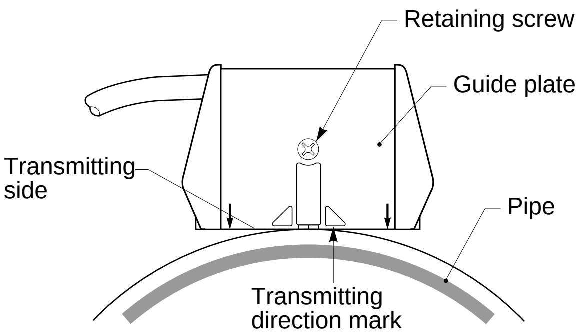
4. Remove foreign objects from the terminal section, and mold the whole terminal section with silicone filler.
   - Cut the tip of the silicone filler tube. Apply silicone while pressing the head of the tube against the bottom of the terminal section Be careful not to let babbles form.



8.1 (11) Mounting of large type sensor on pipe

1. Adjustment of guide plate height

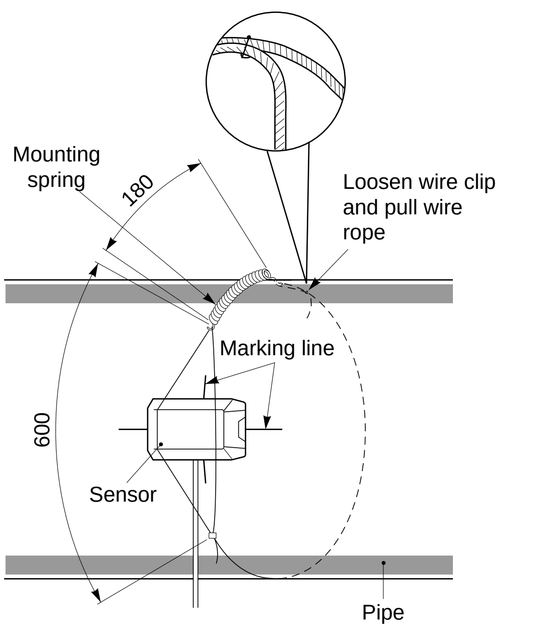
   Attach the sensor to the pipe. Make sure that it is parallel with the pipe shaft.



   Loosen the guide plate retaining screw, and slide the plate until its edge and the transmitting side are in contact with the pipe surface.
   Tighten the retaining screw.

2. Setting of wire rope length

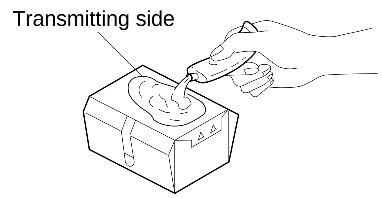
   Place the sensor on the marking line and attach the wire rope and mounting spring.



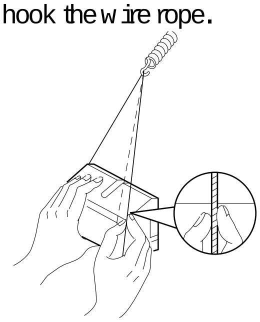
   Loosen the wire clip, stretch the wire rope until the overall length of the mounting spring becomes 180mm, and secure the wire clip (free length of the mounting spring is 110mm).
   Remove the sensor with the wire rope fixed in place.

3. Mounting of sensor

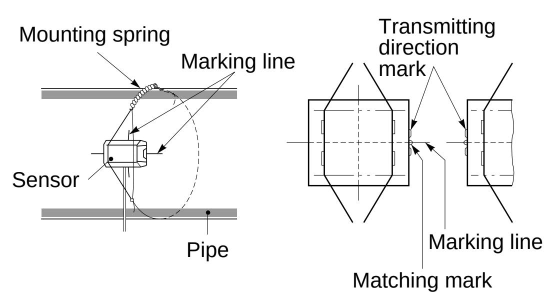
   - Clean the sensor transmitting surface and pipe mounting surface.
   - Spread silicone filler over the whole transmitting surface of the sensor.
   - The thickness of silicone filler should be about 3mm.



   - Spread the wire rope near the marking line to right and left. Attach the sensor firmly to the pipe and hook the wire rope.



   - Make sure that the matching mark on the sensor is aligned with the marking line. Also, make sure the transmitting direction marks on the sensor are facing with each other.

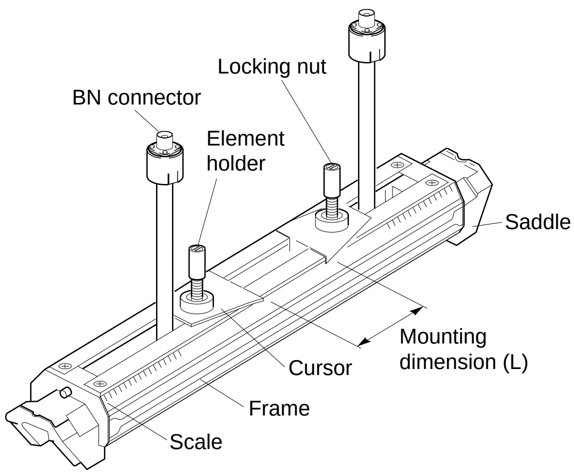


   - Confirm that the sensor matching mark is aligned with the marking line, then connect the coaxial cable to sensor.

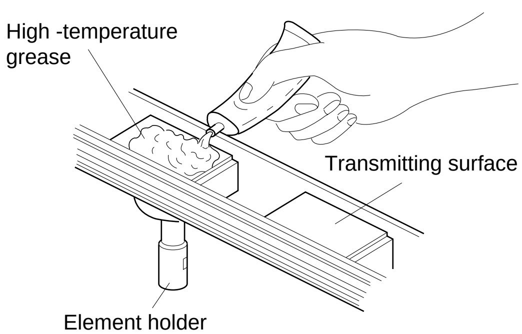
Note) Do not pull the coaxial cable. If it is pulled, the sensor may move from its mounting position which affects correct measurements.

8.1 (12) Mounting of high temperature sensor on pipe

1. By loosening lock nuts, slide the sensor to fit the mounting size displayed on the converter. Tighten the lock nuts.

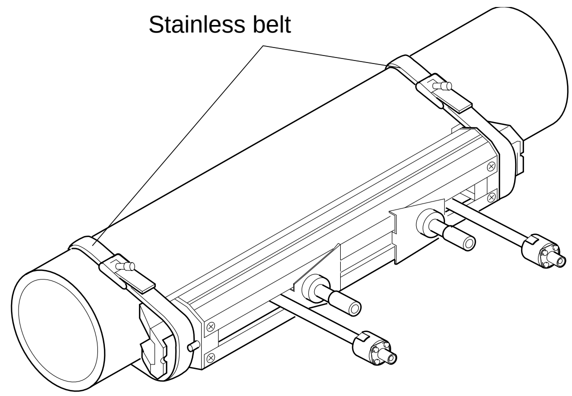


2. Spread high-temperature grease over the whole transmitting surface of the sensor.

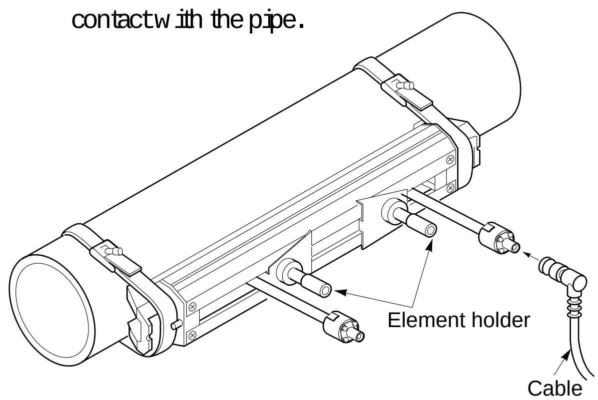


Turn the element holder counterclockwise to return the sensor. Clean the surface of the pipe and mount the sensor on the pipe.

3. Mount the sensor saddles on the pipe with stainless belt.



4. Check that the sensor is properly attached in parallel to the pipe and it is mounted according to the mounting dimension. Then, turn the element holder clockwise, so that the sensor makes a close contact with the pipe.



Stop turning the element holder where the transmitting surface contact the surface of pipe, and thus the element holder won't rotate. Don't turn it excessively.

(1) Specifications

Services

- Measuring fluid : Homogeneous liquid suitable for the pass of ultrasonic wave (water, sea water or oil. Even liquid of which sound velocity is not clear is measurable)
- Turbidity of fluid : 10,000 deg. (mg/l) or less
- Flow : Uniform flow, free from drift in pipe filled with fluid.
- Fluid temperature : Small type sensor ; –40 to +176°F
  Large type sensor ; –40 to +176°F
  High temperature sensor ; –40 to +392°F
- Measuring range : –105 to 0 to +105 ft./s

Piping conditions

- Material of piping : Carbon steel, stainless steel, cast iron, FRP, asbestos, copper, aluminum, acrylic, etc.
- Diameter of pipe : Small type sensor ø2 to ø16 in.
  Large type sensor ø8 to ø236 in.
  High temperature sensor ø2 to ø16 in.
- Lining material : None, tar epoxy, mortar, rubber, or material with known sound velocity
- Length of straight pipe : Upstream side : 10D or more
  Downstrem side : 5D or more (D: inner diameter of pipe)

Accuracy rating

Diameter	Flow velocity	Accuracy
ø2 to ø12 in. or less	6.56 to 105 ft./s	1.0% of rate
	0 to 6.56 ft./s	3.3 ft./s
ø12 to ø236 in.	3.26 to 105 ft./s	1.0% of rate
	0 to 3.26 ft./s	0.03 ft./s

Converter (Type: FLV)

- Measuring method : Propagation delay time system
- Power supply : 100 to 240V ±10% AC, 50/60Hz
- Electric power : Approx. 20VA (about 10W)
- LCD : Character display (16th digits, 2 lines) with back light
- Operation unit : Seat key (20 keys)
- Reset after power interruption : Backup by non-volatile memory (available for 10 years)
- Response speed : 0.5 sec or less
- Output signal : Analog signal 4 to 20mA DC, 1 point (load resistance: 0 to 1kW)
  Contact signal open collector (30V DC, 0.1A), 1 point
- Ambient temperature : +14 to +140°F
- Ambient humidity : 90% RH or less
- Enclosure : Immersion-proof (aluminum casting case), IP65 or equivalent
- Color of paint : Cover (blue), case (silver)
- Dimensions : H 10.91 ´ W 9.61 ´ D 3.74 ft.
- Mass : Approx. 10 lbs.

Sensor (Type : FLW)

- Mounting method : Pipe-mounting
- Mounting method of sensor: V method or Z method
- Attaching belt/wire : Small type sensor: stainless chain
  Large type sensor: stainless wire
  High temperature sensor: stainless belt
- Sound coupler : Silicon rubber
- Signal cable : Dedicated coaxial cable (standard 16 ft., max. 492 ft.)
- Connection : Terminal screw
  High temperature sensor: BNC connector
- Ambient temperature : –4 to +140°F
- Ambient humidity : 100% RH or less
- Enclosure : Immersion-proof type (IP67 or equivalent)
  High temperature sensor: Drip-proof type (IP52 or equivalent)
- Material :
- Dimensions and mass :

Types	Sensor case	Guide rail
Small type sensor	Plastic	SUS304 + plastic
Large type sensor	Plastic	– – – – – –
High temperature sensor	SUS304	Aluminum alloy + SUS304

Types	Dimensions (H ´ W ´ D)	Mass
Small type sensor	1.67 ´ 2.62 ´ 1.31 ft.	Approx. 2.2 lbs.
Large type sensor	.34 ´ .3 ´ .2 ft.	Approx. 3.1 lbs.
High temperature sensor	1.74 ´ .17 ´ .67 ft.	Approx. 3.6 lbs.

(2) Function

- Display language : Japanese (Katakana)/English selectable
- Instantaneous value display function :Flow velocity/flow rate (with flow direction) selection
  Unit:metric system /inch system selectable

	Metric system	English sytem
Flow velocity	m/s	ft/s
Flow rate	l/s, l/m, l/h, Ml/d m^3/s, m^3/m, m^3/h, Mm^3/d BBL/s, BBL/m, BBL/h, MBBL/d	gal/s, gal/m, gal/h, Mgal/d ft^3/s, ft^3/m, ft^3/h, Mft^3/d BBL/s, BBL/m, BBL/h, MBBL/d

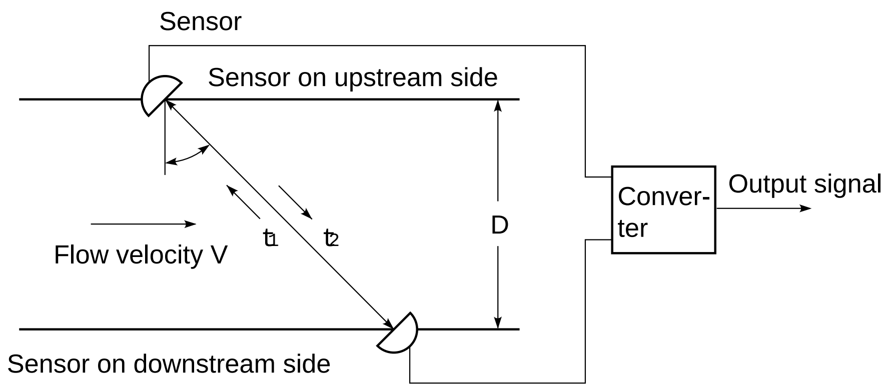
- Integral value display function : forward integral value selection
  Unit:metric/inch selectable

	Metric system	English sytem
Integral value	ml, l, m^3, km^3, Mm^3 mBBL, BBL, kBBL	gal, kgal, ft^3, kft^3, Mft^3 mBBL, BBL, kBBL

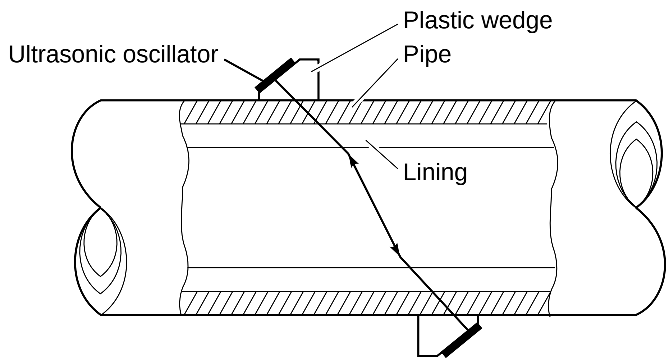
- Instantaneous value output function :analog signal 4 to 20mA DC
- Damping : 0 to 100 sec (time constant)
- Low flow cut : 0 to 16.4 ft./s
- Output setting function :Scaling/limit of current output, burnout setting
  Current output calibration available
- Communication function :nstantaneous flow velocity, instantaneous flow rate, integral value, status
- Auto range selection : Judgement of range by 2 range and contact output
- Forward/reverse selection : Judgement of flow direction by forward/reverse range and contact output
- Integrated pulse output: 5P/s, max. pulse width (50, 100ms selectable)
- Others : Self diagnosis function

(3) Principle of measurement

With ultrasonic pulses propagated diagonally from the upstream and downstream sides, flow rate is measured by detecting the time difference obtained by the flow of fluid.

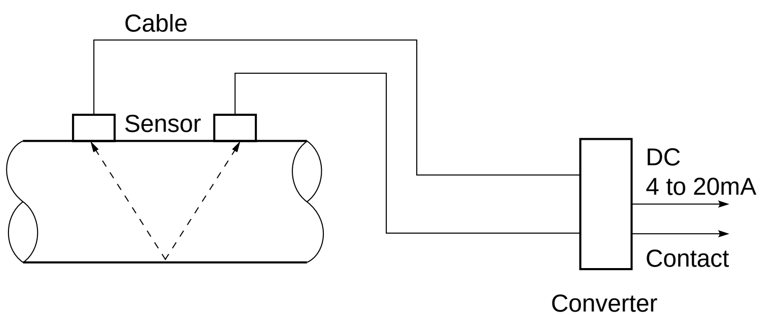


(4) Mounting of sensor

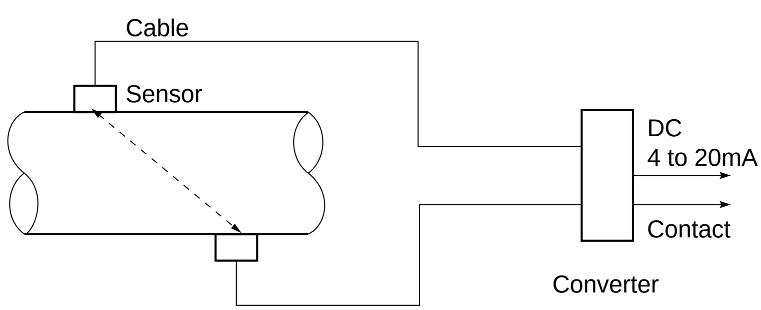


(5) Construction

(1) Single-measuring-path system (V method)



(2) Single-measuring-path system (Z method)



Data Sheet

SS/MAG/WW Issue 17

Electromagnetic Flowmeter

MagMaster – Water & Waste Water Version

- **Industry-specific design**
  - suitable for all applications found in the water and waste water industries
- **Widest flow range, highest accuracy**
  - diameters from 15mm to 2200mm (0.5 to 84 in.)
- **Submersible sensor**
  - suitable for flooded chambers and pits
- **Buriable sensor**
  - eliminates chambers and ensures fast, low-cost installation
- **Hazardous area approvals**
  - FM, CSA, ATEX
  - ideal for waste water treatment works
- **Built-in earthing (grounding) electrode**
  - eliminates the need for earthing (grounding) flanges
- **2-year warranty as standard**
  - high-quality product guarantees reliable maintenance-free operation
- **CalMaster compatible**
  - in situ verification of flow meter calibration
- **Remote Communications**
  - including Profibus DP v0

MagMaster – bringing unsurpassed flowmetering performance to the Water and Waste Water industries

ABB

Setting the Standard

Designed specifically to target the diverse applications found in the supply and treatment of both potable and waste water, MagMaster sets new levels of accuracy, reliability and low cost of ownership.

MagMaster's ground-breaking design guarantees long-term calibration stability, coupled with the wide range of sizes, 15 to 2600mm (0.5 to 102 in.), choice of lining and electrode material quickly established MagMaster as the de facto industry standard electromagnetic flow meter.

Class-leading Flow Performance

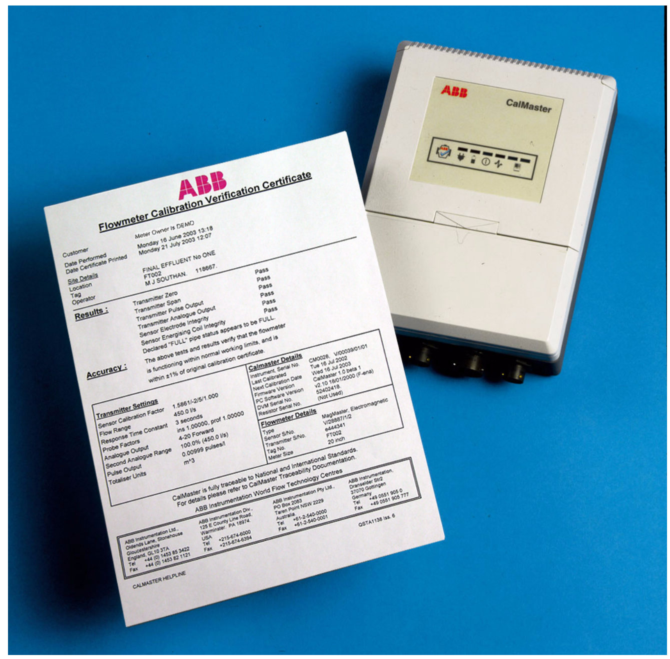
The combination of sensors with ultra-linear magnetics, proven technology, signal processing and sensor drive results in unsurpassed accuracy and an operable flow range of 1500:1. MagMaster's class-leading performance ensures reliable and accurate measurement over the widely varying flow rates, including minimal night flows, which occur in typical water and waste water systems.

Assured Quality

MagMaster is designed and manufactured in accordance with international quality procedures (ISO 9001) and all flowmeters are calibrated on nationally-traceable calibration rigs to provide the end user with complete assurance of both quality and performance of the meter.

Calibration Verification

CalMaster is the world's first in situ calibration verification system. The system allows the calibration of MagMaster electromagnetic flow meters to be verified without the need for 'wet calibration'. The complex series of tests automatically performed by CalMaster is completed and a certificate produced without costly excavation of the sensor or disruption to the water supply. A complete solution to the regulatory requirement for routine verification and traceability of electromagnetic flow meters.



For further information on CalMaster refer to the brochure PB/CALMASTER

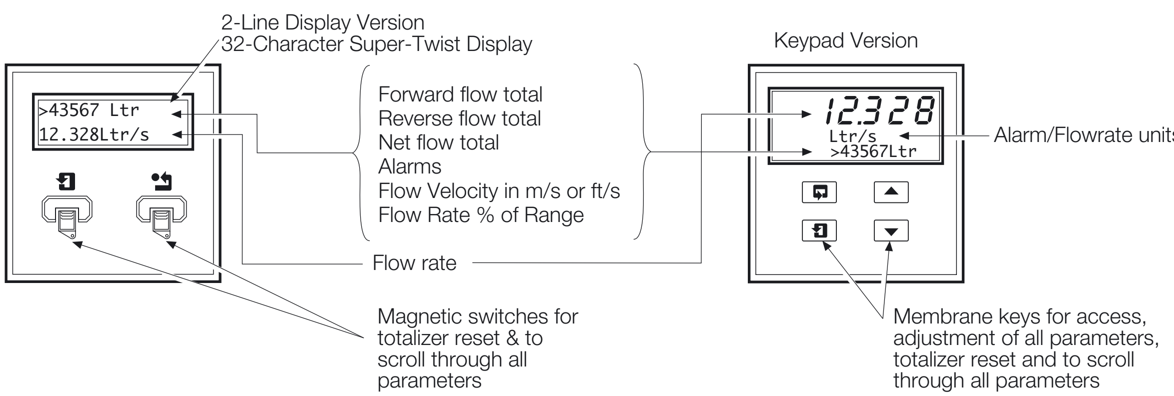
ABB operated national and internationally accredited flow calibration facilities in the UK, USA, Australia, Germany and India.

Electronic Display Unit

- Comprehensive display
- Forward, reverse and net totals
- 4 digital outputs: forward pulse, reverse pulse, alarm 1 and alarm 2
- 2 analog outputs (output 2 optional)
- Communications: serial data (RS232), HART and Profibus DP v0

MagMaster is available with integral or remote transmitters, configuration is achieved either with a configurator of via the optional integral keypad. The software features multi-level password protection to prevent unauthorized configuration changes. In the 2-line display only variant, display data can only be changed using a magnetic wand, no operational parameters can be changed without the use of a configurator and appropriate passwords.

Wallmount Version



Programming Options

- Local hand-held configurator (for example Psion Workabout)
- Integral keypad
- HART
- Personal computer

Easy, Low-cost Installation

MagMaster sensors' rugged and robust construction ensure a long, maintenance-free life under the arduous conditions experienced in the water and waste water industry. The sensors are fully submersible, meeting the requirements of IP68 (NEMA6P) enabling installation in flooded chambers or metering pits.

MagMaster sensors in all sizes are buriable. Installation merely involves excavating to the underground pipe, fitting the sensor, cabling back to the transmitter and then backfilling the hole. No metering chambers or pits are required so the installation is simple, fast and low cost.

Underground Installation of MagMaster

International Approvals

Alternative versions of MagMaster are available for general locations with FM Approval/CSA Certification and for Hazardous Area locations to ATEX, FM and CSA Standards. A brief summary of these Hazardous Area versions is given below, covering the safety designation inside the pipe. No external safety barriers are required.

<table>
<tr><th>SENSOR</th><th>INSIDE PIPE</th><th>TRANSMITTER LOCATION</th></tr>
<tr><td colspan="3">FM & CSA HAZARDOUS AREA APPROVAL – CLASS 1, DIV. 2, GROUPS A B C D</td></tr>
<tr><td>FM APPROVED</td><td rowspan="2">INTRINSICALLY SAFE ELECTRODES</td><td>REMOTE ONLY IN HAZARDOUS AREA</td></tr>
<tr><td>CSA CERTIFIED</td><td>REMOTE ONLY IN HAZARDOUS AREA</td></tr>
<tr><td>CSA CERTIFIED</td><td>NON INCENDIVE</td><td>INTEGRAL AND REMOTE IN HAZARDOUS AREA</td></tr>
<tr><td colspan="3">ATEX — II 2 (i) G EEx e m ia IIC T4</td></tr>
<tr><td>ZONE 1</td><td>ZONE 0</td><td>REMOTE TRANSMITTER IN SAFE AREA</td></tr>
</table>

Specification

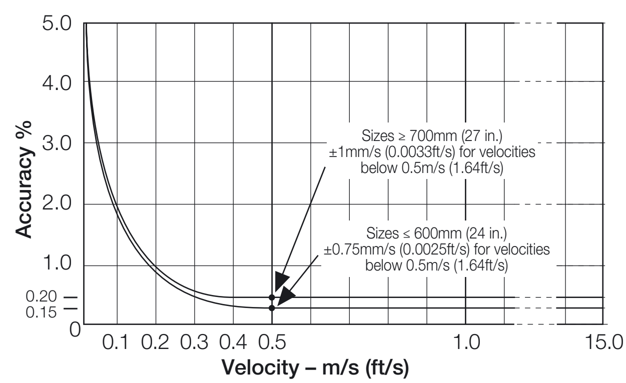
Sensor

Sizes

Sizes mm (in.)	Flow Range	
	Minimum	Maximum*
	m^3/h (US g/min)	m^3/h (US g/min)
15 (0.6)	0.005 (0.021)	6 (28)
20 (0.8)	0.009 (0.038)	11 (50)
25 (1)	0.014 (0.059)	17 (77)
40 (1.6)	0.035 (0.15)	45 (197)
50 (2)	0.053 (0.23)	71 (311)
65 (2.5)	0.089 (0.40)	119 (525)
80 (3)	0.136 (0.59)	181 (796)
100 (4)	0.21 (0.94)	283 (1243)
150 (6)	0.47 (2.10)	640 (2797)
200 (8)	0.84 (3.73)	1130 (4974)
250 (10)	1.32 (5.83)	1770 (7771)
300 (12)	1.91 (8.4)	2540 (11190)
350 (14)	2.60 (11)	3460 (15230)
400 (16)	3.39 (15)	4520 (19890)
450 (18)	4.29 (19)	5730 (25180)
500 (20)	5.3 (23)	7070 (31090)
600 (24)	7.6 (33)	10180 (44760)
700 (28)	14 (46)	13850 (60920)
760 (30)	16 (52)	15900 (69930)
800 (31)	18 (60)	18100 (79560)
900 (35)	23 (75)	22900 (100700)
1000 (39)	28 (93)	28300 (124300)
1050 (41)	31 (112)	34200 (150400)
1200 (47)	41 (134)	40700 (179000)
1400 (55)	55 (182)	55400 (243700)
1500 (59)	64 (208)	63600 (279700)
1600 (63)	72 (238)	72400 (318300)
1800 (71)	92 (302)	91600 (402800)
2000 (79)	113 (372)	113100 (497400)
2200 (87)	136 (451)	137000 (602000)

* Based on 10ms^{-1} (33fts^{-1}), but instrument capability in excess of 15ms^{-1} (50fts^{-1})

Accuracy (under forward flow reference conditions)



Analog output	Additional < ±0.008mA
Temperature effect	
Transmitter	<±0.08% of reading/10°C
	Analog output – Additional
	<±0.08% of reading/10°C
Power supply variation	Negligible
Pressure effect	<0.15% over the operating range of the equipment

Wetted Material

Lining

Suitable for potable water and waste water (all materials UKWFBS listed)
Contact factory for non-standard materials

Electrodes

Stainless steel 316
Contact factory for non-standard materials

Flanges

Carbon steel

Pressure limitations

≤600mm as flange rating

≥700mm 6, 10 or 16 bar

Environmental protection

IP68 (NEMA6P)

Buriable to 5m (16 ft) depth

Pressure equipment directive 97/23/EC

This product is applicable in networks for the supply, distribution and discharge of water and associated equipment and is therefore exempt.

Conductivity

≥5μS/cm

End connections

PN6	ANSI B16.5 Class 150
PN10	ANSI/AWWA C207 Class B and D
PN16	AS2129 Table C or BS10/AS2129 Table D and E

Electronic Display Unit

Mounting

Integral with sensor

OR

Remote up to 100m (325 ft)
Longer lengths available on request

Housing

IP65 (NEMA4)

Glass-loaded polypropylene, polycarbonate window ULVO rated

Electrical connections

20mm glands, or accepts

1/2 in. NPT connections

Sensor cable

ABB cable supplied as standard

Armored version available on request

Power supply*

Voltage Type	Voltage Range (V) Absolute rating	Frequency (Hz)	VA
AC	85 to 265	47 to 440	<20
DC	11 to 40	–	<20

*Power supply fully isolated

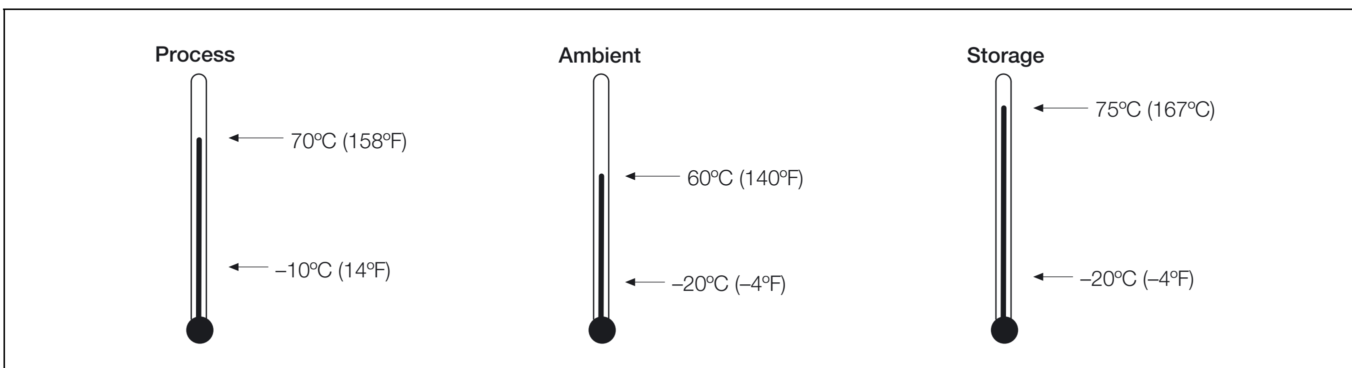
Liquid Sensing

Drives output to zero with an empty pipe

Languages

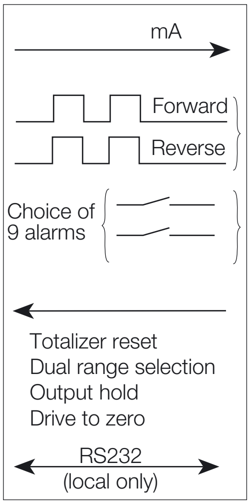
Operation in English, French, German, Spanish, Italian, Dutch plus others on application

Temperature Ranges



Output/Inputs

Common



<21mA, -16V

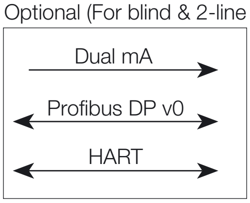
<800Hz, <35V open collector square wave, or fixed pulse width <2.5s, -250mA

<35V, >250mA open collector

Contact closure or logic input

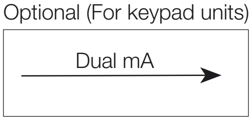
9-pin D-connector (PC compatible)

Optional (For blind & 2-line display units)



Dual analog (optional)
Non-active output is 4mA or 0mA

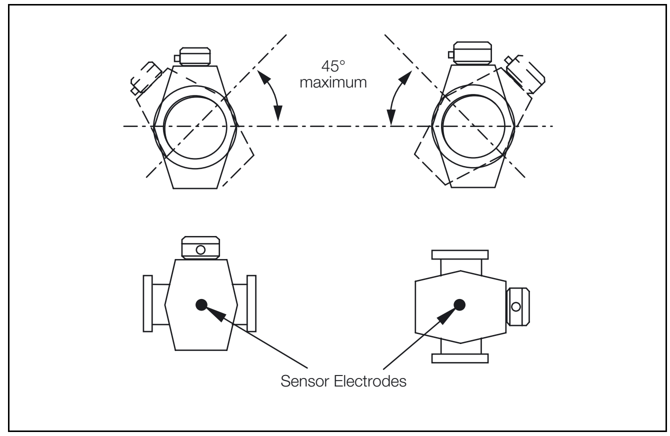
Optional (For keypad units)



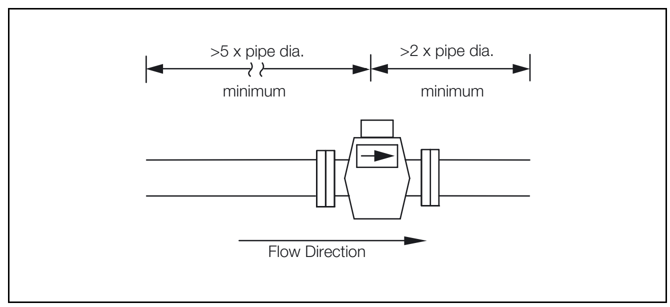
Dual analog
Non-active output is 4mA or 0mA

Galvanic isolation to 50V DC between analog pulse/alarm and earth/ground

Mounting



Pipe Connections

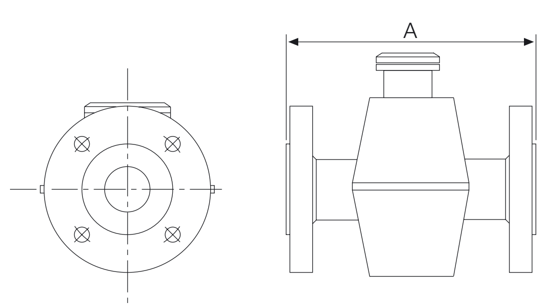


Sensor Specification (nominal dimensions)

15 to 2200mm (0.5 to 84 in.)

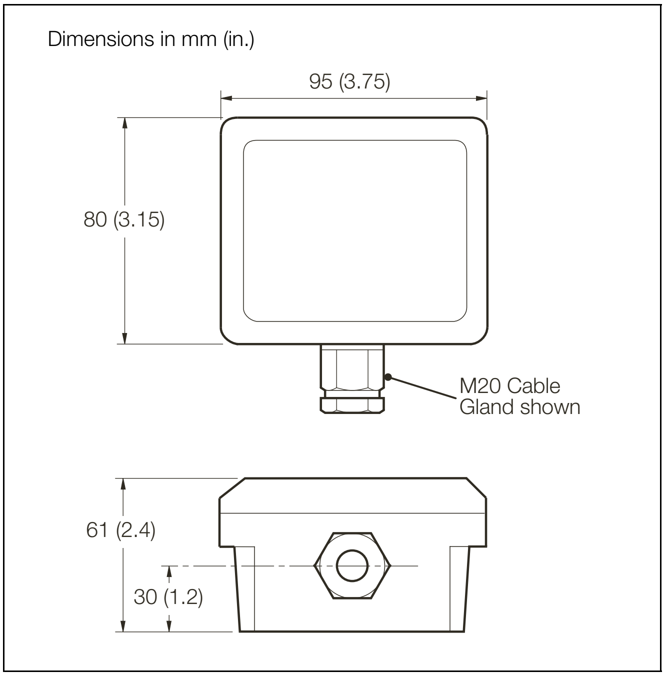
Meter Size mm	Flange Size			Length A mm (in.)	Approximate Weight kg (lb)
	Metric Flanges (DN)	BS10 Flanges (in.)	AWWA C207 Flanges (NPS)		
15	15	1/2	1/2	200 (7.9)*	7 (15)
20	20	3/4	3/4		
25	25	1	1		
40	40	1 1/2	1 1/2		9 (20)
50	50	2	2		10 (23)
65	65	2 1/2	2 1/2		18 (40)
80	80	3	3		18 (40)
100	100	4	4	250 (9.8)*	24 (54)
150	150	6	6	300 (11.8)*	38 (84)
200	200	8	8	350 (13.8)**	55 (121)
250	250	10	10	450 (17.7)**	88 (194)
300	300	12	12	500 (19.7)**	128 (282)
350	350	14	14	550 (21.7)**	100 (220)
400	400	16	16	600 (23.6)**	115 (253)
450	450	18	18	698 (27.5)**	160 (352)
500	500	20	20	768 (30.2)**	217 (455)
600	600	24	24	918 (36.1)**	315 (693)
700	700	27	28	700 (27.6)***	430 (945)
760	760	30	30	762 (30)***	
800	800	–	–	800 (31.5)***	
900	900	36	36	900 (35.4)***	540 (1190)
1000	1000	39	39	1000 (39.4)***	720 (1585)
1050	1050	42	42	1067 (42)***	880 (1930)
1200	1200	48	48	1200 (47.2)***	1000 (2160)
1400	1400	54	54	1400 (55.1)***	1450 (3190)
1500	1500	60	60	1524 (59)***	1370 (3000)
1600	1600	66	66	1600 (63)***	2000 (4400)
1800	1800	72	72	2250 (88.6)***	2400 (5280)
2000	2000	78	78	2500 (98.4)***	3200 (7040)
2200	2200	84	84	2750 (110)***	4200 (9300)

*Typical tolerance +0/–3mm
**Typical tolerance +0/–5mm
***Typical tolerance +0/–10mm

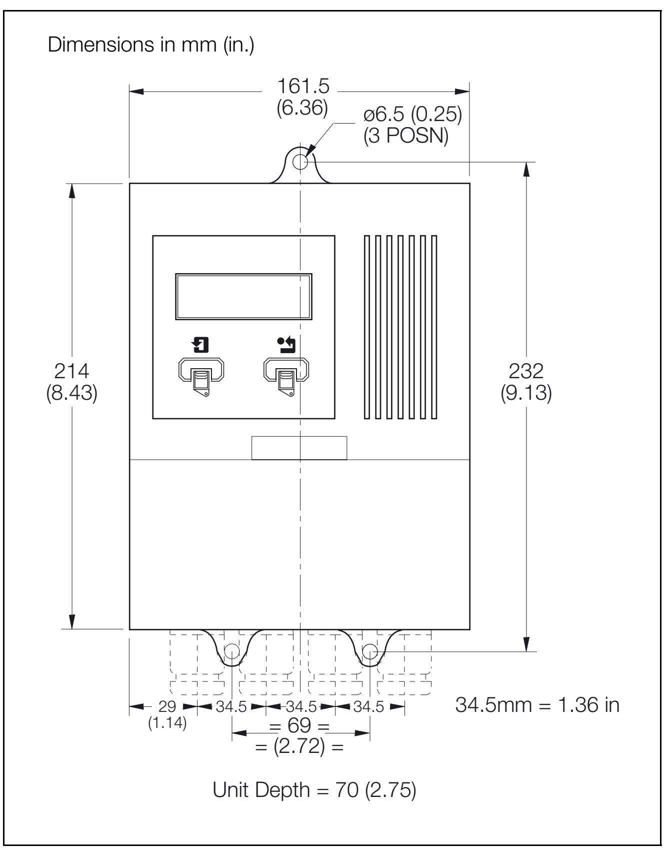


Overall Dimensions

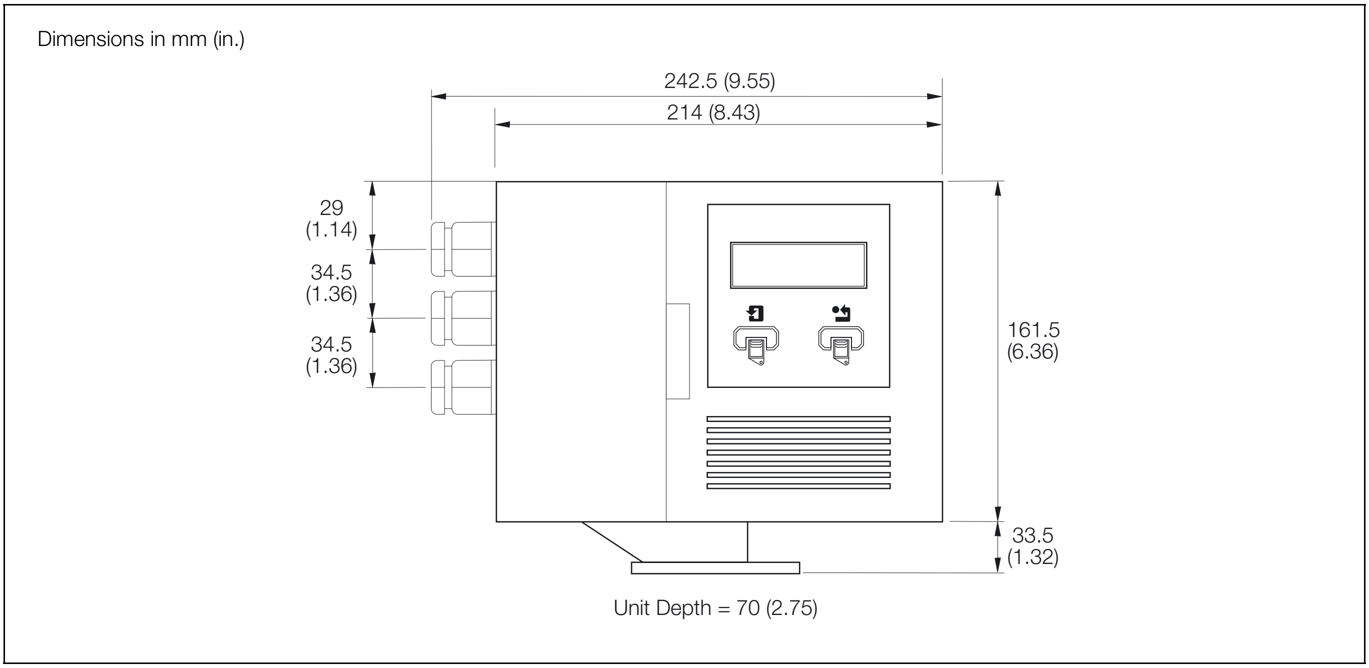
Terminal Box – Sensor Mounted



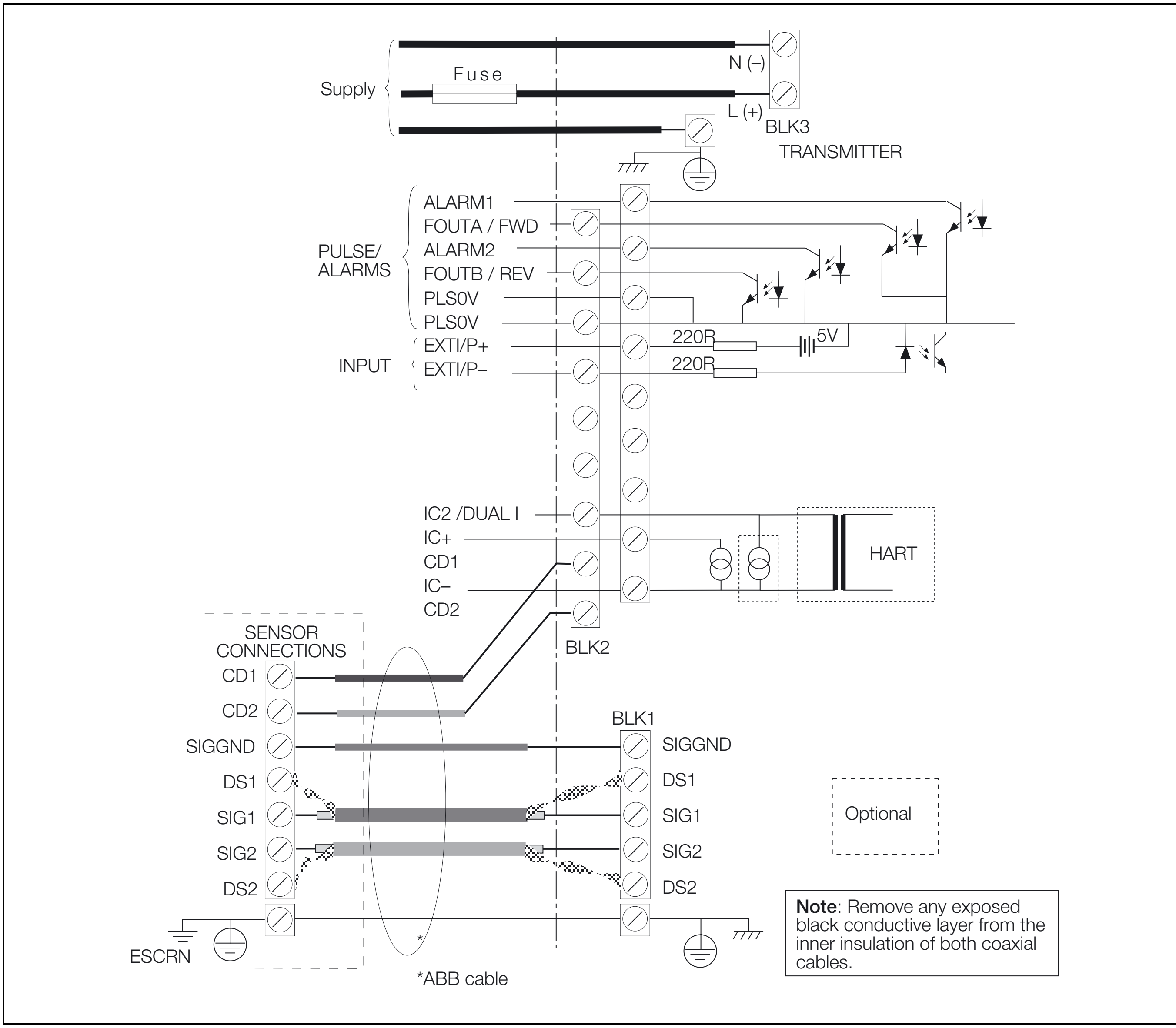
IP65/NEMA4 Remote Electronic Display Unit



Integral Electronic Display Unit (mounted on Sensor)



Electrical Connections



Ordering Information

Sensor Ordering Code	**MF**	**XXXX**	**X**	**X**	**X**	**X**	**0**	**X**	**XX**	**X**	**XX**
Calibrated Bore											
No sensor (Transmitter only)		E000									
15mm (1/2 in.)		E150									
20mm (3/4 in.)		E200									
25mm (1 in.)		E250									
40mm (1 1/2 in.)		E400									
50mm (2 in.)		E500									
65mm (2 1/2 in.)		E650									
80mm (3 in.)		F800									
100mm (4 in.)		F101									
150mm (6 in.)		F151									
200mm (8 in.)		F201									
250mm (10 in.)		F251									
300mm (12 in.)		F301									
350mm (14 in.)		F351									
400mm (16 in.)		F401									
450mm (18 in.)		F451									
500mm (20 in.)		F501									
600mm (24 in.)		F601									
700mm (28 in.)		F701									
760mm (30 in.)		F761									
800mm (31 in.)		F801									
900mm (35 in.)		F901									
1000mm (39 in.)		F102									
1050mm (41 in.)		F112									
1200mm (47 in.)		F122									
1400mm (55 in.)		F142									
1500mm (59 in.)		F152									
1600mm (63 in.)		F162									
1800mm (71 in.)		E182									
2000mm (79 in.)		E202									
2200mm (87 in.)		E222									
≥2400mm (94 in.) – apply to Sales Office											
End Connections – Flanged											
None (Transmitter only)			0								
PN16, fully rated			1								
PN16, 10 bar rated 700mm to 2200mm			C								
PN16, 6 bar rated 700mm to 2200mm			B								
PN10, fully rated			5								
PN6, fully rated 700mm to 2200mm			8								
ANSI B 16.5 class 150, fully rated ≤24 in.			3								
ANSI/AWWA C207 class B fully rated 27 in. to 66 in.			U								
ANSI/AWWA C207 class D fully rated 27 in. to 66 in.			V								
AS2129 Table C fully rated ≤24 in.			F								
AS2129 Table D fully rated ≤66 in.			L								
BS10/AS2129 Table E, fully rated ≤48 in.			7								
BS10 Table D fully rated ≤66 in.			K								
AS4087 Class 16			Z								

Sensor Ordering Code	MF	XXXX	X	X	X	X	0	X	XX	X	XX

Option	Code
Lining Material	
None (Transmitter only)	0
Elastomer suitable for potable water and waste water – WRAS (UK) Listed	4
Elastomer suitable for potable water and waste water – ACS (France) Approved	F
Others on application	
Electrodes	
None (Transmitter only)	0
316 Stainless Steel (suitable for water and waste water)	1
Others on application	
Sensor Build Standard	
Transmitter only	0
General	1
FM/CSA – GENERAL	8
Calibration	
Transmitter only	0
Standard 3-point, with pressure test	1
8-point, with pressure test	2
UKAS, with pressure test	5
Standard 3-point, no pressure test	A
8-point, no pressure test	B
UKAS, no pressure test	D
Standard 3-point; CalMaster Fingerprint & disk; No pressure test	I
Standard 3-point; CalMaster Fingerprint & disk; With pressure test	J
Cable Length – User-specified length in 10m increments (90m max.) (Must be '00' for glanding digit 4)	XX
Glanding	
None (Transmitter only)	0
20mm plastic gland (sensor cable fitted and potted)	1
Conduit entry: 1/2 in. NPT (Blanked) – all North American versions (cable length to be '00')	4
20mm plastic. Cable not fitted.	5
20mm armor. Cable not fitted.	7
Transmitter	
Sensor-mounted MagMaster Transmitter, ≤400mm (16 in.) only	EH
Remote MagMaster Transmitter	ER

Transmitter Ordering Code	X	X	X	X	X	X	X
Power Supply							
None - Sensor only	0						
95V to 240V AC nominal, 47 to 440Hz	1						
11V to 40V DC (Max)	3						
Display							
None (or sensor only)		0					
2-Line Display		3					
3-Line Display with keypad (no HART)		4					
Output Options							
Standard outputs (or sensor only)			0				
Dual current output			1				
HART communications			2				
Profibus DP v0			8				
Transmitter Build Standard							
Transmitter only				0			
General				1			
FM/CSA – GENERAL				3			
Display Orientation							
None (or sensor only)					0		
Standard					1		
Other please enquire							
Language							
None (or sensor only)						0	
English						1	
French						2	
German						3	
Spanish						4	
Italian						5	
Dutch						6	
Labelling							
Factory allocated (internal only)							X

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Printed in UK (08.07)

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SS/MAG/WW Issue 17

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GE Panametrics

Model DF868

Startup Guide
(One- and Two-Channel)

June 2004

Process Control Instruments

Model DF868 (1 & 2 Channel) Multipurpose Ultrasonic Liquid Flowmeter

Startup Guide *910-176UB1*

GE Panametrics

Warranty

Each instrument manufactured by GE Panametrics is warranted to be free from defects in material and workmanship. Liability under this warranty is limited to restoring the instrument to normal operation or replacing the instrument, at the sole discretion of GE Panametrics. Fuses and batteries are specifically excluded from any liability. This warranty is effective from the date of delivery to the original purchaser. If GE Panametrics determines that the equipment was defective, the warranty period is:

- one year for general electronic failures of the instrument
- one year for mechanical failures of the transducers

If GE Panametrics determines that the equipment was damaged by misuse, improper installation, the use of unauthorized replacement parts, or operating conditions outside the guidelines specified by GE Panametrics, the repairs are not covered under this warranty.

The warranties set forth herein are exclusive and are in lieu of all other warranties whether statutory, express or implied (including warranties or merchantability and fitness for a particular purpose, and warranties arising from course of dealing or usage or trade).

Return Policy

If a GE Panametrics instrument malfunctions within the warranty period, the following procedure must be completed:

1. Notify GE Panametrics, giving full details of the problem, and provide the model number and serial number of the instrument. If the nature of the problem indicates the need for factory service, GE Panametrics will issue a RETURN AUTHORIZATION NUMBER (RAN), and shipping instructions for the return of the instrument to a service center will be provided.
2. If GE Panametrics instructs you to send your instrument to a service center, it must be shipped prepaid to the authorized repair station indicated in the shipping instructions.
3. Upon receipt, GE Panametrics will evaluate the instrument to determine the cause of the malfunction.

Then, one of the following courses of action will then be taken:

- If the damage is covered under the terms of the warranty, the instrument will be repaired at no cost to the owner and returned.
- If GE Panametrics determines that the damage is not covered under the terms of the warranty, or if the warranty has expired, an estimate for the cost of the repairs at standard rates will be provided. Upon receipt of the owner's approval to proceed, the instrument will be repaired and returned.

Table of Contents

Table of Contents (cont.)

Chapter 1

Installation

Introduction

To ensure safe and reliable operation of the Model DF868 Ultrasonic Liquid Flowmeter, the system must be installed in accordance with the guidelines established by GE Panametrics' engineers. Those guidelines, which are explained in detail in this chapter, include the following specific topics:

- Unpacking the Model DF868 system
- Selecting a suitable site for the electronics console and the flowcell/transducers
- Installing a flowcell
- Installing temperature transmitters
- Installing the Electronics Console
- Wiring the Electronics Console.

!WARNING!
The Model DF868 flowmeter can measure the flow rate of many liquids, some of which are potentially hazardous. In such cases, proper safety practices must be observed.

Be sure to follow all applicable local safety codes and regulations for installing electrical equipment and working with hazardous liquids or flow conditions. Consult company safety personnel or local safety authorities to verify the safety of any procedure or practice.

ATTENTION EUROPEAN CUSTOMERS!
In order to meet CE Mark requirements, all wiring connections must be made in accordance with the instructions in Appendix A, *CE Mark Compliance*.

Unpacking

Carefully remove the electronics console, the transducers, and the cables from the shipping containers. Before discarding any of the packing materials, account for all components and documentation listed on the packing slip. The discarding of an important item along with the packing materials is all too common. If anything is missing or damaged, contact the factory immediately for assistance.

Site Considerations

Because the relative physical locations of the flowcell and the Model DF868 electronics console are important, use the guidelines given in this section to plan the Model DF868 system installation.

Electronics Console Location

The standard Model DF868 electronics enclosure is a NEMA-4X weather-resistant, dust-tight, indoor/outdoor type. Typically, the electronics console is mounted in a meter shed. When choosing a mounting site, make sure that the location permits easy access to the console for programming, testing, and servicing.

Note: *For compliance with the European Union's Low Voltage Directive (73/23/EEC), this unit requires an external power disconnect device such as a switch or circuit breaker. The disconnect device must be marked as such, clearly visible, directly accessible, and located within 1.8 m (6 ft) of the Model DF868.*

Flowcell Location

The pipeline flowcell consists of the flow transducers and any temperature transducers employed as part of the flowmeter system. Ideally, choose a section of pipe with unlimited access as the flowcell, such as a long stretch of pipe that is above ground. However, if the flowcell is mounted on an underground pipe, dig a pit around the pipe to facilitate installation of the transducers.

Transducer Location

For a given fluid and pipe, the Model DF868's accuracy depends primarily on the location and alignment of the transducers. In addition to accessibility, when planning for transducer location, adhere to the following guidelines:

1. Locate the transducers so that there are at least 10 pipe diameters of straight, undisturbed flow upstream and 5 pipe diameters of straight, undisturbed flow downstream from the measurement point. To ensure undisturbed flow, avoid sources of turbulence in the fluid such as valves, flanges, expansions and elbows.

2. Because sediment at the bottom of the pipe and gas at the top of the pipe may cause attenuation of the ultrasonic signal, locate the transducers on the side of a horizontal pipe, when possible. If limited pipe access necessitates top-mounted transducers and the sound beam path includes a reflection, shift the transducers to at least 10° off top center. This will minimize the influence of any sediment or gas on the reflected ultrasonic signals.

Cable Lengths

Locate the flowcell/transducers as close as possible to the electronics console. GE Panametrics supplies transducer cables up to 1,000 ft (306 m) in length. If longer cables are required, consult the factory for assistance.

Temperature Transmitters

When installing temperature transmitters in the flowcell, locate them downstream of the flow transducers. These transmitters should be positioned no closer to the flow transducers than 2 pipe diameters and no further away from the flow transducers than 20 pipe diameters.

Transducer Cables

When installing the transducer cables, always observe established standard practices for the installation of electrical cables. Specifically, do not route transducer cables alongside high amperage AC power lines or any other cables that could cause electrical interference. Also, protect the transducer cables and connections from the weather and corrosive atmospheres.

Note: *When using non-GE Panametrics cables to connect the flow transducers to the Model DF868 electronics console, the cables must have electrical characteristics identical to the GE Panametrics cables. Type RG 62 a/u coaxial cable should be used, and each cable must be the same length (within ±4 in.).*

Installing a Flowcell

A flowcell is the section of pipe where the transducers are mounted. It can be created either by mounting the transducers on the existing pipeline or by mounting them on a spoolpiece. A spoolpiece is a separately manufactured pipe section, matched to the existing pipe, which contains ports for mounting the transducers. This approach allows the transducers to be aligned and calibrated before inserting the spoolpiece into the pipeline.

Figure 1-1 on page 1-4 shows a diagram of a typical Model DF868 system. For detailed instructions on installing the transducers and/or spoolpiece, refer to the supplied drawings and the GE Panametrics *Liquid Transducer Installation Guide (916-055)*.

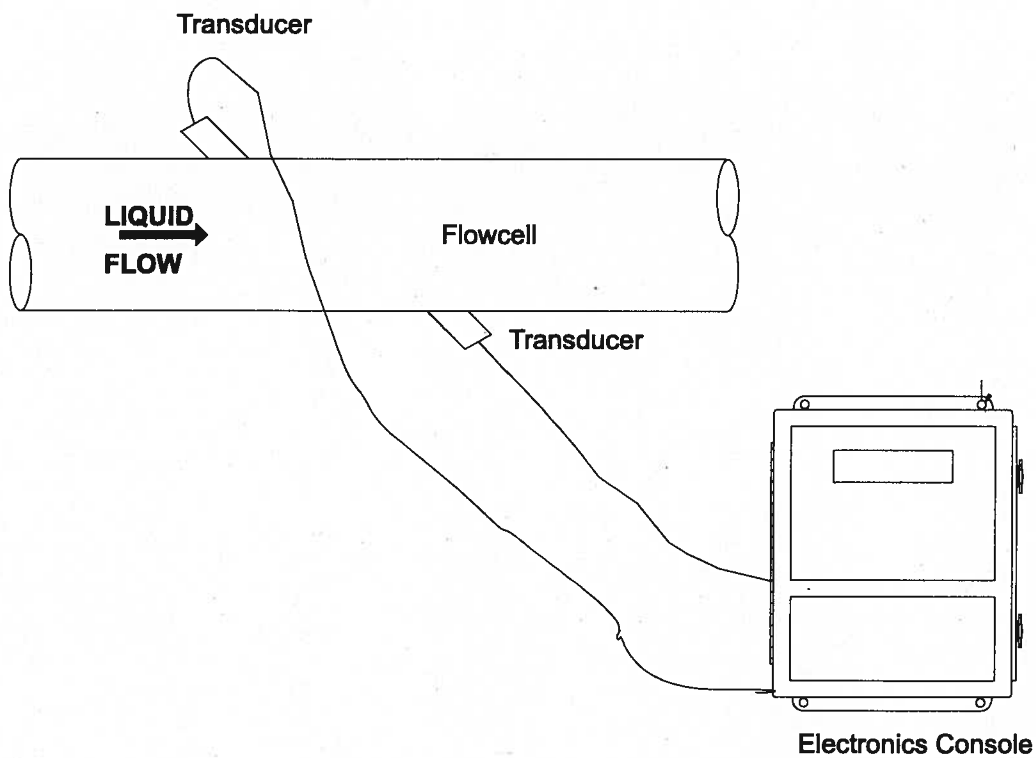


Figure 1-1: A Typical Model DF868 System

Installing Temperature Transmitters

Optional temperature transmitters may be installed as part of the flowcell, near the ultrasonic transducer ports. Be sure to observe the siting requirements given earlier in this chapter. These transmitters must use a 0/4-20 mA signal to transmit the temperature values to the Model DF868 electronics console. In turn, the electronics console will provide a 24 VDC signal to power the transmitters. Any desired transmitters or sensors may be used, but they must have an accuracy equal to 0.5% of the reading or better.

Note: *Resistive Thermal Devices (RTDs) are a good choice for measuring the temperature. If you use direct RTD inputs, you do not require transmitters.*

Typically, a 1/2" NPT female threaded port is used to mount the transmitters on the flowcell. If the pipeline is insulated, the coupling may need to be extended to provide convenient access. Of course, other types of mounting ports, including flanged ports, may be used for the transmitters.

Figure 1-2 below shows a typical mounting arrangement for the pressure and temperature transmitters. The temperature sensor should protrude 1/4 to 1/2 way into the pipe.

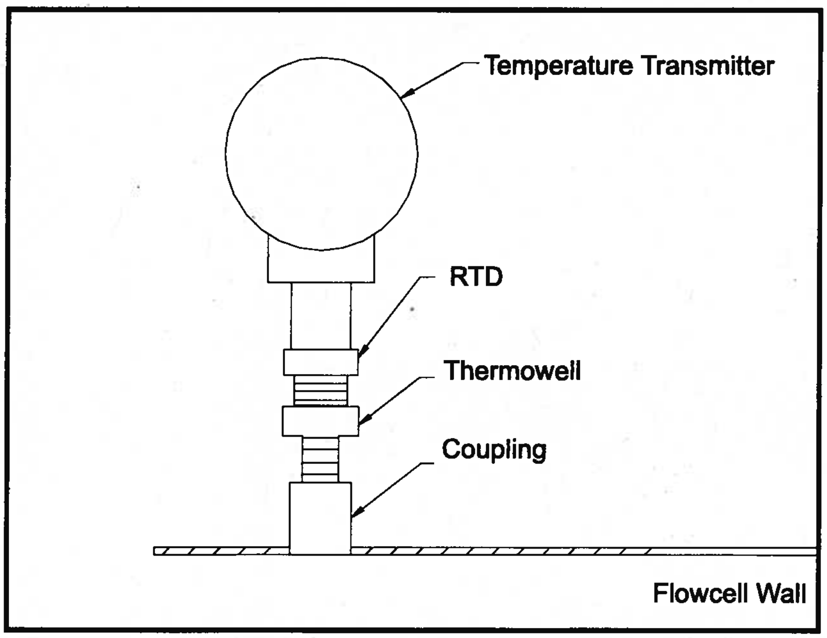


Figure 1-2: Typical Temperature Transmitter Mounting

Mounting the DF868 Electronic Console

The standard Model DF868 electronics package is housed in a NEMA-4X weather-resistant enclosure. Refer to Figure 1-7 on page 1-16 for the mounting dimensions of this enclosure. For meters housed in one of the optional enclosures, a dimensional drawing will be shipped with the unit.

IMPORTANT: *For meters supplied in one of the optional enclosure styles, refer to Appendix C,* Optional Enclosures, *for specific mounting dimensions and instructions.*

Making the Electrical Connections

This section contains instructions for making all the necessary electrical connections to the Model DF868 flowmeter. Refer to Figure 1-8 on page 1-17 for a complete wiring diagram of the unit.

IMPORTANT: *For meters supplied in one of the optional enclosure styles, refer to Appendix C,* Optional Enclosures, *for the appropriate wiring diagram and specific wiring instructions.*

Except for the power connector, all electrical connectors are stored in their terminal blocks during shipment and may be removed from the enclosure for more convenient wiring. Feed the cables through the conduit holes on the bottom of the enclosure, attach the wires to the appropriate connectors and plug the connectors back into their terminal blocks.

Note: *For compliance with the European Union's Low Voltage Directive (73/23/EEC), a transparent plastic shroud protects the electrical connections. The shroud must remain in place, except while wiring the unit. Reinstall the shroud after the wiring has been completed.*

Once the Model DF868 is completely wired, proceed to Chapter 2, *Initial Setup*, to configure the unit for operation.

Wiring the Line Power

The Model DF868 may be ordered for operation with power inputs of 100-120 VAC, 220-240 VAC, or 12-28 VDC. The label on the shroud inside the electronics enclosure, just above the TB1 line power terminal block, lists the required line voltage and the fuse rating for the unit (the fuse rating is also listed in Chapter 4, *Specifications*). Be sure to connect the meter only to the specified line voltage.

Note: *For compliance with the European Union's Low Voltage Directive (73/23/EEC), this unit requires an external power disconnect device such as a switch or circuit breaker. The disconnect device must be marked as such, clearly visible, directly accessible, and located within 1.8 m (6 ft) of the Model DF868.*

Refer to Figure 1-8 on page 1-17 to locate terminal block TB1 and connect the line power as follows:

!WARNING!
Improper connection of the line power leads or connecting the meter to the incorrect line voltage will damage the unit. It will also result in hazardous voltages at the flowcell and associated piping and within the electronics console.

1. Prepare the line power leads by trimming the line and neutral AC power leads (or the positive and negative DC power leads) to a length 0.5 in. (1 cm) shorter than the ground lead. This ensures that the ground lead is the last to detach if the power cable is forcibly disconnected from the meter.

2. If the unit is so equipped, remove the plastic shroud that covers the terminal blocks. Be sure to reinstall the shroud after all of the wiring has been completed.

3. Strip 1/4 in. of insulation from the end of each of the three line power leads.

4. Connect the line power leads to terminal block TB1, using the pin number assignments shown in Figure 1-8 on page 1-17.

Wiring the Transducers

Wiring a typical Model DF868 ultrasonic liquid flowmeter system requires interconnection of the following components:

- a pair of transducers (per channel) mounted in the flowcell
- a lightning protector (optional)
- the electronics console

To wire the transducers, complete the following steps:

!WARNING!
Before connecting the transducers, take them to a safe area and discharge any static buildup by shorting the center conductor of the transducer cables to the metal shield on the cable connector.

1. If an optional lightning protector is being installed, connect it to the electronics end of the cables according to the instructions provided.
2. Locate the CH1 transducer cables and connect them to the two CH1 transducers.
3. Refer to the wiring diagram in Figure 1-8 on page 1-17 and connect the transducer cables to the CH1 terminal block. Then, secure the cable clamp.
4. For a 2-channel Model DF868 flowmeter, repeat steps 2-3 to wire the Channel 2 transducer system to terminal block CH2.

Note: *It is not required that Channel 2 of a 2-channel Model DF868 be used. This channel may be left inactive for future use.*

After the wiring has been completed, the transducer channel(s) must be activated before measurements can begin. See Chapter 2, *Initial Setup*, for instructions.

Wiring the 0/4-20 mA Analog Outputs

The standard configuration of the Model DF868 flowmeter includes two isolated 0/4-20 mA analog outputs (designated as A and B). Connections to these outputs may be made with standard twisted-pair wiring. The current loop impedance for these circuits must not exceed 550 ohms.

Refer to Figure 1-8 on page 1-17 for the location of terminal block I/O and wire the terminal block as shown.

Wiring the Serial Port

The Model DF868 is equipped with a built-in serial communications port. The standard port is an RS232 interface, but an optional RS485 interface is available upon request. Proceed to the appropriate sub-section for wiring instructions. For more information on serial communications, refer to the *EIA-RS Serial Communications* Manual (916-054).

Wiring the RS232 Interface

Use the serial port to connect the Model DF868 flowmeter to a printer, an ANSI terminal or a personal computer. The RS232 interface is wired as Data Terminal Equipment (DTE), and the signals available at terminal block J1 are shown in Table 1-1 below. Refer to Figure 1-8 on page 1-17 and complete the following steps:

1. Disconnect the main power to the unit and remove the cover.

2. Install the required cable clamp in the chosen conduit hole on the side of the electronics enclosure.

3. Use the information in Table 1-1 below to construct a suitable cable for connecting the Model DF868 to the external device. If desired, an appropriate cable may be purchased from GE Panametrics.

Table 1-1: RS232 Connection to DCE or DTE Device

J1 Pin	Signal Description	DCE DB25 Pin #	DCE DB9 Pin #	DTE DB25 Pin #	DTE DB9 Pin #
5	DTR (Data Terminal Ready)	20	4	20	4
6	CTS (Clear to Send)	4	7	5	8
7	COM (Ground)	7	5	7	5
8	RX (Receive)	2	3	3	2
9	TX (Transmit)	3	2	2	3

Note: *Signal names that imply direction (e.g., transmit and receive) are named from the point of view of the DTE device (the GE Panametrics meter is usually considered the DTE device). When the RS232 standard is strictly followed, these signals are labeled with the same name and pin # on the DCE device side as well. Unfortunately, the convention is not followed because the DTE and DCE side get confused. Therefore, connections that imply direction are changed to reflect their direction on the DCE side.*

Wiring the RS232 Interface (cont.)

4. Feed the flying leads end of the cable through the conduit hole and wire it to terminal block J1. Connect the other end of the cable to the printer, ANSI terminal or personal computer, and secure the cable clamp.

!ATTENTION EUROPEAN CUSTOMERS!
To meet CE Mark requirements, all cables must be installed as described in Appendix A, *CE Mark Compliance*.

After the wiring has been completed, consult the *User's Manual* for the external device to configure it for use with the Model DF868.

Wiring the RS485 Interface

Use the optional RS485 serial port to network multiple DF868 flowmeters to a single computer terminal. Upon request, the standard RS232 port on the DF868 may be configured as a two-wire, half-duplex RS485 interface, through a device such as the INMAC Model 800052 RS232-RS422/RS485 converter.

IMPORTANT: *The DF868 must be configured at the factory for RS485 operation.*

To wire the RS485 serial port, refer to Figure 1-8 on page 1-17 and complete the following steps:

1. Disconnect the main power to the unit and remove the cover.
2. Install the required cable clamp in the chosen conduit hole on the side of the electronics enclosure.
3. Feed one end of the cable through the conduit hole, wire it to terminal block J1 and secure the cable clamp. Connect the other end of the cable to the converter, as shown in Figure 1-3 below.

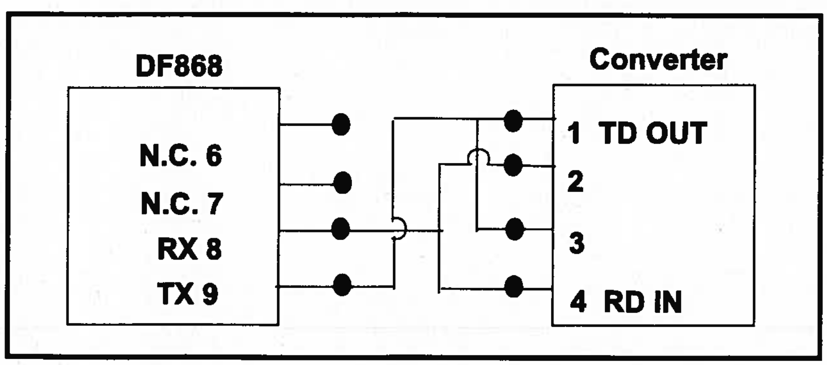


Figure 1-3: Typical RS485 Connections

Wiring the RS485 Interface (cont.)

!ATTENTION EUROPEAN CUSTOMERS!
To meet CE Mark requirements, all cables must be installed as described in Appendix A, *CE Mark Compliance.*

4. If wiring of the unit has been completed, reinstall the rear cover on the enclosure and tighten the set screw.

Wiring an Alarms Option Card

The Model DF868 flowmeter can accommodate up to 4 alarm option cards. Each alarms option card includes three *Form C relays* (designated as A, B and C).

The alarm relays on the option card are available in two types:

- general purpose
- hermetically sealed for Class I, Division 2 hazardous areas.

The maximum electrical ratings for the relays are listed in Chapter 4, *Specifications*. Each of the three alarm relays can be wired either as *Normally Open* (NO) or *Normally Closed* (NC).

In setting up an alarm relay, it may be wired for either *conventional* or *fail-safe* operation. In fail-safe mode, the alarm relay is constantly energized, except when it is triggered or a power failure or other interruption occurs. See Figure 1-4 below for the operation of a NO alarm relay in both conventional and fail-safe mode.

Connect the two wires required for each alarm relay in accordance with the pin number assignments shown in Figure 1-8 on page 1-17.

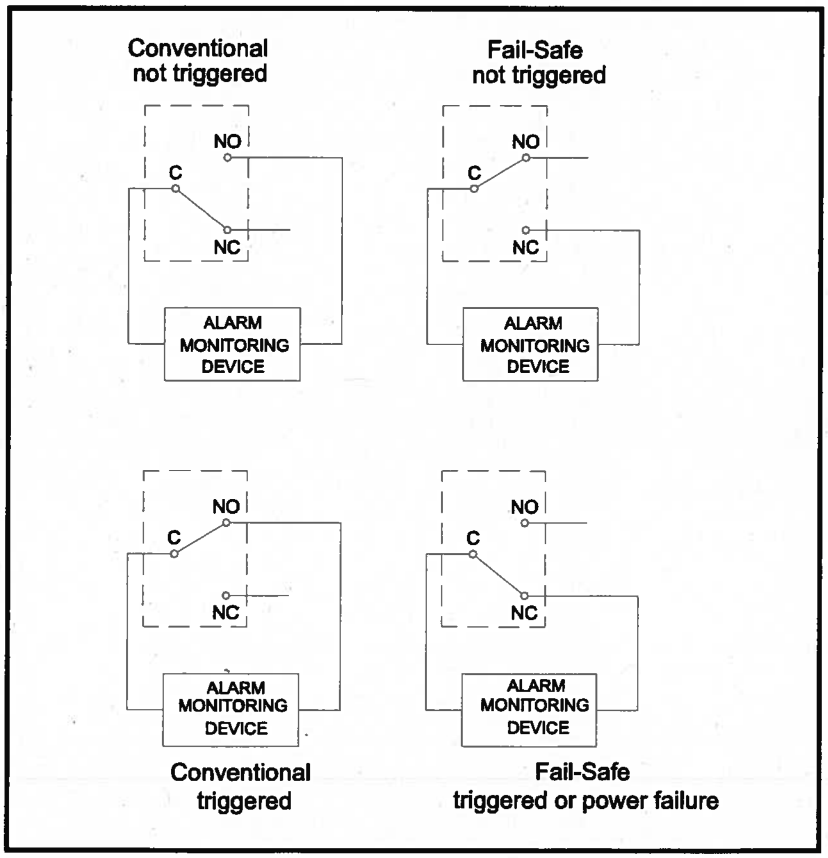


Figure 1-4: Conventional and Fail-Safe Operation

Wiring a 0/4-20 mA Analog Inputs Option Card

To calculate energy measurement, the Model DF868 requires accurate *temperature data* from the measurement site. Transmitters installed in the flowcell can provide this information via an optional 0/4-20 mA analog inputs card. This option card includes two isolated 0/4-20 mA analog inputs (designated as A and B), each of which includes a 24 VDC power supply for loop-powered transmitters. Either input may be used to process the temperature signal.

Note: *To enter programming data during operation of the meter, it will be necessary to know which input is assigned to which process parameter. This information should have been entered in Appendix B,* Data Records.

The analog inputs, which have an impedance of 118 ohms, should be connected with standard twisted-pair wiring. Power to the transmitters may be supplied either by the integral 24 VDC power supply on the analog input card or by an external power supply. Figure 1-5 below shows typical wiring diagrams, with and without an external power supply, for one of the analog inputs.

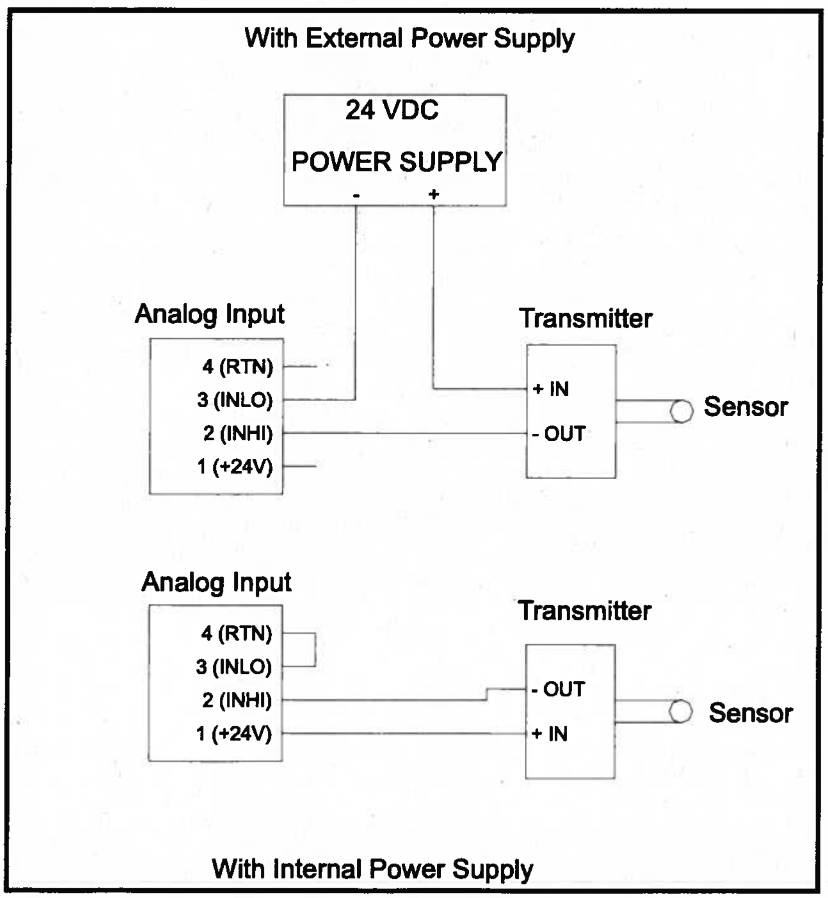


Figure 1-5: Analog Input Wiring Diagram

Wiring a 0/4-20 mA Analog Inputs Option Card (cont.)

Wire the analog input terminal block in accordance with the pin number assignments shown in Figure 1-8 on page 1-17.

If the flowmeter system includes additional transmitters, the Model DF868 can accommodate up to three more analog inputs option cards. These option cards are identical to the temperature card described on page 1-13 and they should be wired in the same manner (see Figure 1-5 on page 1-13).

The analog inputs on the option card(s) can be calibrated with the Model DF868's built-in analog outputs. However, be certain that the analog outputs have been calibrated first. See Chapter 1, *Calibration*, in the *Service Manual* for the appropriate procedures.

Wiring a Totalizer/ Frequency Outputs Option Card

The Model DF868 can accommodate up to four totalizer/frequency outputs option cards. Each totalizer/frequency outputs option card provides four outputs (designated as A, B, C, and D) that can be used as either totalizer or frequency outputs.

Each totalizer/frequency output requires two wires. Wire this terminal block in accordance with the pin number assignments shown in Figure 1-8 on page 1-17. Figure 1-6 below shows sample wiring diagrams of a totalizer output circuit and a frequency output circuit.

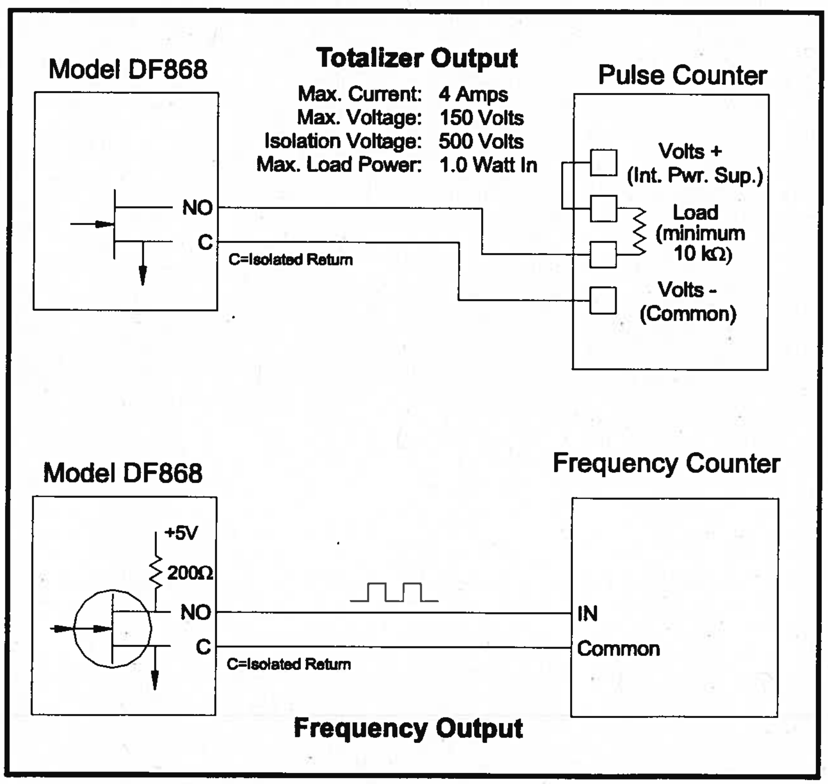


Figure 1-6: Totalizer/Frequency Outputs Wiring

Wiring an RTD Inputs Option Card

The Model DF868 can accommodate up to four RTD (Resistance Temperature Device) inputs option cards. Each RTD inputs option card provides two direct RTD inputs (designated as A and B).

Each RTD input requires three wires, which should be fed through one of the conduit holes on the bottom of the electronic console. (For maximum accuracy, the three wires must be of equal length.) Wire this terminal block in accordance with the pin number assignments shown in Figure 1-8 on page 1-17.

Wiring a 0/4-20 mA Analog Outputs Option Card

The Model DF868 flowmeter can accommodate up to 4 analog outputs option cards. Each analog outputs option card includes four isolated 0/4-20 mA outputs (designated as A, B, C and D).

Connections to these outputs may be made with standard twisted-pair wiring. The total current loop impedance for these circuits must not exceed 1000 ohms. Wire this terminal block in accordance with the pin number assignments shown in Figure 1-8 on page 1-17.

Wiring a MODBUS Option Card

A modified DF868 can use the RS485 standard for MODBUS communications. This standard allows up to 32 nodes (drivers and receivers) on one multidrop network, at distances up to 4,000 ft (1,200 m). To connect the instrument(s) to the host system, GE Panametrics recommends using a 24-gauge (24 AWG) twisted-pair cable with a characteristic impedance of 120 ohms and a 120-ohm termination at each end of the communications line.

The MODBUS option card must be plugged into either slot 5 or slot 6 of the DF868. On the option card, pin 1 is the [TMT-] inverting or negative connection and pin 2 is the [TMT+] non-inverting or positive connection. To link the DF868 to the control system, connect the two wires of the twisted-pair cable from these terminals to the corresponding terminals at the control system, in accordance with the pin number assignments shown in Figure 1-8 on page 1-17.

Note: *If two MODBUS option cards are installed in the DF868, only the card in slot 5 is activated.*

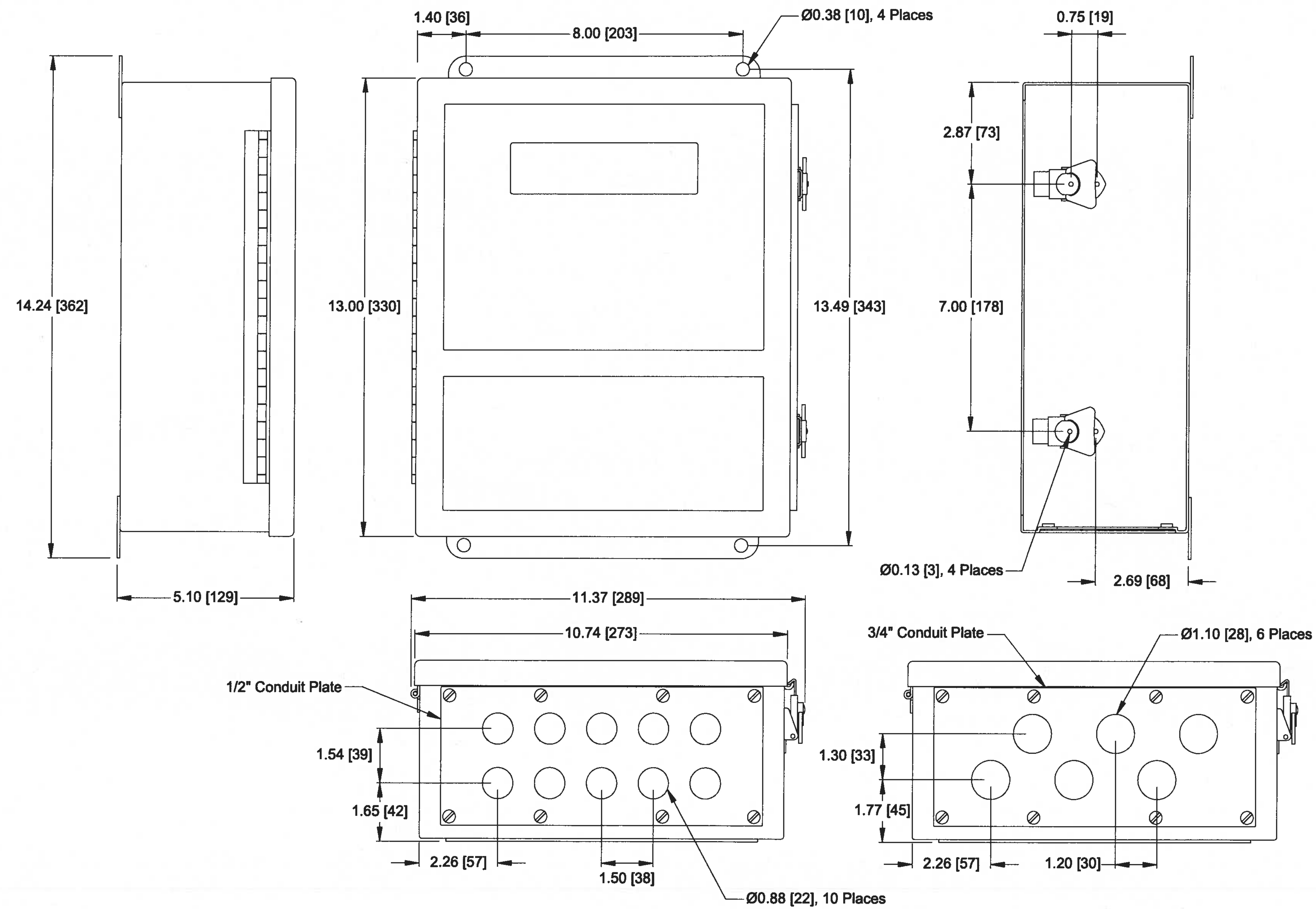
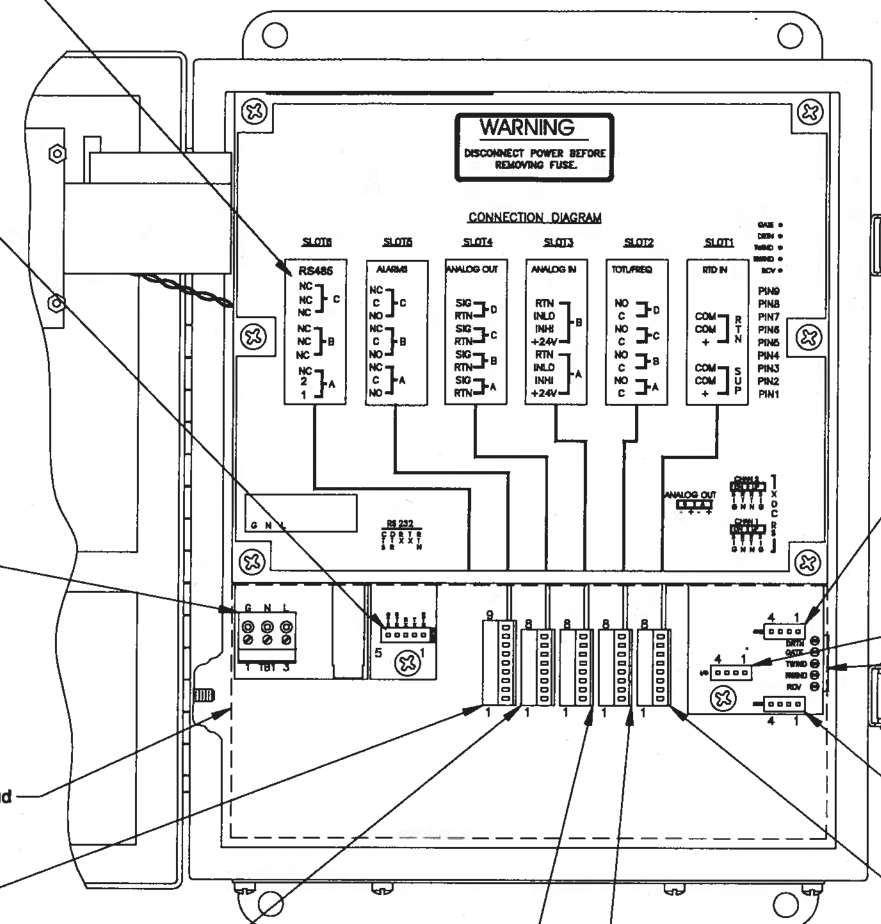


Figure 1-7: Model DF868 NEMA 4X Enclosure - Drawing #425-208

RS232 SERIAL PORT	
Pin #	Description
1	RTN - Digital Return
2	TX - Transmit
3	RX - Receive
4	DTR - Data Terminal Ready
5	CTS - Clear to Send

RS485 PORT (MODBUS)	
Pin #	Description
1	TMT-
2	TMT+
3	Unused
4	Unused
5	Unused

NOTE: For compliance with the European Union's Low Voltage Directive (73/23/EEC), this unit requires an external power disconnect device such as a switch or circuit breaker. The disconnect device must be marked as such, clearly visible, directly accessible and located within 1.8 m (6 ft) of the Model DF868.



CH2 TRANSDUCER	
Pin #	Description
1	Upstream SIG(+)
2	Upstream RTN(-)
3	Downstream RTN(-)
4	Downstream SIG(+)

0/4-20 mA ANALOG OUTPUTS	
Pin #	Description
1	Output A - SIG(+)
2	Output A - RTN(-)
3	Output B - SIG(+)
4	Output B - RTN(-)

TB1 POWER INPUT	
Pin #	Description
1	G - Earth Ground
2	N- Line Neutral
3	L - Line Power

Test Points

Plastic LVD Shroud

NOTE: For compliance with the European Union's Low Voltage Directive (73/23/EEC), a transparent plastic shroud protects the electrical connections. The shroud must remain in place, except while wiring the unit. Reinstall the shroud after the wiring has been completed.

CH1 TRANSDUCER	
Pin #	Description
1	Upstream SIG(+)
2	Upstream RTN(-)
3	Downstream RTN(-)
4	Downstream SIG(+)

NOTE
One option card of each available type is shown in this diagram. These cards are not always installed in the same slots used for this example.

ALARM RELAYS	
Pin #	Description
1	Relay A - Normally Open (NO)
2	Relay A - Common (C)
3	Relay A - Normally Closed (NC)
4	Relay B - Normally Open (NO)
5	Relay B - Common (C)
6	Relay B - Normally Closed (NC)
7	Relay C - Normally Open (NO)
8	Relay C - Common (C)
9	Relay C - Normally Closed (NC)

0/4-20 mA ANALOG OUTPUTS	
Pin #	Description
1	Output A - RTN(-)
2	Output A - SIG(+)
3	Output B - RTN(-)
4	Output B - SIG(+)
5	Output C - RTN(-)
6	Output C - SIG(+)
7	Output D - RTN(-)
8	Output D - SIG(+)

0/4-20 mA ANALOG INPUTS	
Pin #	Description
1	Input A - +24V
2	Input A - INHI
3	Input A - INLO
4	Input A - RTN
5	Input B - +24V
6	Input B - INHI
7	Input B - INLO
8	Input B - RTN

TOTALIZER/FREQUENCY OUTPUTS	
Pin #	Description
1	Output A - Common (C)
2	Output A - Normally Open (NO)
3	Output B - Common (C)
4	Output B - Normally Open (NO)
5	Output C - Common (C)
6	Output C - Normally Open (NO)
7	Output D - Common (C)
8	Output D - Normally Open (NO)

RTD INPUTS	
Pin #	Description
1	Input A - SIG(+)
2	Input A - Common (C)
3	Input A - Common (C)
4	Unused
5	Input B - SIG(+)
6	Input B - Common (C)
7	Input B - Common (C)
8	Unused

Figure 1-8: Model DF868 Electronics Console Wiring - Drawing #702-213 (Sheet 1 of 2)

Chapter 2

Initial Setup

Introduction

This chapter provides instructions for entering the minimum amount of programming data required to place the Model DF868 flowmeter into operation. Before the Model DF868 can begin taking measurements and displaying valid data, the system and pipe parameters must be entered. In addition, if you plan to use both channels of a 2-channel meter, each channel must be activated prior to use. Additional programming options provide access to the more advanced features of the Model DF868, but this information is not required to begin taking measurements.

Note: *See the* Programming Manual *for information on those* User Program *options not covered in this chapter.*

Navigating Through the User Program

In order to begin using the Model DF868, the following submenus within the *User Program* will be accessed:

- ACTIV - enables selection of the desired measurement method (for a 2-Channel meter, it is also used to activate a channel)
- SYSTM - prompts the user to enter the required system data
- PIPE - prompts the user to enter the required pipe parameters

As a guide in following the programming instructions in this chapter, the relevant portions of the Model DF868 menu map have been reproduced in Figures 2-1 and 2-2 on pages 2-27 and 2-28.

Note: *There are minor differences at the start of the* ACTIV *and* SYSTM *submenus for the 1-Channel and 2-Channel models, but the* PIPE *submenus are identical.*

The following discussion assumes that the left screen pane is active. If the right screen pane is active, only the function key designations change. That is, replace [F1]-[F4] with [F5]-[F8]. Be sure to record all programming data in Appendix B, *Data Records*.

Use the keypad, as described in the *Programming Manual*, to navigate through the *User Program*. The menu map may be followed in sequence, or the [↑] and [↓] keys may be used to scroll through the prompt screens. The [←] key may be used to delete the last alphanumeric character that was entered from the keypad.

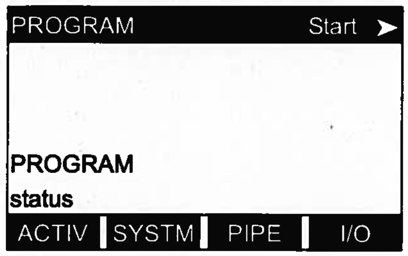
Accessing the User Program

To access the *User Program*, press the [PROG] key on the keypad.

Note: *If the security feature is active, enter the password and press* [ENT] *to enter the* User Program. *See the SECUR submenu section in Chapter 1 of the* Programming Manual *for more information on the security feature.*

1-Channel Meter

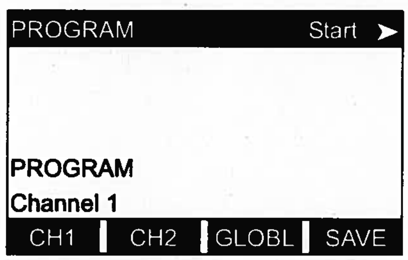
For a 1-Channel Model DF868, the measurement mode screen is replaced by the following initial programming mode screen:



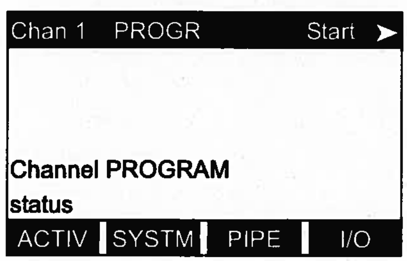
At the *User Program* screen shown, press [F1] and proceed to *"The* ACTIV *Submenu"* section for instructions.

2-Channel Meter

For a 2-Channel Model DF868, the following two-step sequence is required to reach the initial programming screen:



Press [F1] or [F2] to select the submenu for Channel 1 or Channel 2, respectively, from the option bar.



At the *User Program* screen shown, press [F1] and proceed to *"The* ACTIV *Submenu"* section for instructions.

Only the submenus ACTIV, SYSTM and PIPE are discussed in this manual. Refer to the *Programming Manual* for information on the other submenus.

Note: *In this manual, only the programming of Channel 1 will be described. To program Channel 2, simply repeat the same procedures presented for Channel 1.*

The ACTIV Submenu

The ACTIV submenu permits selection of the desired measurement method. In addition, it is used to activate/deactivate one or both of the channels in a 2-Channel Model DF868.

1-Channel Meter

For a 1-Channel Model DF868, the following screen appears:

```
PROGRAM                    Start >
PROGRAM
status

Site status
current status appears here
TRANS | TRNFL |        |
```

At the *User Program* screen shown, press [F1] to specify Transit-Time, or [F2] to specify TransFlection mode.

2-Channel Meter

For a 2-Channel Model DF868, the following screen appears:

```
Chan 1
Channel PROGRAM
status

Channel status
current status appears here
 OFF  | TRANS | TRNFL |
```

At the *User Program* screen shown, press [F2] to activate Channel 1 in Transit-Time mode, or [F3] to activate TransFlection mode.

Note: *If a customer has not ordered the DF868 with TransFlection mode, the* TRNFL *option does not appear.*

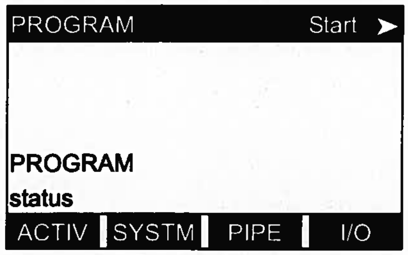
Proceed directly to the next section to program the SYSTM submenu.

The SYSTM Submenu

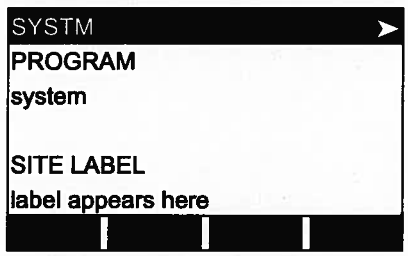
Begin the programming of the SYSTM submenu in either the *1-Channel* or *2-Channel* section below.

1-Channel Meter

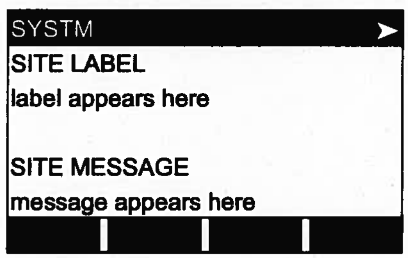
For the 1-Channel Model DF868, the information entered in the SYSTM submenu pertains to the global operation of the flowmeter.



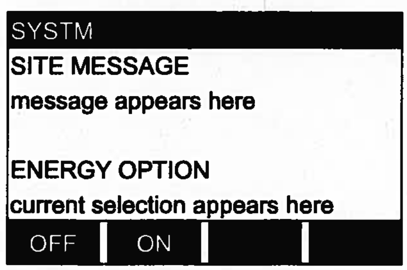
At the *User Program* screen shown, press the [F2] function key to program the SYSTM submenu.



Enter a site label of up to 9 characters and press the [ENT] key. (While taking measurements, the site label appears on the locator bar.)



Enter a site message of up to 21 characters. Use this screen to enter a brief description of the site. When the message has been entered, press the [ENT] key.



Press [F1] to turn the Energy Option OFF or press [F2] to turn it ON. (The Energy Option calculates the energy of a system based on temperatures at the supply and return points, and the flow of fluid.)

1-Channel Meter (cont.)

```
SYSTM
ENERGY OPTION
current selection appears here

SYSTEM UNITS
current units appear here
ENG | METRC |  |
```

Press [F1] to display parameters and measurements in English units or press [F2] to display parameters and measurements in Metric units.

```
SYSTM
SYSTEM UNITS
current units appear here

TOTALIZER OPTION
current setting appears here
AUTO | MNUAL |  |
```

Press [F1] to measure totals automatically, or press [F2] to measure totals manually.

The remainder of the SYSTM submenu is identical for the 1-Channel and 2-Channel versions of the Model DF868. Proceed to the *1- and 2-Channel Meters* section to complete the programming of this submenu.

2-Channel Meter

For the 2-Channel Model DF868, the information entered in the SYSTM submenu pertains only to the currently selected channel.

```
PROGRAM                    Start ➤



PROGRAM
status
ACTIV | SYSTM | PIPE | I/O
```

At the *User Program* screen shown, press [F2] to program the SYSTM submenu.

```
Chan 1 SYSTM                     ➤
Channel 1 PROGRAM
system

CHANNEL LABEL
label appears here
 |  |  |
```

Enter a channel label of up to 9 characters. While taking measurements, the channel label will appear on the locator bar. When the label has been entered, press [ENT].

```
Chan 1 SYSTM                     ➤
CHANNEL LABEL
label appears here

CHANNEL MESSAGE
message appears here
 |  |  |
```

Enter a channel message of up to 21 characters. Use this screen to enter a brief description of the channel. When the message has been entered, press [ENT].

2-Channel Meter (cont.)

```
Chan 1 SYSTM
CHANNEL MESSAGE
message appears here

ENERGY OPTION
current selection appears here
 OFF | ON |  |
```

Press [F1] to turn the Energy Option OFF or press [F2] to turn it ON. (The Energy Option calculates the energy of a system based on temperatures at the supply and return points, and the flow of fluid.)

Note: *For the 2-Channel Model DF868, the* System Units *and* Totalizer *prompts, which are not required to make the unit operational, are located in the* GLOBL *submenu. See the* Programming Manual *for details.*

The remainder of the SYSTM submenu is identical for the 1-Channel and 2-Channel versions of the Model DF868. Proceed to the *1- and 2-Channel Meters* section to complete programming.

1- and 2-Channel Meters

After responding to the last prompt shown in either the *1-Channel* or the *2-Channel* section of this chapter, the following screen appears:

```
(Chan 1) SYSTM                    ➤
previous prompt appears here
previous selection appears here

VOLUMETRIC UNITS
current setting appears here
 GAL/S | GAL/M | GAL/H | MGD
```

Press [F1]-[F4] to select the desired volumetric units for the flow rate display. Press [→] to access the additional choices.

Note: *The above option bar shows English units, as an example.*

The abbreviations and definitions of all the available volumetric units are shown in Table 2-1 below. The choices shown on the option bar are determined by the selections made at the previous SYSTEM UNITS prompt screen.

Table 2-1: Volumetric Unit Options

English Volumetric Units	Metric Volumetric Units
GAL/S - U.S. Gallons per Second	L/S- Liter per Second
GAL/M - U.S. Gallons per Minute	L/M - Liters per Minute
GAL/H - U.S. Gallons per Hour	L/H - Liters per Hour
MGD - Millions of U.S. Gallons per Day	ML/D - Millions of Liters per Day
ft^3/s - Cubic Feet per Second	m^3/s - Cubic Meters per Second

Table 2-1: Volumetric Unit Options (Continued)

English Volumetric Units	Metric Volumetric Units
ft^3/m - Cubic Feet per Minute	m^3/m- Cubic Meters per Minute
ft^3/h- Cubic Feet per Hour	Mm^3/h - Millions of Cubic Meters per Hour
Mft^3/d- Millions of Cubic Feet per Day	Mm^3/d - Millions of Cubic Meters per Day
BBL/S - Barrels per Second	BBL/S - Barrels per Second
BBL/M - Barrels per Minute	BBL/M - Barrels per Minute
BBL/H - Barrels per Hour	BBL/H - Barrels per Hour
BBL/D - Barrels per Day	BBL/D- Barrels per Day
MBBL/D - Millions of Barrels per Day	MBBL/D - Millions of Barrels per Day
Acre-inch/sec -Acre-inches per second	N/A
Acre-inch/min -Acre-inches per minute	N/A
Acre-inch/hr -Acre-inches per hour	N/A
Acre-inch/day -Acre-inches per day	N/A
Acre-foot/sec -Acre-feet per second	N/A
Acre-foot/min -Acre-feet per minute	N/A
Acre-foot/shr -Acre-feet per hour	N/A
Acre-foot/day -Acre-feet per day	N/A

(Chan 1) SYSTM
VOLUMETRIC UNITS
current setting appears here

VOL DECIMAL DIGITS
current setting appears here
0 | 1 | 2 | 3

Press [F1]-[F4] to select the desired number of digits to the right of the decimal point in the volumetric flow rate display.

1- and 2-Channel Meters (cont.)

(Chan 1) SYSTM ➤			
VOL DECIMAL DIGITS			
current setting appears here			
TOTALIZER UNITS			
current setting appears here			
GAL	MGAL	ft^3	Mft^3

Press [F1]-[F4] to select the desired units for the totalized flow display. Press [→] to access the additional choices.

Note: *The above prompt shows the* ENG *versions of the available totalizer units, as an example.*

The abbreviations and definitions of all the available totalizer units are shown in Table 2-2 below. The choices shown on the option bar in the prompt screen above are determined by the selections made at the previous SYSTEM UNITS prompt screen.

Table 2-2: Totalizer Unit Options

English Totalizer Units	Metric Totalizer Units
Gal - U.S. Gallons	L - Liters
MGAL - Mega U.S. gallons	ML - Megaliters
ft^3 - Cubic Feet	m^3- Cubic Meters
Mft^3 - Mega Cubic Feet	Mm^3- Mega Cubic Meters
BBL - Barrels	BBL - Barrels
MBBL - Megabarrels	MBBL - Megabarrels
Acre-inches	
Acre-feet	

(Chan 1) SYSTM			
TOTALIZER UNITS			
current setting appears here			
TOTAL DECIMAL DIGITS			
current setting appears here			
0	1	2	3

Press [F1]-[F4] to select the desired number of digits to the right of the decimal point in the totalized flow display.

Mass Flow

If the Mass Flow prompt in the SETUP submenu is not enabled, skip this sub-section. However, the following programming sequence appears if Mass Flow is enabled.

(Chan 1) SYSTM			
TOTAL DECIMAL DIGITS			
current value appears here			
MASS FLOW			
current setting appears here			
LB	KLB	MMLB	TONS

Press [F1]-[F4] to select the desired mass flow units for the flow rate display.

Note: *The option bar above shows English units, as an example. If Metric units were specified, these appear instead.*

The abbreviations and definitions of all the available mass flow units are shown in Table 2-3 below. The choices shown on the option bar are determined by the selections made at the SYSTEM UNITS prompt.

Table 2-3: Available Mass Flow Units

English	Metric
LB = Pounds	KG = Kilograms
KLB = Thousands of LB	TONNE = Metric Tons (1000 KG)
MMLB = Millions of LB	
TONS = Tons (2000 LB)	

(Chan 1) SYSTM			
MASS FLOW			
current setting appears here			
MASS FLOW TIME			
current setting appears here			
/SEC	/MIN	/HR	/DAY

Press [F1]-[F4] to select the desired time units for the mass flow rate display.

(Chan 1) SYSTM			
MASS FLOW TIME			
current setting appears here			
MDOT DECIMAL DIGITS			
current setting appears here			
0	1	2	3

Press [F1]-[F4] to select the desired number of digits to the right of the decimal point in the mass flow rate display.

Mass Flow (cont.)

```
(Chan 1) SYSTM
MDOT DECIMAL DIGITS
current setting appears here

MASS TOTALS
current setting appears here
 LB | KLB | MMLB | TONS
```

Press [F1]-[F4] to select the desired units for the totalized mass flow display.

```
(Chan 1) SYSTM
MASS TOTALS
current setting appears here

MASS DECIMAL DIGITS
current setting appears here
 0 | 1 | 2 | 3
```

Press [F1]-[F4] to select the desired number of digits to the right of the decimal point in the totalized mass flow display.

Energy Option

If you did not select the Energy Option earlier, the meter now returns to the initial System prompt. But if you selected the Energy Option, several more prompts appear.

```
(Chan 1) SYSTM
MASS DECIMAL DIGITS
current setting appears here

POWER
current setting appears here
 kBTU | MMBTU | kW | TONS
```

Press [F1]-[F4] to select the desired units for measuring power.

The abbreviations and definitions of all the available power units are shown in Table 2-4 below. The choices shown on the option bar in the prompt screen above are determined by the selections made at the previous SYSTEM UNITS prompt screen.

Table 2-4: Power Unit Options

English Power Units	Metric Power Units
kBTU—Thousands of British Thermal Units per Hour	kCAL/sec—Kilocalories/second
MMBTU—Millions of British Thermal Units per Hour	MCAL/sec—MegaCalories/ second
kW—kilowatts	kW—kilowatts
Tons	MW—Megawatts

Energy Option (cont.)

```
(Chan 1) SYSTM
POWER
current setting appears here

POWER DECIMAL DIGITS
current setting appears here
  0  |  1  |  2  |  3
```

Press **[F1]-[F4]** to select the desired number of digits to the right of the decimal point in the power display.

```
(Chan 1) SYSTM
POWER DECIMAL DIGITS
current setting appears here

ENERGY (TOTAL)
kBTU/hr
 kBTU | MMBTU |  kW  | TONS
```

Press **[F1]-[F4]** to select the desired units for measuring total energy.

The abbreviations and definitions of all the available total energy units are shown in Table 2-5 below. The choices shown on the option bar in the prompt screen above are determined by the selections made at the previous **SYSTEM UNITS** prompt screen.

Table 2-5: Energy Unit Options

English Energy Units	Metric Energy Units
kBTU—Thousands of British Thermal Units	kCAL—Kilocalories
MMBTU—Millions of British Thermal Units	MCAL—MegaCalories
kWHr—Kilowatt-Hours	kW—Kilowatt-Hour
Tons	MW—Megawatt-Hour

```
(Chan 1) SYSTM
ENERGY (TOTAL)
current setting appears here

ENERGY DECIMAL DIGITS
current setting appears here
  0  |  1  |  2  |  3
```

Press **[F1]-[F4]** to select the desired number of digits to the right of the decimal point in the total energy display.

```
(Chan 1) SYSTM
ENERGY DECIMAL DIGITS
current setting appears here

HEATING or COOLING
current setting appears here
 COOL | HEAT |      |
```

Press **[F1]** to make measurements in a cooling system, or **[F2]** to make measurements in a heating system.

Energy Option (cont.)

(Chan 1) SYSTM		
HEATING or COOLING		
current setting appears here		
Flow Measurement		
current setting appears here		
RTN	SPPLY	

Press [F1] to measure flow at the point of return (where the liquid exits), or [F2] to measure flow at the point of supply (where the liquid enters).

When the above selection has been made, the meter exits the SYSTM submenu and returns to the initial *User Program* screen. Proceed directly to the next section to program the PIPE submenu.

The PIPE Submenu

The PIPE submenu permits entry of the transducer and pipe specifications. To program this menu, complete the following steps:

```
PROGRAM                    Start >

PROGRAM
status
ACTIV | SYSTM | PIPE | I/O
```

At the *User Program* screen shown, press [F3] to program the PIPE submenu.

Note: *Text in parentheses on the locator bar or in the prompt area appears only with the 2-Channel version of the Model DF868.*

```
(Chan 1) PIPE PROG
(Channel) PROGRAM
Pipe parameters

TRANSDUCER NUMBER
number appears here
SPEC |   |   |
```

Enter the number engraved on the head of the transducer and press [ENT]. If there is no engraved number, press [F1] to enter information for a special transducer.

IMPORTANT: *Special transducers, which have no engraved number on the head, are rarely used. Examine the transducer head carefully for a number.*

If you are programming special transducer parameters, see the section below. If you are programming standard transducer parameters, skip to the PIPE MATERIAL prompt (for clamp-on transducers) on page 2-15 or the PIPE OD prompt (for wetted transducers) on page 2-16.

Special Transducers

```
(Chan 1) PIPE PROG
TRANSDUCER NUMBER
Special transducer

SPECIAL TRANSDUCER #
number appears here
   |   |   |
```

Assign a number between 91 and 99 to the special transducer and press [ENT].

```
(Chan 1) PIPE PROG
SPECIAL TRANSDUCER #
number appears here

WEDGE TYPE
current setting appears here
RAYL | SHEAR | WETTD |
```

Press [F1]-[F3] to select the wedge type. Three choices are available: Rayleigh or Shear wave (for clamp-on transducers) or wetted transducers.

Special Transducers (cont.)

(Chan 1) PIPE PROG			
WEDGE TYPE			
current selection appears here			
FREQUENCY			
current setting appears here			
500K	1MHz	2MHz	4MHz

Press [F1]-[F4] to select the frequency of the special transducer.

IMPORTANT: *The frequency is required to transmit an excitation voltage at the transducer's natural frequency.*

(Chan 1) PIPE PROG
FREQUENCY
current setting appears here
Tw
current value appears here

Enter the special transducer time delay value supplied by GE Panametrics and press [ENT].

Note: *Tw is the time required for the transducer signal to travel through the transducer and its cable. This time delay must be subtracted from the transit times of the upstream and downstream transducers to ensure an accurate measurement.*

Special Clamp-On Transducers

If you have selected a special wetted transducer, the meter now rejoins the standard programming sequence. However, if you have selected a special clamp-on transducer, two additional prompts appear.

(Chan 1) PIPE PROG
Tw
current value appears here
WEDGE ANGLE
current value appears here

Use the numeric keys to enter the wedge angle (the angle of the ultrasonic transmission) in degrees and press [ENT].

Note: *In TransFlection mode, you must enter a separate wedge angle for both the transmit transducer and the receive transducer.*

Special Clamp-On Transducers (cont.)

(Chan 1) PIPE PROG
WEDGE ANGLE
current value appears here
WEDGE SOUNDSPEED
current value appears here

Use the numeric keys to enter the wedge soundspeed in ft/sec or m/sec and press [ENT].

The meter now rejoins the standard programming sequence.

Pipe Material

(Chan 1) PIPE PROG ➤
previous prompt appears here
previous selection appears here
PIPE MATERIAL
current setting appears here
STEEL | IRON | Cu | Al

Press [F1]-[F4] to select the pipe material. Press [→] to access additional options, as listed in Table 2-6 below.

Table 2-6: Pipe Materials

Pipe Material Category	Specific Material
Steel	Carbon Steel or Stainless Steel
Iron	Ductile Iron or Cast Iron
Cu - Copper	None
Al - Aluminum	None
Brass	None
CuNi - Copper/Nickel	70% Cu 30% Ni or 90% Cu 10% Ni
Glass	Pyrex, Flint, or Crown
Plastic	Nylon, Polyester, Polypropylene, PVC (CPVC), Acrylic
Other*	Any material

Note: *Depending on the pipe material choice, another window may appear, asking you to specify the specific material. If you have selected "Other," the DF868 prompts you to enter the sound speed.*

The PIPE Submenu (cont.)

The programming sequences for clamp-on and wetted transducers converge at this point.

Pipe OD

```
(Chan 1) PIPE PROG
previous prompt appears here
previous selection appears here

PIPE OD
current value appears here
 inch | feet | in/PI | ft/PI
```

Enter the known pipe OD or circumference and press [F1]-[F4] to select the appropriate units. Press [ENT] when done.

Note: *The first two lines of text in the prompt area depend on the selection made at the* TRANSDUCER NUMBER *prompt. The option bar choices may appear in English or Metric units.*

Obtain the required information by measuring either the pipe outside diameter (OD) or circumference at the transducer installation site. The data may also be obtained from standard pipe size tables. For a list of the available English and Metric units and their definitions for the PIPE OD prompt, refer to Table 2-7 below.

Table 2-7: Available Pipe OD Units

English	Metric
inch = pipe OD in inches	mm = pipe OD in millimeters
feet = pipe OD in feet	m = pipe OD in meters
in/PI = pipe circumference in inches	mm/PI = pipe circumference in millimeters
ft/PI = pipe circumference in feet	m/PI = pipe circumference in meters

```
(Chan 1) PIPE PROG
PIPE OD
current value appears here

PIPE WALL
current value appears here
```

Enter the known thickness of the pipe wall, in the same units used for the pipe OD, and press [ENT].

IMPORTANT: *Because the units can not be independently chosen for this parameter, the value must be entered in the same units used for the pipe OD.*

If the pipe wall thickness is not available, look up the value in a table of standard pipe size data (such as the GE Panametrics brochure *Sound Speeds and Pipe Size Data,* 914-004), or use the Model DF868's on-line *Help Menu* (see the *Programming Manual* for details).

The PIPE Submenu (cont.)

At this point, the prompts vary, depending on whether you have selected clamp-on or wetted transducers. For clamp-on transducers, see the section below. For wetted transducers, skip to page 2-22.

Clamp-On Transducers

The following series of prompts only appears if you have selected clamp-on transducers.

```
(Chan 1) PIPE PROG
PIPE WALL
current value appears here

LINING
current selection appears here
  NO  |  YES  |       |
```

Press [F1] if the pipe does not have a lining, or [F2] if it does have a lining. If you select YES, a second prompt asks for the lining material.

```
(Chan 1) PIPE PROG                  >
LINING
current selection appears here

LINING MATERIAL
current selection appears here
  TAR  | PYREX | ASBES | MORTR
```

Press [F1]-[F4] to select the lining material. Press [→] to access the additional options of RUBBR (rubber), TEFLN (Teflon), and OTHER.

If you choose "OTHER," the DF868 then asks you to enter the lining sound speed. If you do not know the lining sound speed, *Sound Speeds and Pipe Size Data* (914-004) lists some standard materials and their corresponding sound speeds.

```
(Chan 1) PIPE PROG
LINING MATERIAL
current selection appears here

LINING THICKNESS
current value appears here
       |       |       |
```

Enter the known lining thickness, in the same units used for the pipe OD, and press [ENT].

The following prompt only appears if you have selected the Transit-Time mode.

```
(Chan 1) PIPE PROG
LINING THICKNESS
current selection appears here

TRACKING WINDOWS?
current selection appears here
  NO  |  YES  |       |
```

Press [F1] if you do not want tracking windows, or [F2] if you want to enable the windows. (Tracking windows are used to detect the receive signal when you are unsure of the fluid soundspeed.)

Clamp-On Transducers (cont.)

```
(Chan 1) PIPE PROG              ➤
TRACKING WINDOWS
current selection appears here

FLUID TYPE
current setting appears here
WATER | OIL | METH | ETH
```

Press [F1]-[F3] to select the type of fluid to be measured. Selections include water, water/ glycol (energy option only), oil (lube or crude), methanol, ethanol, LN2, freon and other.

The selections for the fluid type vary, depending on whether:

- the ENERGY OPTION is ON or OFF; and
- the TRACKING WINDOW is enabled or disabled.

Refer to Table 2-8 below if ENERGY OPTION is OFF, or to Table 2-9 on page 2-19 if ENERGY OPTION is ON.

Note: *Some of the fluid types may require additional selections as shown in the following tables.*

Table 2-8: Fluid Types for ENERGY OFF

Tracking Windows =			
NO	**Additional Selections**	**YES**	**Additional Selections**
WATER	Select **NORML** or **SEA** and press **[ENT]**. If **NORML** is selected, enter the Water Temperature and press **[ENT]**.	W100	No additional selections required.
OIL	Select **LUBE** or **CRUDE** and press **[ENT]**.	W260	No additional selections required.
METH	No additional selections required.	OIL	No additional selections required.
ETH	Enter the Fluid Soundspeed and press **[ENT]**.	OTHER	Enter the Minimum Soundspeed and press **[ENT]**. Then enter the Maximum Soundspeed and press **[ENT]**.

Table 2-8: Fluid Types for ENERGY OFF (Continued)

Tracking Windows =			
NO	Additional Selections	YES	Additional Selections
LN2	No additional selections required.		
FREON	No additional selections required.		
OTHER	Enter the Fluid Soundspeed and press **[ENT]**.		

Table 2-9: Fluid Types for ENERGY ON

Tracking Windows =			
NO	Additional Selections	YES	Additional Selections
WATER	Enter the Water Temperature and press [ENT].	W260	No additional selections required.
MIXED	Enter the Fluid Soundspeed and press **[ENT]**. Then enter the Percentage of Water and press **[ENT]**.	MIXED	Enter the Percentage of Water and press **[ENT]**.
OTHER	Enter the Fluid Soundspeed and press **[ENT]**.	OTHER	Enter the Minimum Soundspeed and press **[ENT]**. Then enter the Maximum Soundspeed and press **[ENT]**.

(Chan 1) PIPE PROG
FLUID TYPE
current selection appears here

REYNOLDS CORRECTION
current selection appears here
OFF | ON

Press [F1] to turn Reynolds Correction off, or [F2] to turn it on.

Note: *Reynolds Correction is a number based on the Kinematic Viscosity and flow rate of the fluid. It should be enabled for most applications.*

Clamp-On Transducers (cont.)

```
(Chan 1) PIPE PROG
REYNOLDS CORRECTION
current selection appears here

KINEMATIC VISCOSITY
current value appears here
```

When you enable the Reynolds Correction Factor, you must also enter the Kinematic Viscosity of your fluid, as listed in *Sound Speeds and Pipe Size Data.* Use the numeric keys to enter a value, and press [ENT].

```
(Chan 1) PIPE PROG
previous prompt appears here
previous selection appears here

CALIBRATION FACTOR
current value appears here
```

Enter a value for the flow calibration factor and press [ENT]. The default value is 1.00, but values between 0.50 and 2.00 may be entered.

The following prompt only appears if you activated the TransFlection mode.

```
(Chan 1) PIPE PROG
CALIBRATION FACTOR
previous setting appears here

DEPTH OF REFLECTOR
current percentage appears here
```

The Depth of Reflector setting determines where in the pipe the DF868 looks for the reflected signal. The default value is 50%. Use the numeric keys to enter a value, and press [ENT].

Note: *GE Panametrics recommends activating the Reynolds Correction Factor when the Depth of Reflector is set at 50%. You can disable the Reynolds Correction Factor when the Depth of Reflector is set at any other value.*

You have completed entering the pipe parameters for clamp-on transducers in the TransFlection mode. However, if you have activated the Transit-Time mode, two different prompts appear instead.

```
(Chan 1) PIPE PROG
CALIBRATION FACTOR
previous setting appears here

NUMBER OF TRAVERSES
current selection appears here
 1(Z) | 2(V) | 3 | 4
```

Enter the number of times the ultrasonic signal traverses the pipe, from 1 to 5. Press [F1]-[F4] to select the desired number of traverses.

Clamp-On Transducers (cont.)

```
(Chan 1) PIPE PROG
NUMBER OF TRAVERSES
previous setting appears here

  TRANSDUCER SPACING
current value appears here
```

The Transducer Spacing prompt displays the spacing of the transducers, as calculated from the information you have entered. Record this number and use it to properly space transducers.

Note: *If necessary, you can overwrite the spacing shown (using the numeric keys) to match the actual physical spacing of the transducers. GE Panametrics does not recommend overwriting the spacing. If you must, do not change the spacing by more than ±10% from the value shown.*

You have completed entering pipe parameters for clamp-on transducers. Press [ENT] to return to the start of the PIPE submenu, and [EXIT] to leave the submenu.

Wetted Transducers

After the PIPE WALL prompt, the following series of prompts appears only if you have selected wetted transducers.

```
(Chan 1) PIPE PROG
PIPE WALL
current selection appears here

PATH LENGTH P
current value appears here
inch | feet | |
```

Press [F1] or [F2] to select the desired units. Then, enter the path length of the ultrasonic signal and press [ENT].

Note: *GE Panametrics has calculated both the transducer signal path length* (P) *and the transducer signal axial length* (L), *based on the exact transducer configuration used for the application. These values are engraved on the flowcell and/or are included in the documentation supplied with the meter. See Appendix D for an explanation as to how these values are calculated.*

The following prompts only appear if you have activated the Transit-Time mode.

```
(Chan 1) PIPE PROG
PATH LENGTH P
current value appears here

AXIAL LENGTH L
current value appears here
inch | feet | |
```

Press [F1] or [F2] to select the desired units. Then, enter the axial length of the ultrasonic signal and press [ENT].

```
(Chan 1) PIPE PROG
AXIAL LENGTH L
current value appears here

TRACKING WINDOWS?
current selection appears here
NO | YES | |
```

Press [F1] if you do not want tracking windows, or [F2] if you want to enable the windows. (Tracking windows are used to detect the receive signal when you are unsure of the fluid soundspeed.)

The following prompt only appears if you have activated the TransFlection mode.

```
(Chan 1) PIPE PROG
PATH LENGTH P
current value appears here

TRANSDUCER ANGLE
current setting appears here
 | | |
```

Use the numeric keys to enter the number of degrees for the transducer angle, and press [ENT].

Wetted Transducers (cont.)

(Chan 1) PIPE PROG ➤
previous prompt appears here
previous entry appears here

FLUID TYPE
current setting appears here
WATER | OIL | METH | ETH

Press [F1]-[F3] to select the type of fluid to be measured. Selections include water, water/glycol (energy option only), oil (lube or crude), methanol, ethanol, LN2, freon and other.

The selections for the fluid type vary, depending on whether:

- the ENERGY OPTION is ON or OFF; and
- the TRACKING WINDOW is enabled or disabled.

Refer to Table 2-10 below if ENERGY OPTION is OFF, or to Table 2-11 on page 2-24 if ENERGY OPTION is ON.

Note: *Some of the fluid types may require additional selections as shown in the following tables.*

Table 2-10: Fluid Types for ENERGY OFF

Tracking Windows =			
NO	**Additional Selections**	**YES**	**Additional Selections**
WATER	Select **NORML** or **SEA** and press **[ENT]**. If **NORML** is selected, enter the Water Temperature and press **[ENT]**.	W100	No additional selections required.
OIL	Select **LUBE** or **CRUDE** and press **[ENT]**.	W260	No additional selections required.
METH	No additional selections required.	OIL	No additional selections required.
ETH	Enter the Fluid Soundspeed and press **[ENT]**.	OTHER	Enter the Minimum Soundspeed and press **[ENT]**. Then enter the Maximum Soundspeed and press **[ENT]**.

Table 2-10: Fluid Types for ENERGY OFF (Continued)

Tracking Windows =			
NO	**Additional Selections**	**YES**	**Additional Selections**
LN2	No additional selections required.		
FREON	No additional selections required.		
OTHER	Enter the Fluid Soundspeed and press **[ENT]**.		

Table 2-11: Fluid Types for ENERGY ON

Tracking Windows =			
NO	**Additional Selections**	**YES**	**Additional Selections**
WATER	Enter the Water Temperature and press [ENT].	W260	No additional selections required.
MIXED	Enter the Fluid Soundspeed and press **[ENT]**. Then enter the Percentage of Water and press **[ENT]**.	MIXED	Enter the Percentage of Water and press **[ENT]**.
OTHER	Enter the Fluid Soundspeed and press **[ENT]**.	OTHER	Enter the Minimum Soundspeed and press **[ENT]**. Then enter the Maximum Soundspeed and press **[ENT]**.

```
(Chan 1) PIPE PROG
FLUID TYPE
current selection appears here

REYNOLDS CORRECTION
current selection appears here
 OFF | ON |   |
```

Press [F1] to turn Reynolds Correction off, or [F2] to turn it on.

Note: *Reynolds Correction is a number based on the Kinematic Viscosity and flow rate of the fluid. It should be enabled for most applications.*

Wetted Transducers (cont.)

```
(Chan 1) PIPE PROG
REYNOLDS CORRECTION
current selection appears here

KINEMATIC VISCOSITY
current value appears here
```

When you enable the Reynolds Correction Factor, you must also enter the Kinematic Viscosity of your fluid, as listed in *Sound Speeds and Pipe Size Data.* Use the numeric keys to enter a value, and press [ENT].

```
(Chan 1) PIPE PROG
previous prompt appears here
previous selection appears here

CALIBRATION FACTOR
current value appears here
```

Enter a value for the flow calibration factor and press [ENT]. The default value is 1.00, but values between 0.90 and 1.10 may be entered.

The calibration factor is the final parameter in the PIPE submenu.Table 2-12 below lists the numeric parameters in the PIPE submenu, with their high and low limits.

Table 2-12: Low and High Limits for PIPE Parameters

Parameter	Low Limit	High Limit
Wedge Angle	25°	90°
Pipe OD	0.12 in.	300 in.
Pipe Wall	0 in.	4.0 in.
Lining Thickness	0 in.	4.0 in.
Kinematic Viscosity	0.1	10,000 (E-6 ft^2/s)
Path Length	0.12 in.	480 in.
Axial Length	0.12 in.	480 in.

Exiting the User Program

After the calibration factor entry has been made, the meter will exit the PIPE submenu and return to the initial *User Program* screen.

```
PROGRAM                    Start >


PROGRAM
status
ACTIV | SYSTM | PIPE | I/O
```

To leave the *User Program* and begin taking measurements, press [EXIT].

At the conclusion of the initial setup programming sequence, the following screen appears:

```
PROGRAM                    Start


Do you want to SAVE
current selection appears here
 No  |  Yes  |       |
```

At the *User Program* screen shown, press [F1] to return to measurement mode without saving the file or press [F2] to enter the SAVE submenu.

Note: *If you press [NO], the DF868 still retains the newly programmed information. See the* Programming Manual *for instructions on using the* SAVE *submenu.*

Proceed to Chapter 3, *Operation*, for instructions on taking measurements or refer to the *Programming Manual* for instructions on programming the Model DF868's advanced features.

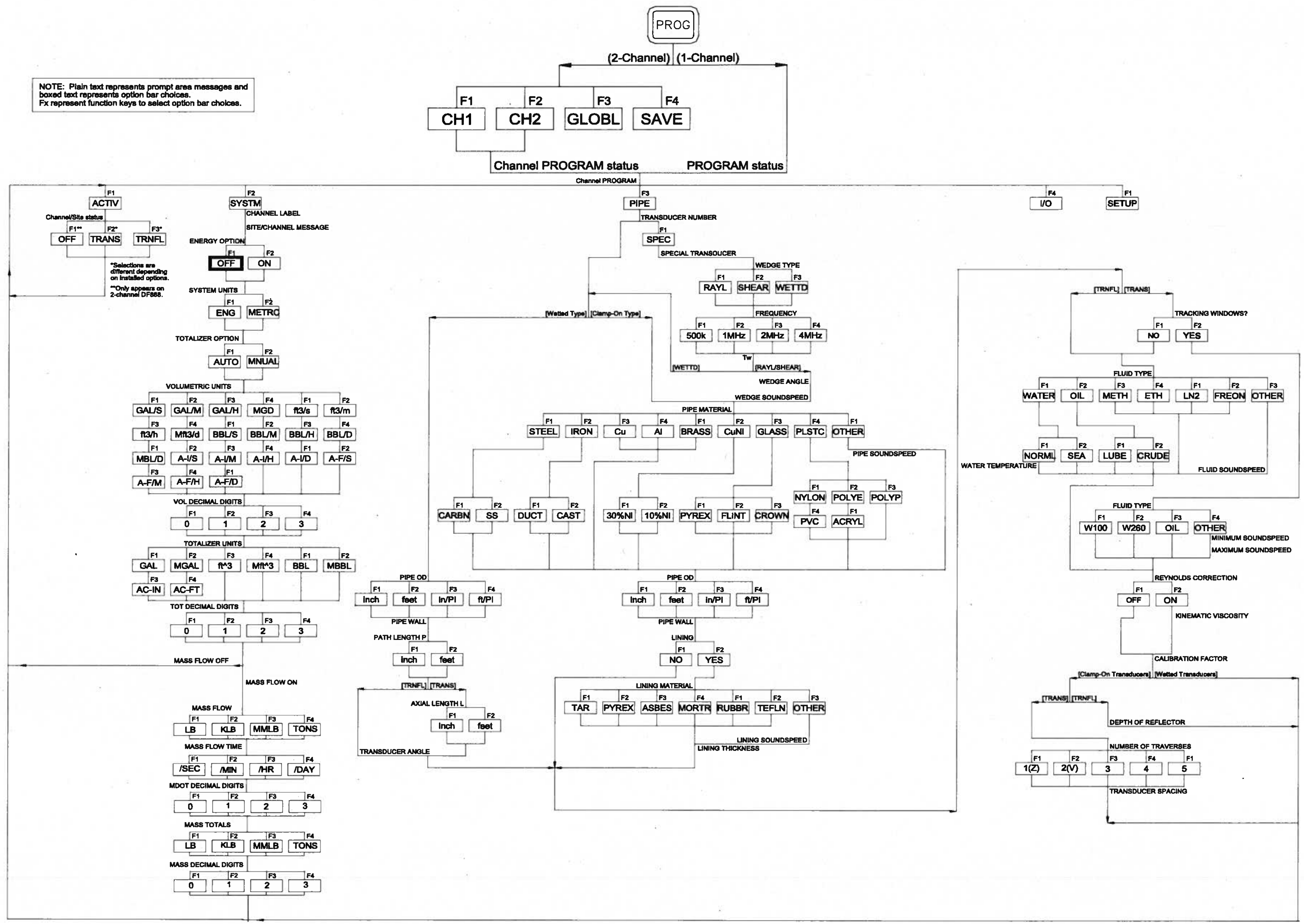


Figure 2-1: Model DF868 Initial Setup Menu Map with Energy Option Turned OFF

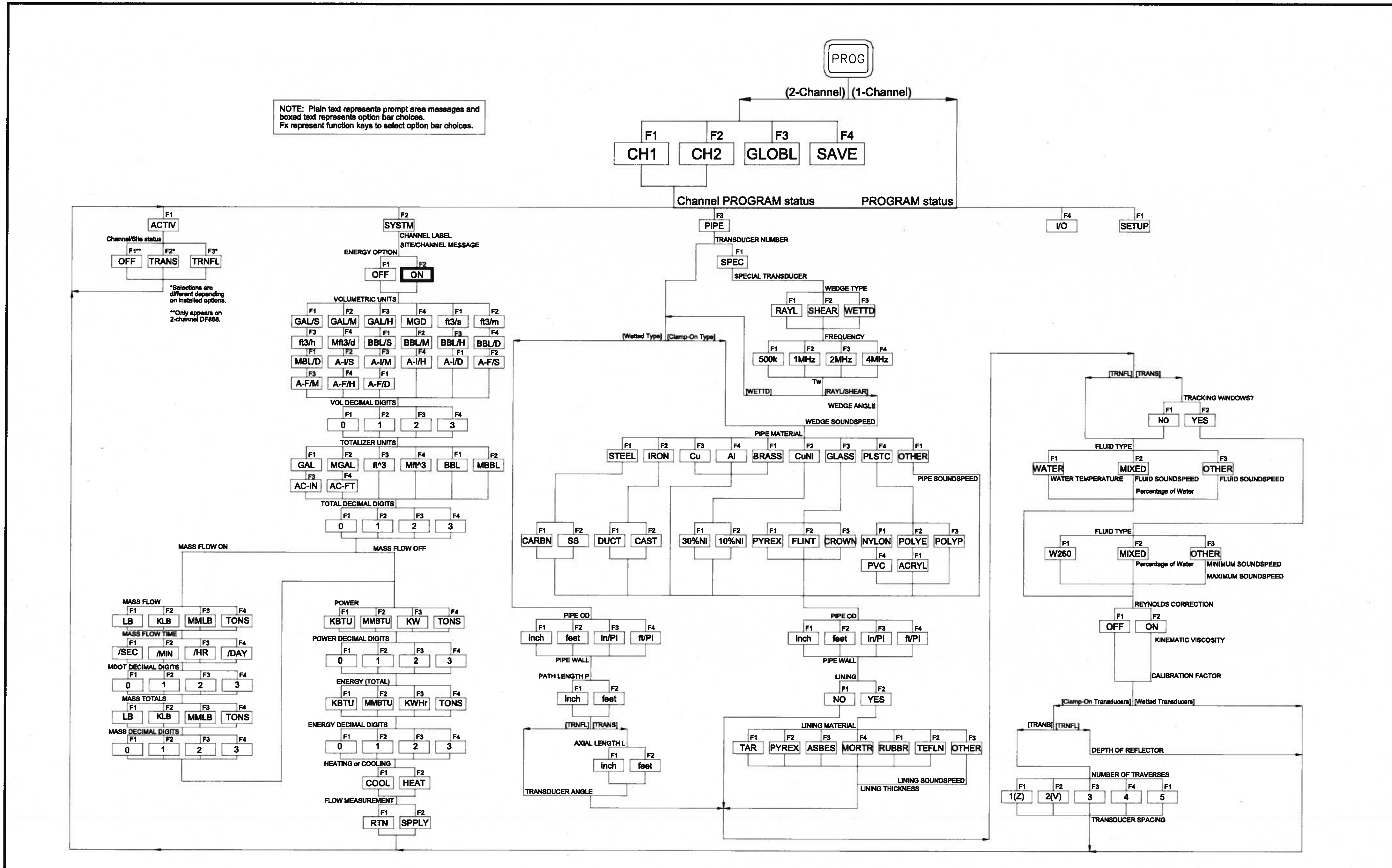


Figure 2-2: Model DF868 Initial Setup Menu Map with Energy Option Turned ON

Chapter 3

Operation

Introduction

See Chapter 1, *Installation*, and Chapter 2, *Initial Setup*, to prepare the system for operation. When the meter is ready to take measurements, proceed with this chapter. The following specific topics are discussed:

- Powering Up
- Using the Display
- Taking Measurements

Note: *All inputs and outputs of the Model DF868 are calibrated at the factory, prior to shipment. If it becomes necessary to recalibrate any of the inputs and/or outputs, see Chapter 1,* Calibration, *of the* Service Manual.

!WARNING!
To ensure the safe operation of the Model DF868, it must be installed and operated as described in this manual. In addition, be sure to follow all applicable local safety codes and regulations for the installation of electrical equipment.

Powering Up

Because the Model DF868 does not have an ON/OFF switch, it will power up as soon as the connected power source is energized.

Note: *For compliance with the European Union's Low Voltage Directive (73/23/EEC), this unit requires an external power disconnect device such as a switch or circuit breaker. The disconnect device must be marked as such, clearly visible, directly accessible, and located within 1.8 m (6 ft) of the Model DF868.*

Immediately upon power up, the Model DF868 displays the GE Panametrics logo and the software version (2AA) in the left pane of the display window. The Model DF868 performs a series of internal checks and display the results in the right pane of the display window.

Note: *If the Model DF868 fails any of the internal checks, try disconnecting the power and then re-powering the unit. If the Model DF868 continues to fail any of the internal checks, contact the factory for assistance.*

After successfully performing the internal checks, the Model DF868 begins taking measurements. The power up display is replaced by a measurement mode display similar to that shown in Figure 3-1 below.

Note: *As a minimum, the system and pipe parameters (for each installed channel of a 2-channel meter) must be entered before the Model DF868 can display valid data. Refer to Chapter 2,* Initial Setup, *for specific instructions.*

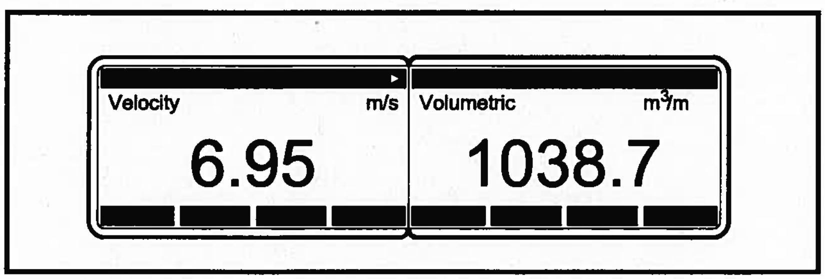


Figure 3-1: A Typical Measurement Display

Proceed to the next section for a description of the components of the Model DF868 display screen.

Using the Display

The Model DF868 display is divided into a left pane and a right pane. The two screen panes can be set independently to display any of the available measurement or diagnostic parameters. The components of a typical measurement mode screen are shown in Figure 3-2 below.

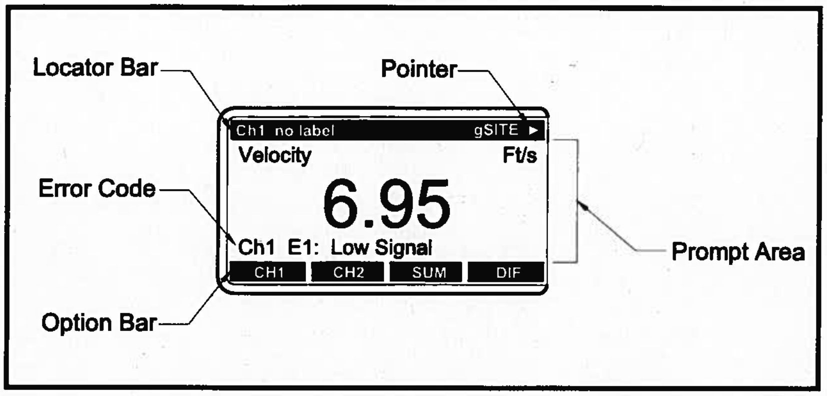


Figure 3-2: Display Screen Components

Both panes of the display screen are continuously updated, but only one pane at a time may be programmed or changed. To select a pane, press the corresponding side of the [SCREEN] key on the keypad. The currently selected screen pane will have function names in the option bar, while the other screen pane will have a blank option bar. See the *Programming Manual* for detailed instructions on using the keypad.

As shown in Figure 3-2 above, each pane of the display screen is divided into the following three general areas:

- the locator bar
- the prompt area
- the option bar.

The upper portion of the screen pane is called the *locator bar.* While the meter is taking measurements, the locator bar displays the name of the currently selected site file. In addition, the locator bar identifies the task that is currently being performed and the status of that task. For example, pressing the [PROG] key on the keypad will cause the locator bar to display "PROGRAM" and "Start" to indicate that the meter is ready to be programmed from the start of the *User Program.*

Using the Display (cont.)

At various times, one or more of the following four symbols may be displayed on the far right of the locator bar:

- ➤: This symbol, which is called the *pointer*, indicates that additional option bar entries are available. These options can be accessed by using the [←] and [→] keys.
- *: A flashing asterisk indicates that the Model DF868 is currently logging information. See the *Programming Manual* for instructions on creating a log file.
- S or S_L: This symbol indicates the status of the red [SHIFT] key. "S" indicates that the [SHIFT] key is activated for the next keystroke only, while "S_L" indicates that the [SHIFT] key is locked. See the next section for instructions on using the keypad.
- T: This symbol indicates that the Model DF868 is currently totalizing data.

The middle portion of the screen pane is the *prompt area*. This area displays data, graphs, and logs in measurement mode and menu prompts in programming mode. In addition, error code messages, which are described in the *Service Manual*, are displayed in the prompt area.

The lower portion of the screen pane is called the *option bar*. The option bar displays the functions assigned to the four keys immediately below the display screen ([F1]-[F4] for the left pane and [F5]-[F8] for the right pane). Press a function key to select the function listed in the option bar immediately above it. If more than four functions are available, a pointer (➤) appears on the far right of the locator bar. Press the [←] or [→] keys to display the additional functions on the option bar.

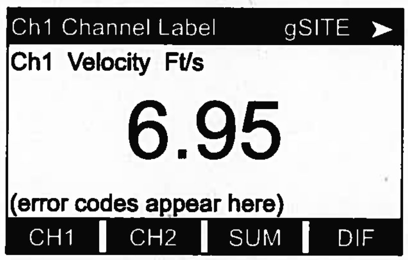
For information about other symbols and text that may appear on the display screen, refer to the *Service Manual*.

Taking Measurements

The Model DF868 is capable of displaying several different variables in a variety of formats. However, this manual will only discuss the basic measurement displays in the default screen format. Refer to the *Programming Manual* for instructions on setting up alternate screen displays and see the *Service Manual* for a discussion of the diagnostic parameters listed under the DIAG option.

Note: *This section assumes that the left pane of the display screen is currently active. However, the same instructions apply equally to the right screen pane, when it is active. Just change the function keys from* [F1]-[F4] *to* [F5]-[F8].

For a 2-channel Model DF868, the following initial screen appears immediately upon completion of the internal checks. As an example, the display shows the measured velocity in ft/sec for Channel 1.

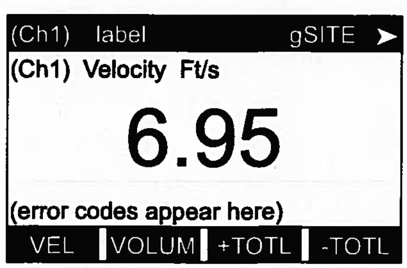


To select a different channel display option, press [F1]-[F4] (or [→] and [F1]). See Table 3-1 below for a complete description of the available options.

Table 3-1: Channel Display Options

Option Bar Choice	Description
[F1] = CH1	Channel 1
[F2] = CH2	Channel 2
[F3] = SUM	(Channel 1) + (Channel 2)
[F4] = DIF	(Channel 1) - (Channel 2)
[→] + [F1] = AVE	[(Channel 1) + (Channel 2)]/2

The following screen appears after selection of the channel mode display option for a 2-channel Model DF868 or immediately after the internal checks for a 1-channel Model DF868.



Use the [F1]-[F4], [←] and [→] keys to select the desired display parameter option. See Table 3-2 on page 3-6 for a complete description of the available options.

Taking Measurements (cont.)

Note: *Ch1 (or Ch2), which is shown in parentheses above, appears only with a 2-Channel Model DF868.*

Table 3-2: Measurement Parameter Options

Option Bar Choice	Description
[F1] = VEL	Flow Velocity
[F2] = VOLUM	Volumetric Flow
[F3] = +TOTL	Forward Totalized Volume Flow
[F4] = -TOTL	Reverse Totalized Volume Flow
[→] + [F1] = TIME	Total Flow Measurement Time
[→] + [F2] = MDOT*	Mass Flow
[→] + [F3] = +MASS*	Forward Totalized Mass Flow
[→] + [F4] = -MASS*	Reverse Totalized Mass Flow
[→] + [→] + [F1] = POWER**	Energy Flow Power
[→] + [→] + [F2] = +ENRG**	Forward Energy Flow
[→] + [→] + [F3] = -ENRG**	Reverse Energy Flow
[→] + [→] + [F4] = DIAG	Diagnostic
* Available only if Mass Flow is enabled ** Available only if Energy Option is enabled	

In the SETUP submenu, the Advanced Features option offers a MASS (Mass Flow) option. The SYSTEM submenu offers an ENERGY OPTION. If you enable these options, the related options listed in Table 3-2 above are available. However, if you do not enable these options, the six options indicated do not appear and the DIAG option will appear in the [F2] position on the second option bar screen.

By following the instructions in this section, the Model DF868 can be set up to display the desired channel option (for a 2-Channel meter) and the desired measurement parameter. To utilize the more advanced display capabilities of the Model DF868, refer to the *Programming Manual* and/or the *Service Manual* for the instrument.

Chapter 4

Specifications

General Specifications

The general specifications for the Model DF868 flowmeter are divided into the following categories:

Hardware Configuration

Package Options:

Epoxy-coated aluminum (standard), Stainless steel, Fiberglass, Explosion-proof

Physical:

Size: 14.24 × 11.4 × 5.12 in. (36.2 × 29 × 13 cm)

Weight: 11 lb (5 kg)

Environmental

Operating Temperature:

14° to 122°F (–10° to 50°C)

Storage Temperature:

14° to 122°F (–10° to 50°C)

Flow Accuracy (% of Reading)

Transit-Time Mode:

Pipe Diameter (ID) > 6 in. (150 mm):

Velocity >1 ft/s (>0.3 m/s), 2% of reading typical;

0.5 to 1% of reading with calibration.

Velocity ≤ 1 ft/s (≤ 0.3 m/s), ±0.03 ft/s (±0.01 m/s)

Pipe Diameter (ID) ≤ 6 in. (150 mm):

Velocity >1 ft/s (>0.3 m/s), 2 to 5% of reading typical.

Velocity ≤ 1 ft/s (≤ 0.3 m/s), ±0.15 ft/s (±0.05 m/s)

TransFlection Mode:

Pipe Diameter (ID) 2 in. (50 mm) and larger:

±5% of reading typical: ±2% of reading with calibration.

Note: *Specifications assume a fully developed flow profile. Accuracy depends on pipe size and other factors.*

Range

Transit-Time Mode:

–40 to 40 ft/s (–12.2 to 12.2 m/s)

TransFlection Mode:

-1 to -30 ft/s (-0.3 to -9.1 m/s)

1 to 30 ft/s (0.3 to 9.1 m/s)

±1 to 15 ft/s (0.3 to 4.6 m/s)

Rangeability

Transit-Time Mode: 400:1.
TransFlection Mode: 30 to 1.

Repeatability

Transit-Time Mode:

Wetted Transducers: ±0.2% of full scale.
Clamp-on Transducers: ±0.2 to 0.5% of full scale.

TransFlection Mode:

Clamp-on Transducers: ±0.5% of full scale.

Energy Accuracy

The accuracy of the energy measurement is a combination of the accuracy of the associated flow and temperature measurements.

Transit-Time Mode:

1% of reading typical for calibrated systems.

TransFlection Mode:

2% of reading typical for calibrated systems.

Fluid Types

Transit-Time Mode:
Acoustically conductive fluids, including most clean liquids and many with entrained solids or gas bubbles. Maximum void fraction depends on transducer interrogation carrier frequency, path length and pipe configuration.

TransFlection Mode:
Multiphase fluids, including raw sewage, sludge, slurries, tar sands, acoustically attenuating liquids and other demanding applications.

Electrical Specifications

The electrical specifications for the Model DF868 flowmeter are divided into the following categories:

Power Supply

Standard:

110 to 120 VAC, 50/60 Hz, ±10%

220 to 240 VAC, 50/60 Hz, ±10%

Optional:

12 to 28 VDC, ±5%

Power Usage

20 W maximum

Operating Modes

Flow Measurement:

Transit-Time for clamp-on or wetted transducers.

TransFlection for clamp-on transducers.

Energy Measurement:

To calculate energy flow rate, use Analog Input Board for transmitters. Use RTD Input board for direct RTDs.

European Compliance

This unit complies with EMC Directive 89/336/EEC and 73/23/EEC Low Voltage Directive (Installation Category II, Pollution Degree 2).

Hazardous (Classified) Location Compliance

CENELEC: ISSeP Ex 96D1031261, EEx d IIC T6 when housed GUB 6 enclosure.

NEC: Factory Mutual Research Corporation, J.K. 3Z9A1.AX, Class I, Division 2, Group A, B, C, D; Class II, division 2, Group F, G; Class III, Division 2, NEMA TYPE 4X, Tamb 50° C T4

CEC: Canadian Standards Association, LR44204, Class I, Division 2, Group A, B, C, D; Class II, division 2, Group F, G; Class III, Division 2, TYPE 4X, Tamb 50° C T4

Note: *Refer to Certificate of Compliance for details.*

Input/Output Specifications

Keypad:

39-key membrane keypad with tactile feedback

Display:

Both single- and dual-channel models have two independent software-configurable 64 x 128-pixel LCD graphic displays

Input/Output Specifications (cont.)

Printer/Terminal Communications:

Standard: One RS232 port for printer, terminal, or PC.

Optional: RS485/MODBUS (multiuser).

Analog Input Options:

Select up to 3 boards of one of the following types:

1. *Transmitter Input Board* with two isolated 0/4-20 mA inputs and 24-V loop power.
2. *RTD Input Board* with two isolated 3-wire RTD inputs; Span –148° to 662°F (–100° to 350°C).

Analog Output Options:

All meters come with two isolated 0/4–20 mA current outputs (550 Ω maximum load).

Optional selection of up to 3 additional output boards, each with four isolated 0/4–20 mA outputs (1,000 Ω maximum load).

Totalizer/Frequency Output Options:

Select up to 3 Totalizer/Frequency Output Boards, each with four outputs per board, 10 kHz max.

All boards allow software-selectable functioning in two modes:

Totalizer Mode: one pulse per defined unit of parameter (e.g., 1 pulse/gal).

Frequency Mode: pulse frequency proportional to magnitude of parameter (e.g., 10 Hz = 1 gpm).

Alarm Options:

Select up to 2 boards of one of the following types:

Basic Relay Board with three general purpose Form-C relays.

Hermetic Relay Board with three hermetically sealed Form-C relays.

Maximum Relay Ratings:

120 VAC AC Voltage, 28 VDC DV Voltage, 5A AC/DC Current,

60 VA AC Power, 30 W DC Power (General Purpose) or

56 W DC Power (Hermetically Sealed)

Note: *A maximum of six input/output option boards may be installed.*

Operational Specifications

The operational specifications for the Model DF868 flowmeter are divided into the following categories:

Site Parameter Programming

Menu-driven operator interface using keypad and "soft" function keys. Storage for 10 sites.

Data Logging

Keypad-programmable for setting up log units, update interval, start and stop times. Memory capacity for more than 43,000 flow data points in a linear or circular log.

Display Functions

Liquid crystal graphic display shows flow in numeric or graphic format. Also displays logged data and diagnostics.

Printer Signal Output

Supports wide variety of thermal and impact printers. Output data in numeric or graphic ("strip chart") format.

Transducer Specifications

The transducer specifications for the Model DF868 flowmeter are divided into the following categories:

Wetted Ultrasonic Flow Transducers

Temperature Range

Standard: –40° to 212°F (–40° to 100°C)
Optional: –310° to 932°F (–190° to 500°C)

Pressure Range

Standard: 0 to 3,000 psig (0.1013 to 20 MPa)
Optional: Higher pressures upon request.

Materials

Standard: 316 stainless steel
Optional (for isolating Pan-Adapta Plugs): Titanium, Hastelloy, PVC, PVDF and others.

Process Connections

Standard: 1" NPTM or 3/8" NTPM
Optional: RF flanged, socket weld, fuse bond and others.

Mounting

Spoolpiece, hot tap, cold tap.

Housing

Standard: None
Optional:
Explosion-proof (Division I, Class I, Groups C & D)
Flameproof (INIEX/ISSeP certified for EEx d II C T4 to T6)
Weatherproof (NEMA-4X, IP65)
Submersible

Clamp-On Ultrasonic Flow Transducers

Temperature Range

Standard: –40° to 140°F (–40° to 60°C)
Optional: –310° to 572°F (–190° to 300°C)

Mounting

Stainless steel chain or strap, welded or magnetic clamping fixtures

Housing

Standard: None
Optional:
Explosion-proof (Division I, Class I, Groups C & D)
Flameproof (INIEX/ISSeP certified for EEx d II C T4 to T6)
Weatherproof (NEMA-4X, IP65)
Submersible

Note: *Transducers, spoolpieces and clamping fixtures for special applications are available. Consult GE Panametrics for details.*

Temperature Transducers

Loop-powered, 3-wire platinum RTDs; clamp-on and wetted (thermowell) types are available. (RTD inputs must be PT100 only.)

Accuracy

0.15°, wetted RTDs (matched pairs).

Range

-4 to 500°F (-20° to 260°C).

Note: *Not all extremes of parameters can be achieved simultaneously.*

Pipe Size & Materials

Wetted Transducers

Materials

All metals and most plastics. (Consult GE Panametrics for concrete, glass and cement.)

Pipe Sizes

Transit-Time Mode:
Inside diameter (ID) 0.04 to 200 in. (1 mm to 5 m) and larger.

Clamp-On Transducers

Materials

All metals and most plastics. (Consult GE Panametrics for concrete, composite materials and highly corroded or lined pipes.)

Pipe Sizes

Transit-Time Mode:
Outside diameter (OD) 0.5 to 200 in. (12.7 mm to 5 m) and larger.

TransFlection Mode:
Outside diameter (OD) 2 to 200 in. (5 cm to 5 m) and larger.

Pipe Wall Thickness

Up to 3 in. (76.2 mm)

PC Interface Software

Instrument Data Manager™ (IDM) software options links the DF868 to a PC. Software package includes 3.5-in. diskette, interconnection cable (please specify type needed) and manual.

PanaView software option links the DF868 to a PC. Software package includes CD and manual.

Appendix A

CE Mark Compliance

Introduction

For CE Mark compliance, the Model DF868 flowmeter must be wired in accordance with the instructions in this appendix.

IMPORTANT: *CE Mark compliance is required only for units intended for use in EEC countries.*

Wiring

The Model DF868 must be wired with the recommended cable, and all connections must be properly shielded and grounded. Refer to Table A-1 below for the specific requirements.

Table A-1: Wiring Modifications

Connection	Cable Type	Termination Modification
Transducer	RG62 a/u	Add metallic cable clamp from braid to chassis ground.
	Armored RG62 a/u or conduit	None - grounded via cable gland.
Input/Output	22 AWG shielded (e.g. Baystate #78-1197)	Terminate shield to chassis ground.
	Armored conduit	None - grounded via cable gland.
Power	14 AWG, 3 conductor, shielded (e.g. Belden #19364)	None required
	Armored Conduit	None - grounded via cable gland.
Shielding	For CE compliance, power and I/O cables must be shielded. Cables to be terminated within cable gland at the DF868. Shielded cable is not required when installations include metal conduit.	

Note: *If the Model DF868 is wired as described in this appendix, the unit will comply with the EMC Directive 89/336/EEC.*

Appendix B

Data Records

Option Cards Installed

Whenever an option card is installed in one of the Model DF868's expansion slots, record the type of card and any additional setup information in the appropriate row of Table B-1 below.

Table B-1: Option Cards Installed

Slot #	Type of Option Card	Additional Setup Information
0	Analog Outputs (A, B)	
1		
2		
3		
4		
5		
6		

Initial Setup Data

After the Model DF868 flowmeter has been installed, some initial setup data must be entered via the *User Program*, prior to operation. Record that information in Table B-2 below.

Table B-2: Initial Setup Data

General Information					
Model #			Serial #		
Software Vers.			Setup Date		
GLOBL-SYSTM					
System Units	English	Metric	Vol. Dec. Digits		
Totalizer Option	Auto	Manual	Totalizer Units		
Vol. Units			Tot. Dec. Dig.		
GLOBL-I/O-ERROR					
Error Handling			2-Path Error	No	Yes
GLOBL-COMM					
Meter Address			Baud Rate		
CHx-ACTIVE					
Channel 1			Channel 2 (if applicable)		
Channel Status	Off[1] Trans Tranfl		Channel Status	Off[1] Trans Tranfl	
CHx-SYSTM					
Channel 1			Channel 2 (if applicable)		
Channel Label			Channel Label		
Chan. Message[2]			Chan. Message[2]		
Energy Option	On	Off	Energy Option	On	Off
Vol. Units			Vol. Units		
Vol. Dec. Digits			Vol. Dec. Digits		
Totalizer Units			Totalizer Units		
Tot. Dec. Dig.			Tot. Dec. Dig.		
Mass Flow			Mass Flow		
Mass Flow Time			Mass Flow Time		
MDOT Dec. Dig.			MDOT Dec. Dig.		
Mass Totals			Mass Totals		
Mass Dec. Digits			Mass Dec. Digits		
Power			Power		
Power Dec. Dig.			Power Dec. Dig.		
Energy (Total)			Energy (Total)		
Energy Dec. Dig.			Energy Dec. Dig.		
Heat. or Cool.			Heat. or Cool.		
Flow Meas.			Flow Meas.		
[1]not available for 1-Channel meter, [2]"Site Message" for 1-Channel meter					

Table B-2: Initial Setup Data (cont.)

CHx-I/O						
Zero Cutoff				Temp. Input	Fixed ( )	Live
Pipe/Transducer Parameters - *PIPE*						
Channel 1				Channel 2 (if applicable)		
Trans. Type	STD	SPEC		Trans. Type	STD	SPEC
Transducer #				Transducer #		
Special Transducers				***Special Transducers***		
Wedge Type	Rayl Shear Wettd			Wedge Type	Rayl Shear Wettd	
Frequency Hz				Frequency Hz		
Trans. Tw				Trans. Tw		
Wedge Angle				Wedge Angle		
Wedge Sndspd				Wedge Sndspd		
Pipe Material				Pipe Material		
All Clamp-On and Wetted Transducers				***All Clamp-On and Wetted Transducers***		
Pipe O.D.				Pipe O.D.		
Pipe Wall				Pipe Wall		
Path Length (P)				Path Length (P)		
Axial Length (L)				Axial Length (L)		
Trans. Angle				Trans. Angle		
Lining	Yes	No		Lining	Yes	No
Lining Material				Lining Material		
Lining Sndspd				Lining Sndspd		
Lining Thickness				Lining Thickness		
Track. Window.	Yes	No		Track. Window.	Yes	No
Fluid Type				Fluid Type		
Other/Sndspd				Other/Sndspd		
% of Water				% of Water		
Reynolds Corr.	Off	Active		Reynolds Corr.	Off	Active
KV Input Sel.	Table	Static		KV Input Sel.	Table	Static
Kin. Visc.				Kin. Visc.		
Cal. Factor				Cal. Factor		
# of Traverses				# of Traverses		
Trans. Spacing				Trans. Spacing		
Depth of Reflect.				Depth of Reflect.		
CHx-SETUP-AVRG						
Response Time						

Table B-2: Initial Setup Data (cont.)

CHx-SETUP-ADVAN-KV/SS					
KV/SS Pairs			KV/SS Pairs		
#	Sig. Stren.	Kin. Visc.	#	Sig. Stren.	Kin. Visc.
1			1		
2			2		
3			3		
4			4		
5			5		
6			6		
7			7		
8			8		
9			9		
10			10		
11			11		
12			12		
13			13		
14			14		
15			15		
16			16		
17			17		
18			18		
19			19		
20			20		
CHx-SETUP-ADVAN-MULTIK					
Custom Type	CstV	CstR	Custom Type	CstV	CstR
K-Factor Table			K-Factor Table		
K-Factor #	Vel./Reyn.	K Factor	K-Factor #	Vel./Reyn.	K Factor
1			1		
2			2		
3			3		
4			4		
5			5		
6			6		
7			7		
8			8		
9			9		
10			10		
11			11		
12			12		

Table B-2: Initial Setup Data (cont.)

CHx-SETUP-ADVAN-MULTIK (cont.)							
K-Factor Table				K-Factor Table			
K-Factor #	Vel./Reyn.	K Factor		K-Factor #	Vel./Reyn.	K Factor	
13				13			
14				14			
15				15			
16				16			
17				17			
18				18			
19				19			
20				20			
CHx-SETUP-ADVAN-MASS							
Channel 1				Channel 2 (if applicable)			
Mass Flow	No	Yes		Mass Flow	No	Yes	
Static Density				Static Density			
CHx-SETUP-ADVAN-CODEL							
Code Length	Auto 1bit 2bit 4bit 11bit			Code Length	Auto 1bit 2bit 4bit 11bit		
CHx-SETUP-ADVAN-ActTw							
Active Tw	No	Yes		Active Tw	No	Yes	
Minimum Tw				Minimum Tw			
Maximum Tw				Maximum Tw			

Appendix C

Optional Enclosures

Introduction

Upon request the Model DF868 flowmeter may be supplied in an enclosure other than the standard NEMA-4X enclosure described in Chapter 1, *Installation*, of this manual. Although the standard installation and wiring instructions still apply in general terms, some of the details may vary for different enclosure types. Refer to the appropriate sections of this appendix for the specific type of enclosure provided.

Rack Mount Enclosure

The Model DF868 flowmeter is available in a *rack mount* enclosure for installation in a standard 19" electronics rack. Refer to Figure C-1 on page C-3 for the dimensions of this unit. Simply slide the Model DF868 into the rack at the desired height and fasten the unit securely to the rack with four screws in the locations provided at the sides of the front panel.

After the unit has been physically mounted into the rack, proceed to the next section for instructions on wiring the meter.

Rack Mount Wiring

The rack mount Model DF868 requires exactly the same electrical connections as the standard version. However, the locations and type of connectors used for the various components are different. Refer to Figure C-2 on page C-4 and complete the following steps:

1. Wire the *power input* on the right side of the rear panel as follows:

   a. Make sure a *fuse* (item #4) of the proper size and type is installed.

   b. Connect the female end of the *line cord* provided to the power input receptacle (item #3).

   c. Connect the *earth ground* screw terminal (item #2) to a ground point on the rack.

2. Wire the *transducers* as follows:

   a. Connect the pair of cables supplied with the meter to the *Channel 1* upstream and downstream BNC transducer connectors on the left side of the rear panel.

   b. For a 2-Channel meter, repeat the above step for the *Channel 2* transducer connectors (if the second channel is to be used).

   c. Complete the transducer wiring in accordance with the instructions in Chapter 1, *Installation*, of this manual.

Rack Mount Wiring (cont.)

3. Wire the 0/4-20 mA *analog outputs* at the left side of the rear panel in accordance with the instructions in Chapter 1, *Installation*, of this manual.

4. Wire the *RS232 serial port* by completing the following steps:

   a. Purchase or prepare a suitable serial cable. This cable should have a standard female DB9 connector, wired as shown in Figure C-2 on page C-4, for connection to the rear panel of the Model DF868. The other end should be as required for the external device.

   b. Complete the serial port wiring in accordance with the instructions in Chapter 1, *Installation*, of this manual.

5. Wire any installed *option cards* using the same procedures described in Chapter 1, *Installation*, of this manual and the pin # assignments shown in Figure C-2 on page C-4.

6. Place the *power switch* (item #1) in the ON position.

The Model DF868 is now completely wired. Proceed to Chapter 2, *Initial Setup*, of this manual for further instructions.

Rack Mount Front Panel

The keypad and LCD display for the rack mount Model DF868 are located on the front panel. These items are identical in form and function to those used on the standard NEMA-4X enclosure, but the layout is somewhat different.

Refer to Figure C-3 on page C-5 for the front panel layout of the rack mount Model DF868 and follow the standard procedures detailed in the main body of this manual.

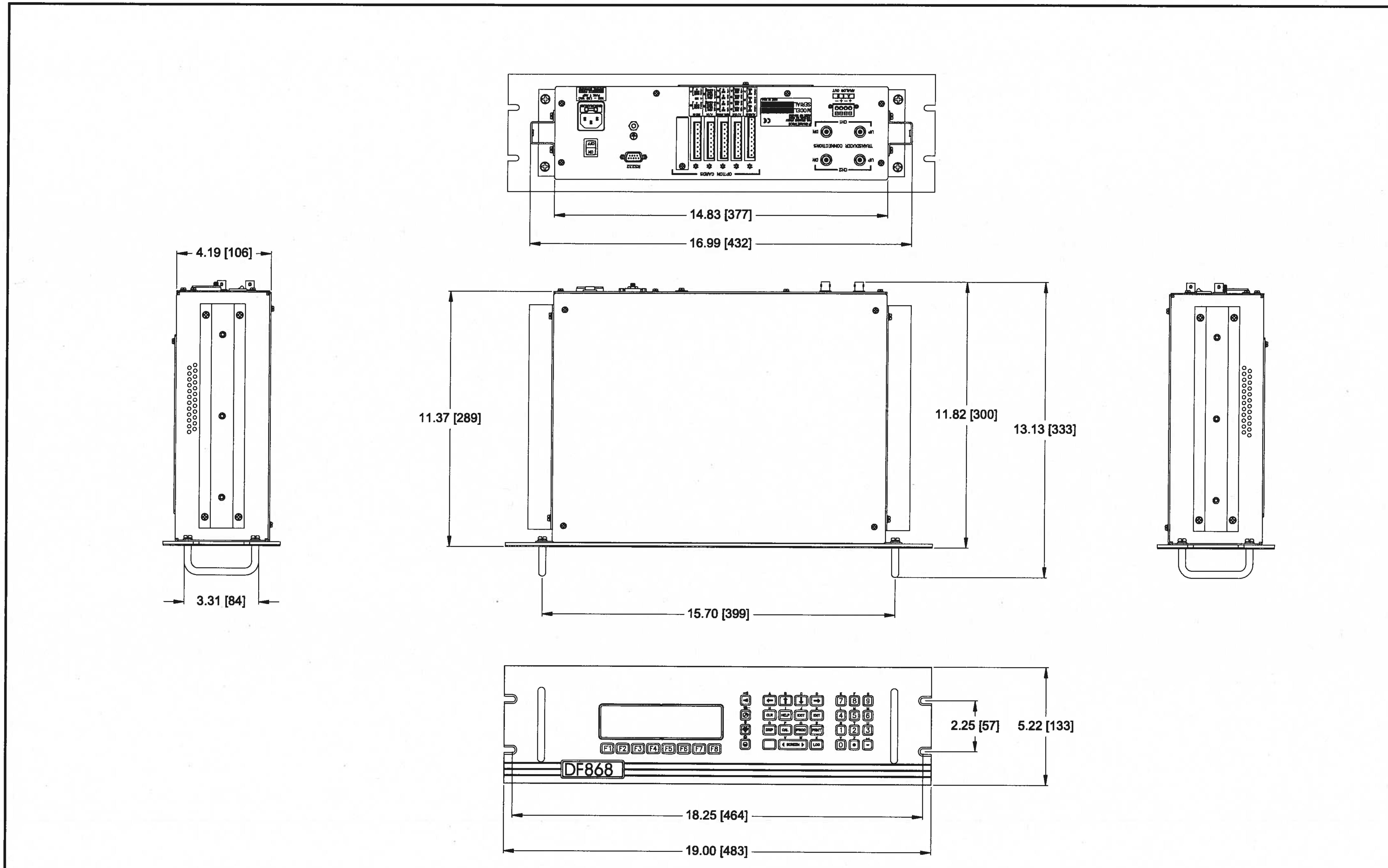


Figure C-1: Model DF868 Rack Mount Enclosure (Dwg. #712-1078)

CH2 TRANSDUCER	
BNC #	Description
UP	Upstream XDCR
DN	Downstream XDCR

CH1 TRANSDUCER	
BNC #	Description
UP	Upstream XDCR
DN	Downstream XDCR

0/4-20 mA ANALOG OUTPUTS	
Pin #	Description
1	Output A - SIG(+)
2	Output A - RTN(-)
3	Output B - SIG(+)
4	Output B - RTN(-)

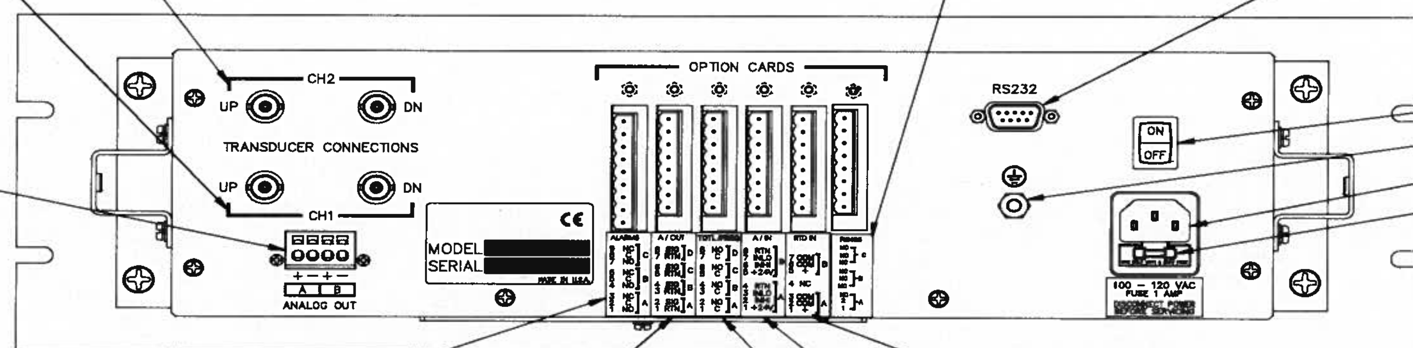
NOTE
One option card of each available type is shown in this diagram. These cards are not always installed in the same slots used for this example.

NOTE: For compliance with the European Union's Low Voltage Directive (73/23/EEC), this unit requires an external power disconnect device such as a switch or circuit breaker. The disconnect device must be marked as such, clearly visible, directly accessible and located within 1.8 m (6 ft) of the Model DF868.

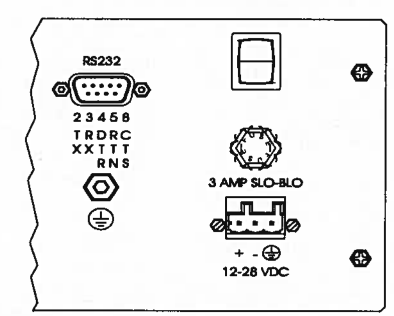
RS485 PORT (MODBUS)	
Pin #	Description
1	TMT-
2	TMT+
3	Unused
4	Unused
5	Unused

RS232 SERIAL PORT (DB9)	
Pin #	Description
1	No Connection
2	TX - Transmit
3	RX - Receive
4	DTR - Data Terminal Ready
5	RTN - Digital Return
6	No Connection
7	No Connection
8	CTS - Clear to Send
9	No Connection

POWER INPUT	
Item #	Description
1	ON/OFF Switch
2	Earth Ground
3	Power Cord
4	Fuse



REAR-VIEW DC OPTION



ALARM RELAYS	
Pin #	Description
1	Relay A - Normally Open (NO)
2	Relay A - Common (C)
3	Relay A - Normally Closed (NC)
4	Relay B - Normally Open (NO)
5	Relay B - Common (C)
6	Relay B - Normally Closed (NC)
7	Relay C - Normally Open (NO)
8	Relay C - Common (C)
9	Relay C - Normally Closed (NC)

0/4-20 mA ANALOG OUTPUTS	
Pin #	Description
1	Output A - RTN(-)
2	Output A - SIG(+)
3	Output B - RTN(-)
4	Output B - SIG(+)
5	Output C - RTN(-)
6	Output C - SIG(+)
7	Output D - RTN(-)
8	Output D - SIG(+)

TOTALIZER/FREQUENCY OUTPUTS	
Pin #	Description
1	Output A - Common (C)
2	Output A - Normally Open (NO)
3	Output B - Common (C)
4	Output B - Normally Open (NO)
5	Output C - Common (C)
6	Output C - Normally Open (NO)
7	Output D - Common (C)
8	Output D - Normally Open (NO)

0/4-20 mA ANALOG INPUTS	
Pin #	Description
1	Input A - +24V
2	Input A - INHI
3	Input A - INLO
4	Input A - RTN
5	Input B - +24V
6	Input B - INHI
7	Input B - INLO
8	Input B - RTN

RTD INPUTS	
Pin #	Description
1	Input A - SIG(+)
2	Input A - Common (C)
3	Input A - Common (C)
4	Unused
5	Input B - SIG(+)
6	Input B - Common (C)
7	Input B - Common (C)
8	Unused

Figure C-2: Model DF868 Rack Mount Enclosure - Wiring Diagram

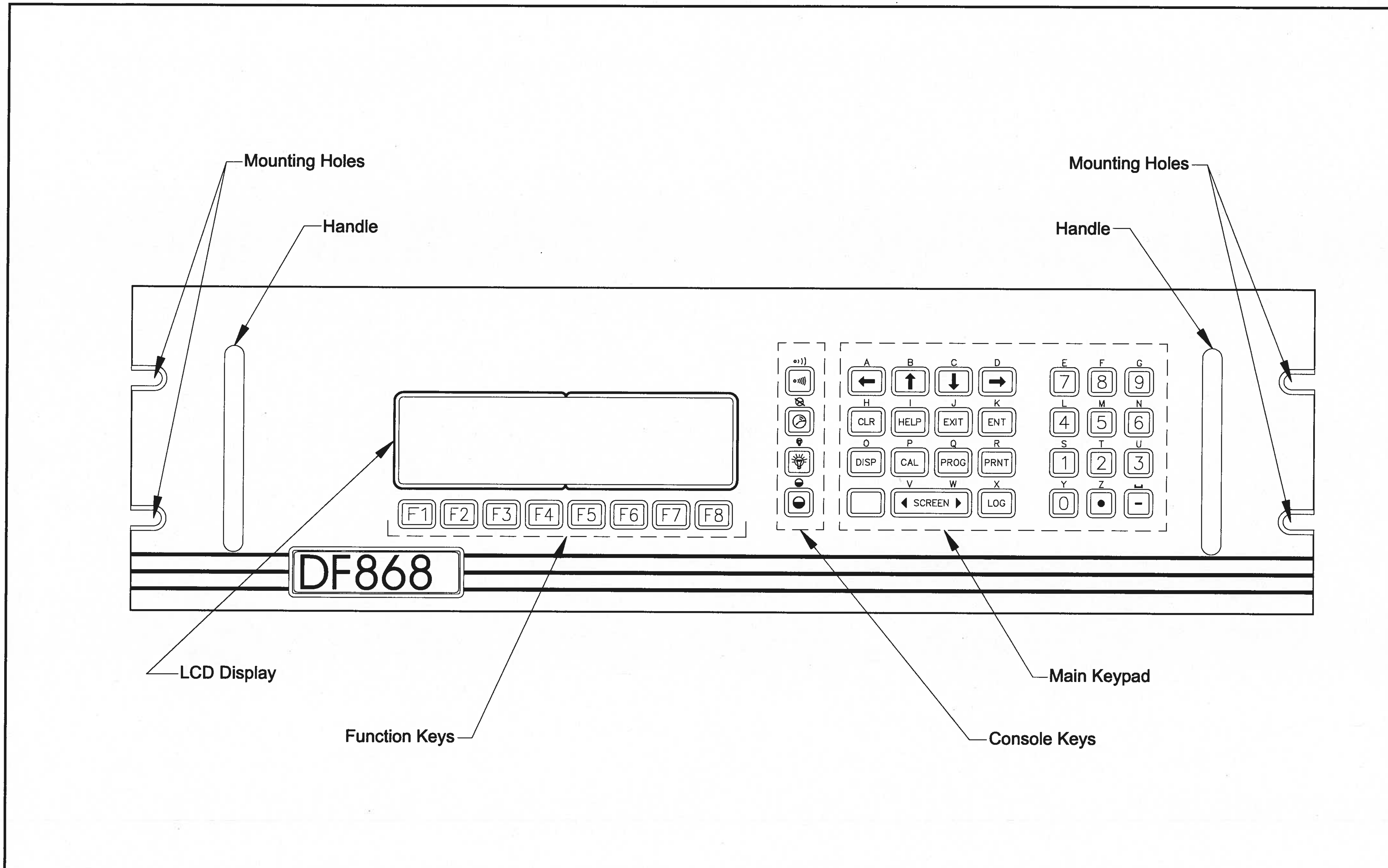


Figure C-3: Model DF868 Rack Mount Enclosure - Front Panel Layout

Appendix D

Measuring P and L Dimensions

Measuring P and L

If you are using wetted transducers, the DF868 requires you to enter the path length (P) and the axial dimension (L). P is the transducer face-to-face distance, and L is the axial projection of P in the flow stream.

To determine L, physically measure the distance between the center of the transducer ports at the inside wall as shown in Figure D-1 below, if possible. If not, consult the factory.

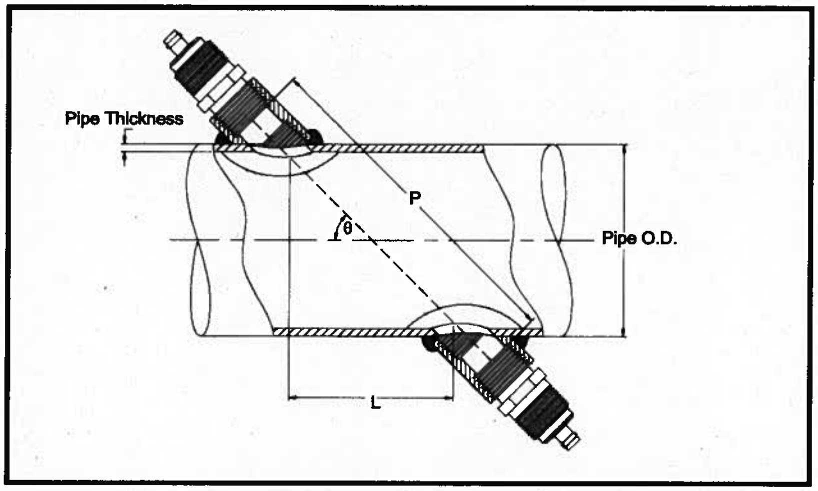


Figure D-1: Top View of 180° Transducer Installation

To determine P, you need the following:

- the pipe inside diameter (ID)
- the wall thickness (WT)
- the installed pipe coupling length (CL)
- the transducers face depth (FD)
- the mounting angle (MA)

Measuring P and L (cont.)

Use Figure D-2 below to properly measure the coupling length. Typically, the transducer face is positioned just outside the inside diameter (ID) of the pipe, or slightly retracted inside the coupling.

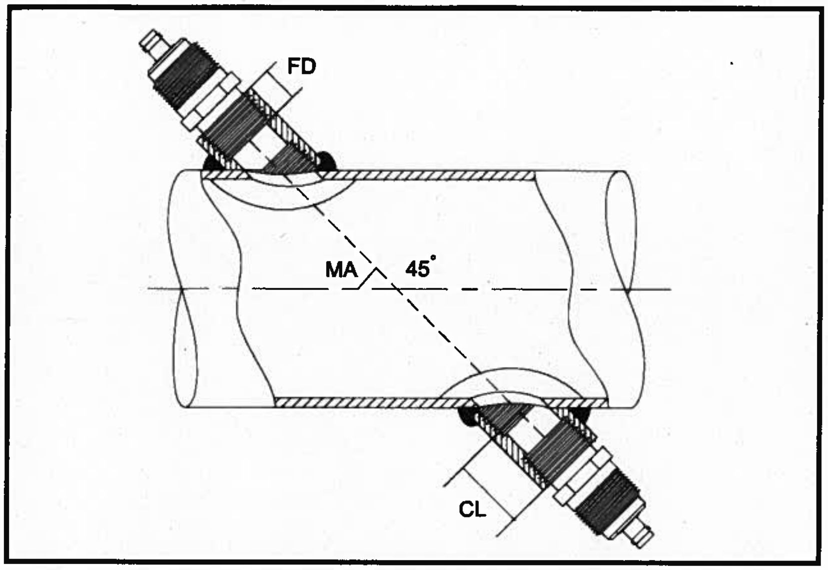


Figure D-2: Determining the Pipe Coupling Length

Use the following formula to determine the P dimension:

[ID + 2(WT)]/(cos MA) = 2 (CL- FD) = P dimension

For example, given the following:

- inside diameter (ID) = 48”
- wall thickness (WT) = 3/8”
- installed coupling length (CL) = 2.0”
- a transducer face depth (FD) = 1.75”
- mounting angle (MA) = 45°

The P dimension would be:
[48 + 2(3/8)]/(0.7071) + 2(2.0-1.75) = 69.4”

Index

Index (cont.)

O

P

R

S

Index (cont.)

GE Panametrics

DECLARATION OF CONFORMITY

We,

GE Panametrics
Shannon Industrial Estate
Shannon, Co. Clare
Ireland

declare under our sole responsibility that the

DF868 Liquid Ultrasonic Flowmeter
GF868 Flare Gas Ultrasonic Flowmeter
GM868 Multi-Purpose Gas Ultrasonic Flowmeter
GN868 Natural Gas Ultrasonic Flowmeter
GS868 Steam Mass Ultrasonic Flowmeter

to which this declaration relates, are in conformity with the following standards:

- EN 61326:1998, Class A, Annex A, Continuous Unmonitored Operation
- EN 61010-1:1993 + A2:1995, Overvoltage Category II, Pollution Degree 2

following the provisions of the 89/336/EEC EMC Directive and the 73/23/EEC Low Voltage Directive.

The *units listed above and any transducers supplied with them (spoolpieces are addressed under a separate declaration of conformity)* do not bear CE marking for the Pressure Equipment Directive, as they are supplied in accordance with Article 3, Section 3 (sound engineering practices and codes of good workmanship) of the Pressure Equipment Directive 97/23/EC for DN<25.

Shannon - June 1, 2002

Mr. James Gibson
GENERAL MANAGER

CE

NSAI
I.S. EN ISO 9002
Shannon

TÜV
TÜV ESSEN
ISO 9001
U.S.

GE Panametrics

DECLARATION DE CONFORMITE

Nous,

GE Panametrics
Shannon Industrial Estate
Shannon, Co. Clare
Ireland

déclarons sous notre propre responsabilité que les

DF868 Liquid Ultrasonic Flowmeter
GF868 Flare Gas Ultrasonic Flowmeter
GM868 Multi-Purpose Gas Ultrasonic Flowmeter
GN868 Natural Gas Ultrasonic Flowmeter
GS868 Steam Mass Ultrasonic Flowmeter

rélatif á cette déclaration, sont en conformité avec les documents suivants:

- EN 61326:1998, Class A, Annex A, Continuous Unmonitored Operation
- EN 61010-1:1993 + A2:1995, Overvoltage Category II, Pollution Degree 2

suivant les régles de la Directive de Compatibilité Electromagnétique 89/336/EEC et de la Directive Basse Tension 73/23/EEC.

Les *matériels listés ci-dessus ainsi que les transducteurs pouvant être livrés avec (les manchettes faisant l'objet d'une déclaration de conformité séparée)* ne portent pas le marquage CE de la directive des équipements sous pression, car ils sont fournis en accord avec la directive 97/23/EC des équipements sous pression pour les DN<25, Article 3, section 3 qui concerne les pratiques et les codes de bonne fabrication pour l'ingénierie du son.

Shannon - June 1, 2002

Mr. James Gibson
DIRECTEUR GÉNÉRAL

I.S. EN ISO 9002
Shannon

TÜV ESSEN
ISO 9001
U.S.

GE Panametrics

KONFORMITÄTS-ERKLÄRUNG

Wir,

GE Panametrics
Shannon Industrial Estate
Shannon, Co. Clare
Ireland

erklären, in alleiniger Verantwortung, daß die Produkte

DF868 Liquid Ultrasonic Flowmeter
GF868 Flare Gas Ultrasonic Flowmeter
GM868 Multi-Purpose Gas Ultrasonic Flowmeter
GN868 Natural Gas Ultrasonic Flowmeter
GS868 Steam Mass Ultrasonic Flowmeter

folgende Normen erfüllen:

- EN 61326:1998, Class A, Annex A, Continuous Unmonitored Operation
- EN 61010-1:1993 + A2:1995, Overvoltage Category II, Pollution Degree 2

gemäß den Europäischen Richtlinien, Niederspannungsrichtlinie Nr.: 73/23/EG und EMV-Richtlinie Nr.: 89/336/EG.

Die *oben aufgeführten Geräte und zugehörige, mitgelieferte Schallwandler (Messrohre werden in einer separaten Konformitätserklärung behandelt)* tragen keine CE-Kennzeichnung gemäß der Druckgeräte-Richtlinie, da sie in Übereinstimmung mit Artikel 3, Absatz 3 (gute Ingenieurpraxis) der Druckgeräte-Richtlinie 97/23/EG für DN<25 geliefert werden.

Shannon - June 1, 2002

Mr. James Gibson
GENERALDIREKTOR

CE

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Isco Product Data

Powered by ADFM™ Technology

ADFM™ Hot Tap Velocity Profiler for Closed Pipes

The ADFM Hot Tap Flow Meter provides precise and accurate flow rate measurement in full and pressurized pipe applications where the pipe diameter is 18" (460 mm) or greater. The Hot Tap can be used in the difficult hydraulic conditions often found in force mains, siphons, process lines, and other full-pipe applications.

The ADFM Hot Tap is a variant of the standard, open channel ADFM flow monitoring system. The Hot Tap combines the widely used ADFM pulse Doppler velocity profiling technology with a unique sensor assembly suitable for insertion into full, operating pipes.

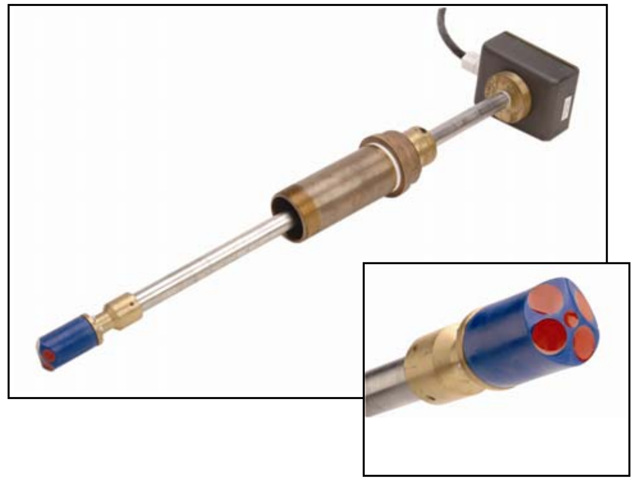
The Hot Tap's velocity profiling technology enables accurate flow rate measurement without the usual lengthy upstream and downstream straight-line conditions required by other technologies. It measures flow rate to within ±2% of actual flow rate in closed pipes, even in difficult applications such as installations near bends, short straight runs, near pumps, etc.

Installation is accomplished by inserting the sensor into an industry standard two-inch tap through the pipe wall. Installation is straight-forward and quick, providing easy access to the sensor for routine inspection and maintenance when needed. The Hot Tap is constructed of robust materials insuring years of worry-free operation.

The Hot Tap sensor uses standard ADFM electronics for data processing, collection, and storage. For customers already familiar with the standard ADFM system, operating the Hot Tap system will be intuitively easy. All standard ADFM software, communication, and interface equipment are available for the Hot Tap.

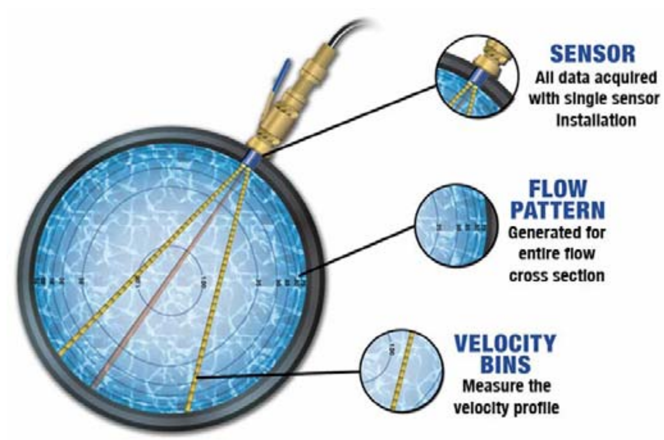
Applications

- Wastewater collection systems
- Combined sewer systems and outfalls
- Wastewater treatment facilities
- Irrigation canals and channels
- Industrial process and discharges
- Stormwater conveyance and outfalls



Standard Features

- Pulse Doppler velocity profiling technology
- Quad-redundant velocity sensors in a single housing
- Data quality verification information (signal strength and correlation)
- In-situ calibration never required
- Rugged, long lasting construction
- Real-time data output
- Industry standard communications protocol interfaces (optional)
- Secondary pressure depth sensor (optional)



Specifications

ADFM™ Hot Tap Velocity Profiler	
Measurement Performance	
Flow Accuracy:	1-2% of reading
Velocity	
Velocity Range:	±30.0 ft/s (± 9 m/s)
Velocity Bin Size:	2 to 12 inches (50 to 300 mm) user selectable
Vertical Profiling Range:	9 to 108 in (230 mm to 2.7m) nominal, for particle concentrations of 50-1000 ppm
Pipe sizes:	18 to 108 inches (460 mm to 2.7 m)
Accuracy:	0.5% of reading ± 0.01 ft/s (3.0 mm/s)
Acoustic Frequency	
Frequency:	1.23 MHz
Physical	
Electronics unit	
Electronic unit configurations:	Cylindrical canister or wall-mount box
Operating Temperature:	-15 to 125º F (-26 to 52º C)
Storage Temperature:	-65 to 160º F (-54 to 71º C)
Packaging:	NEMA 6P (IP 68) for canister NEMA 4X for box
Dimensions:	Canister - 28.5x10 in. (724 x 254 mm) Box - 17.5x14.8x6.7 in (445x375x170 mm)
Weight:	Canister Housing 36 lbs (16 kg) Box Housing 24 lbs (11 kg)
ADFM Hot Tap Insertion Sensor	
Operating Temperature:	23 to 95º F (-5 to 35º C)
Housing Material:	Plastic transducer assembly on corrosion resistant stainless steel stem
Static Pressure:	50 psi Nominal
Dimensions:	1.375 in (35 mm) diameter with standard stem length of 24 in (610 mm); fits 2 in (50 mm) standard tap
Weight (including 50 ft cable):	15 lbs (6.8 kg)
Sensor Signal Cable	
Operating Temperature:	-40 to 125º F (-40 to 52º C)
Material:	Polyethylene jacket
Length:	50 ft (15 m) std. Optional 100 ft length (30 m) available.
Minimum Bend Radius:	6 in (150 mm)
Outer Diameter:	0.5 in (13 mm) nominal

Data Management	
ADFM Hot Tap Data Types	
Q, V, D:	Discharge, average velocity, depth
Velocity:	Velocity profile data (relative to acoustic beam directions) per beam and bin
Echo Intensity:	Echo intensity data (relative backscatter intensity) per beam and bin
Data Quality:	Profile data quality indicators (Correlation magnitude, % - Good) per beam and bin
Temperature:	Transducer temperature output range 20 to 125º F (-7 to 52º C)
Sound Speed:	One output for speed of sound data
Leader:	Output of general leader information (time, data, record number, etc.)
Data Storage and I/O	
Data Storage Capacity:	32 MB std. (300,000 measurements); up to 440 MB optional
Data I/O interface:	RS-232 standard. Multiple industry-standard analog and digital protocols optionally available.
Data Transfer Rate:	Configurable to 57,600 bps
Power	
Internal battery voltage:	24 VDC nominal
Internal Battery Capacity:	26 Ah at 75º F (24º C) – Alkaline. Battery life 22 weeks at 15 minute sampling interval
External DC:	12 - 36 VDC; 10 VDC absolute minimum; 36 VDC absolute maximum
ADFM Velocity Profiler Software	
WinADFM Software for Windows 98, 2000, NT, XP	

The ADFM Hot Tap sensor installs through a standard two-inch tap.

ISCO® Water is life. Protect it.

Teledyne Isco, Inc.
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Lincoln NE 68504 USA
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USA and Canada: (800) 228-4373
Fax: (402) 465-3022
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Internet: www.isco.com

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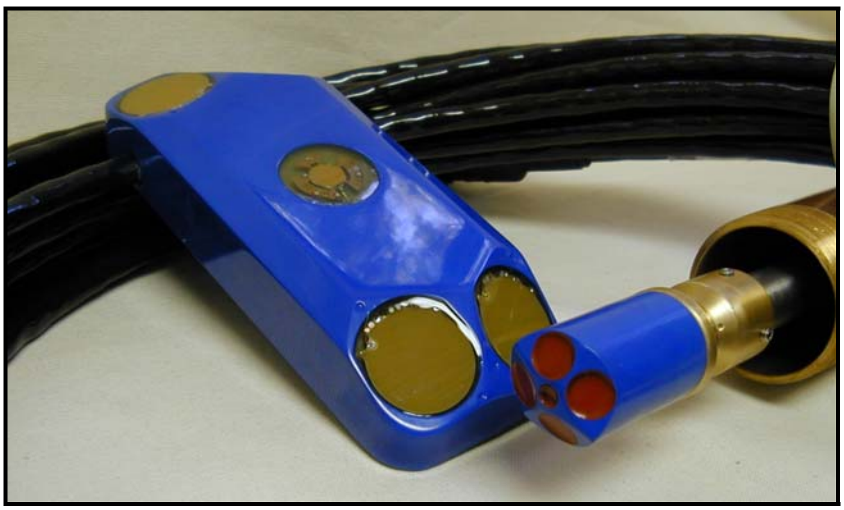
ADFM

Acoustic Doppler Flow Meter

TECHNICAL MANUAL



This manual includes information for the following products:

ADFM Pro20

ADFM Analog Output Module

ADFM Hot Tap

Teledyne Isco P/N 69-7103-001
January 2000

ADFM Velocity Profiler

Technical Manual

January 2000

> **NOTE.** This manual applies to ADFM firmware version 6.37 or higher. When newer firmware versions are released, some commands may be modified or added. Read the README file on the upgrade disk or check MGD's web site for the latest changes.

IMPORTANT NOTICE

MGD Technologies Inc. was acquired as a subsidiary of Teledyne Isco Inc. in December, 2005 and was merged into Teledyne Isco in May, 2006. New contact information is printed below:

Teledyne Isco Inc.

4700 Superior Street
Lincoln, Nebraska, 68504
(800) 228-4373 (402) 464-0231
FAX (402) 465-3022

E-mail (Customer Service): IscoCSR@teledyne.com

E-mail (Technical Service): IscoService@teledyne.com

Web site: www.isco.com

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LIST OF EFFECTIVE PAGES

Edition 4 – January 14, 2000 – Firmware version 6.37

New editions are complete revisions of the manual. Update packages, which are issued between editions, contain additional and replacement pages to be merged into the manual by the customer. The dates on the title page change only when a new and revised edition is published.

A software and/or firmware version code may be printed before the issue data; this indicates the revision level of the software and/or firmware of this instrument at the time of the manual or update was issued. Many product updates and fixes do not require manual changes and, conversely, manual corrections may be done without accompanying product changes. Therefore, do not expect a one to one correspondence between product updates and manual updates.

The total number of pages in this manual is 148.

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RECORD OF CHANGES

Edition	Effective	Description
3	February 96	Firmware version 6.17 through 6.30
4	January 00	Firmware version 6.37

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Chapter
1

Introduction to the ADFM Velocity Profiler™

1-1 Overview

This technical manual is intended to be the detailed reference for the ADFM Velocity Profiler™ (ADFM), using the firmware version listed on the title page. This manual contains information on ADFM setup, operation, data retrieval, maintenance, testing, and troubleshooting.

1-2 Getting Started

Please take the time to read these instructions. We have tried to make the ADFM and it's manual easy to use. Before using the ADFM to collect real data:

- Page through this manual to become familiar with its contents;
- Familiarize yourself with ADFM components by looking at diagrams;
- Use Chapter 2 to install, connect, test, and deploy the ADFM;
- Use Chapter 3 to issue software commands and begin collecting data;
- Use Chapter 4 as a maintenance and troubleshooting guide;
- Use Appendices for additional reference.

If you have questions pertaining to a specific ADFM system installed, please have the following information on hand before contacting us:

Serial # of Electronics Unit and Transducer:	Technical Support will need to know the serial number to obtain the system's configuration before they can help you.
Contents of the WinADFM configuration file:	We need to know the setup of the ADFM, and site details.
A detailed description of the problem:	Try to answer what happened and when it happened. What were the circumstances leading to the problem. Be as detailed as possible.

1-3 General Operation

Before applying mains power, verify that the power entry module voltage selection matches the available line voltage, the correct fuse is installed, and safety precautions are taken.

1-3.1 General Warnings and Cautions

This section contains a list of items you should be aware of every time you use your ADFM. *Please refer to this list often.*

- Before mains power is supplied to the ADFM, the protective earth (ground) terminal of the instrument must be connected to the protective conductor of the mains power cord. The mains plug shall only be inserted in a socket outlet provided with a protective earth contact. The protective action must not be negated by the use of an extension cord (power cable) without a protective conductor (grounding). Grounding one conductor of a two-conductor outlet is not sufficient protection.
- Servicing instructions are for use by service-trained personnel. To avoid dangerous electric shock, do not perform any service unless qualified to do so.
- If this instrument is to be supplied via an auto-transformer, make sure the common terminal is connected to the earth terminal of the power source.
- Any interruption of the earthing (grounding) conductor, inside or outside the instrument, or disconnecting the protective earth terminal will cause a potential shock hazard that could result in personal injury.

- Only fuses with the required rated current, voltage, and specified type should be used. Do not repair fuses or short circuit fuse-holders. To do so could cause a shock or fire hazard.
- Do not install substitute parts or perform any unauthorized modifications to the instrument.
- Certain test measurements described in the manual are performed with power supplied to the instrument while protective covers are removed. Energy available at many points may, if contacted, result in personal injury.
- Any maintenance and repair of the opened instrument under voltage should be avoided as much as possible, and when inevitable, should be carried out only by a skilled person who is aware of the hazards involved.
- Capacitors inside the instrument may still be charged even if the instrument has been disconnected from its source of supply.

1-4 ADFM Components Overview

Figure 1-13 illustrates the three major components of a ADFM system. Two components are installed at each site: a transducer, installed in the bottom of a pipe or channel, and its Electronics Unit, installed nearby in a non-hazardous atmosphere. These two components communicate with the third system component, a remote host IBM compatible PC computer, either via a Modem, or a serial data interface (RS-232 or RS-422).

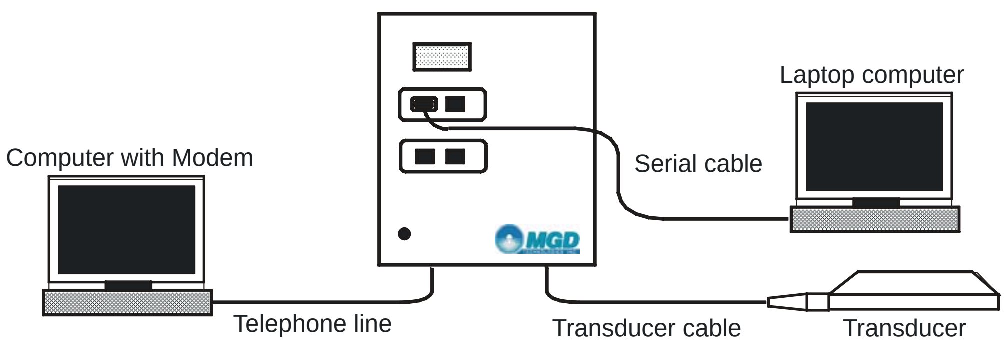

Figure 1-1. ADFM Components

To allow measurements close to the bottom of the pipe or channel and to minimize debris collection on the transducer, the ADFM transducer is designed to have a low profile. It therefore contains a minimum of required electronics. The Electronics Unit and transducer contain all circuitry and systems needed to measure directional flow, the level within the sewer pipe, to record results, and to transfer data from and to local or remote locations.

Use of a laptop computer running Windows 95 and the WinADFM software is recommended for initial setup of the ADFM on-site. Subsequent data collection and re-programming may be performed locally or remotely via modem if a telephone telemetry connection is available.

1-4.1 What is an ADFM?

The ADFM Velocity Profiler™ (ADFM) is a flow meter based on the Doppler principle. The ADFM consists of a transducer assembly mounted in the flow, a signal processing unit and an interface cable

1-4.2 Principles of Operation

Figure 1-24 shows a typical ADFM installation for measuring open channel flow in a pipe. A transducer assembly is mounted on the invert of a pipe or channel. Piezoelectric ceramics emit short pulses along narrow acoustic beams pointing in different directions. Echoes of these pulses are backscattered from material suspended in the flow. As this material has motion relative to the transducer, the echoes are Doppler shifted in frequency. Measurement of this frequency enables the calculation of the flow speed. A fifth ceramic mounted in the center of the transducer assembly, and aimed vertically, is used to measure the depth.

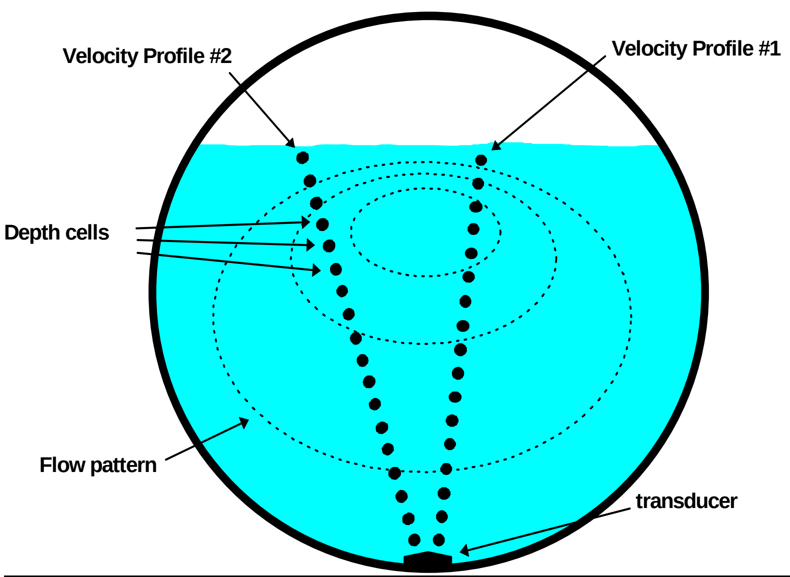

Figure 1-2. Typical ADFM installation

The ADFM divides the return signal into discrete regular intervals that correspond to different depths in the flow. Velocity is calculated from the frequency shift measured in each interval. The result is a profile, or linear distribution of velocities, along the direction of the beam. Each of the small black circles in Figure 1-24 represent an individual velocity measurement in a small volume known as a depth cell.

The directions of the velocity profiles in Figure 1-24 are based on the geometry of the ADFM's transducer assembly. Figure 1-35 shows a side view of the transducer assembly. The profiles shown in Figure 1-24 are generated from velocity data measured by an upstream and downstream beam pair. The data from one beam pair are averaged to generate Profile #1, and a beam pair on the opposite side of the transducer assembly generates Profile #2.

Since Doppler measurements are directional, only the component of velocity along the direction of transmit and receive is measured, as shown in Figure 1-35. Narrow acoustic beams are required to accurately determine the horizontal velocity from the measured component. The narrow acoustic beams of the ADFM insure that this measurement is accurate. Also, the range-gate times are short and the depth cells occupy a small volume - cylinders approximately 5 centimeters (2 inches) long and 5 centimeters (2 inches) in diameter. This insures that the velocity measurements are truly representative of that portion of the flow. Potential bias in the return energy spectrum due to range dependent variables is avoided. The result is a very precise measurement of the vertical and transverse distribution of flow velocities.

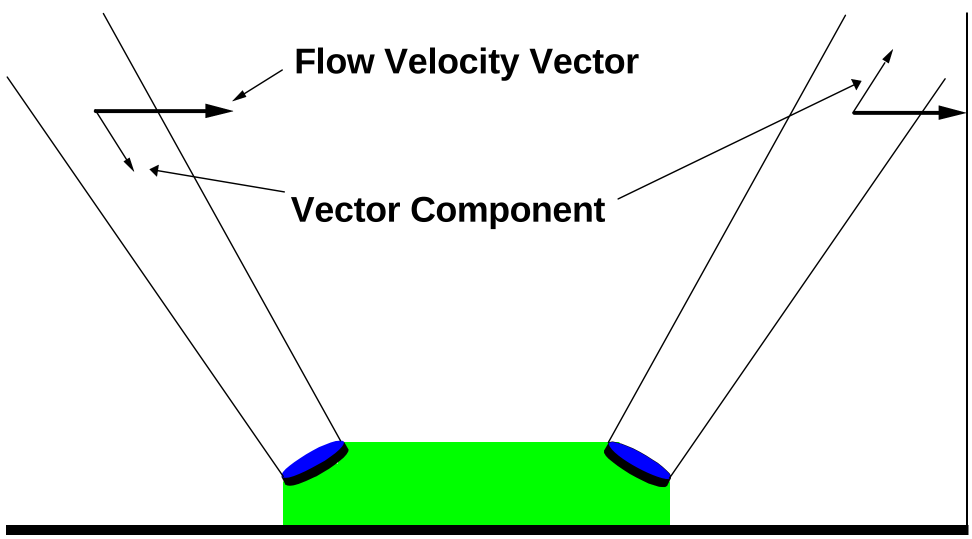

Figure 1-3. ADFM Beam Geometry

The velocity data from the two profiles are entered into an algorithm to determine a mathematical description of the flow velocities throughout the entire cross-section of the flow. The algorithm fits the basis functions of a parametric model to the actual data. The result predicts flow velocities at all points throughout the flow. These results are integrated over the cross-sectional area to determine the discharge.

The key benefit to this approach is that the system will operate accurately under different hydraulic conditions. As hydraulic conditions change, the change will manifest itself in the distribution of velocity throughout the depth of flow. As the ADFM is measuring the velocity distribution directly, it will adapt to the changes in hydraulics, and generate a flow pattern that is representative of the new hydraulic conditions, insuring an accurate estimate of flow rate.

1-4.3 User Data Interfaces

The ADFM has three user data interfaces, which are listed in Table 1-16 below.

Table 1-1: User Data Interface Types

Type:	Description:
RS-232	Serial Data Interface, EIA standard RS-232C, used for local data communication with the ADFM. Not to be used over distances more than 15 meters. Maximum baud rate is 57600 Baud.
RS-422	Serial Data Interface, EIA standard RS-422, used for local or remote data communication over distances up to 1.2 km. Maximum Baud rate is 115 kBaud.
Modem	28800 bps Modem with data compression and error correction capabilities, used for remote data communication with the ADFM.

For a complete set of specifications for the serial data interfaces please refer to the EIA specifications. For more information on available modems, please contact MGD Technologies Inc.

Chapter 2

Equipment Setup and Installation

2-1 Introduction

This section of the manual contains information and instructions for inspection, configuration, testing, installation, and deployment of the ADFM Velocity Profiler™. Included in this section are:

- Initial inspection procedures
- Connecting the ADFM components
- Power supply options
- Built-in tests (BITs)
- Final preparations for use
- Installing and deployment
- Packing and shipping information

The general sequence of events in installing and deployment of an ADFM are:

- Prepare portable computer to be taken to installation site.
- Perform pre-installation equipment and operational checks.
- Connect the ADFM Transducer and Electronics Unit via the Transducer Cable.
- Measure channel dimensions and determine geometry.
- Setup ADFM configuration file for each installation site.
- Install the ADFM transducer and electronics unit, conduct final testing.
- Program desired data logging parameters into the ADFM.
- Connect phone line to ADFM Modem port, if required.

2-2 Initial Inspection

On receipt, inspect the shipping container for damage. If shipping container or cushioning material is damaged, it should be kept until the contents of the shipment have been checked for completeness and the system has been checked both mechanically and electrically. If the contents are incomplete, if there is evidence of mechanical damage or defects, or if the system indicates a failure in some component during the initial testing procedure, please notify MGD Technologies Inc. as soon as possible. If the shipping container is damaged, or the cushioning material shows signs of stress, notify the carrier as well as MGD Technologies Inc. Keep the shipping materials for the carrier's inspection.

2-3 System Interconnection

Use Figure 2-12 to connect the ADFM cables and the computer.

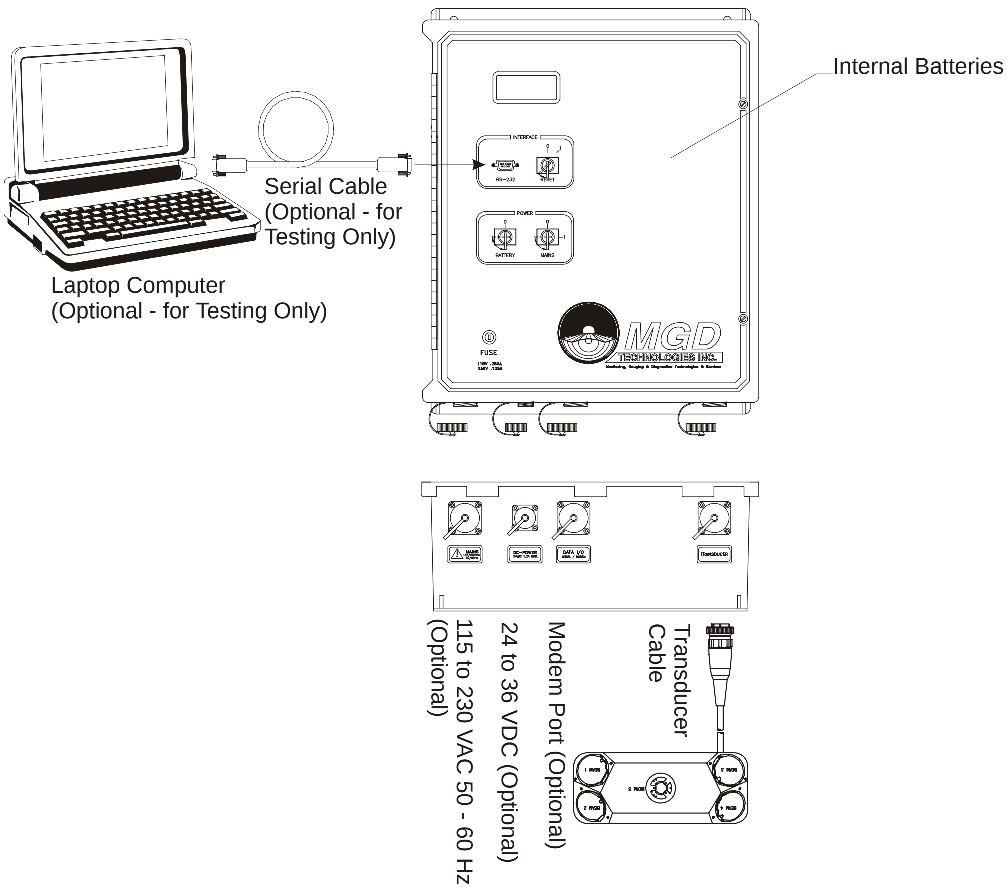

Figure 2-1. ADFM System Interconnection

2-3.1 Connecting the Transducer Cable to the Electronics Unit

The transducer cable is a multi-pair, multi-shielded cable designed specifically for use with the ADFM. The standard cable length is 15 meters (49 feet), but other cable lengths are available. Contact MGD Technologies Inc. for details. Extension cables are not recommended due to EMI/RFI constraints.

⚠ **CAUTION.** Use caution when mating or unmating the transducer cable to the transducer assembly and Electronics Unit to avoid damage to the connector hardware. UNDER ALL CIRCUMSTANCES, THE INTRUSION OF WATER OR ANY OTHER FOREIGN MATTER INTO THE CONNECTOR CONTACT AREA MUST BE AVOIDED, SINCE THIS MAY RESULT IN PERMANENT DAMAGE TO THE CONNECTOR AND MAY RENDER THE ADFM INOPERABLE.

The transducer cable connects to the electronics unit using a 14-position keyed connector. The receptacle on the electronics unit is located on the bottom right side of the unit.

To make the connection, remove the blank cap from the receptacle on the electronics unit. Insert the cable connector into the receptacle, rotating it until the keyed portions are properly aligned. Thread the coupling ring onto the receptacle to complete the connection. Reverse this procedure when disconnecting the cable from the electronics unit.

2-3.2 Power Supply to the ADFM

⚠ **CAUTION.** BEFORE connecting mains (AC) power to this instrument, be sure the line voltage selector jumpers inside the Electronics Unit is set properly and the correct fuse is installed.

Power Supply Options

The ADFM is designed to operate from one of three independent power sources: internal batteries, external DC power supply, or external AC power supply. All sources may be used concurrently; the source that supplies the highest voltage will automatically supply power to the system. Mains (AC) power is converted to a DC supply of approximately 28-30 VDC after rectification and filtering inside the ADFM. By combining external mains power with internal batteries, one can obtain uninterrupted operation of the ADFM during brief power outages. Both front panel power switches must be in the “On” position for this to occur.

Two internal battery options are available for the ADFM. The standard configuration consists of four 6-volt alkaline lantern batteries with spring terminals. Recommended alkaline batteries are the Eveready Energizer, Model EN529. These alkaline batteries have approximately 2.5 times the power/life of the lead-acid type. An optional conversion kit for using two (2) 12-volt, 7-amp hour sealed lead-acid gel cell batteries is also available.

The ADFM will operate from an external DC power supply of 12 to 35 volts, with a power consumption of 3 watts maximum. A supply voltage of 24 to 35 VDC is recommended to allow operation from the internal batteries when the external power supply is interrupted. Operation from external mains (AC) power requires a power source of 115 or 230 VAC, ±10%; 50 to 60 Hz, with a power consumption of 5 VA maximum.

Line Voltage Selection

The ADFM should be delivered pre-configured for the proper voltage. The current configuration will be indicated by a sticker on the exterior of the Electronics Unit adjacent to the AC input connector. Before applying mains power, verify that the ADFM is configured for the correct line voltage. If the ADFM is configured for the wrong voltage, please contact MGD Technologies Inc. for instructions.

Mains (AC) Power Cable

> **CAUTION.** BEFORE CONNECTING THIS INSTRUMENT TO MAINS, the protective earth (ground) terminal of the instrument must be connected to the protective conductor of the mains power cord. The mains power cable must be connected to a protective earth contact. The protective action must not be negated by use of an extension cord (power cable) without a protective conductor (grounding). Grounding a two-conductor outlet does not provide an instrument ground.

This instrument is provided with a three-conductor power cable for mains supply. When connected to an appropriate power outlet, this cable grounds the instrument unit. The mains power supply cable normally ships as a pigtail assembly for field wiring to the mains power supply. The connector on the cable mates with the left-most receptacle on the ADFM, and that is the only receptacle it will mate with. Wiring assignments for the mains power cable are as follows:

	Pin	Color	Function
(L)	1	Brown	Line
(N)	2	Blue	Neutral
(PE)	3	Green	Protective Earth

DC Power Supply Cable

This instrument is provided with a two-conductor cable for DC power supply. This cable provides no grounding. The DC power supply cable normally ships as a pigtail assembly for field wiring to the DC power supply.

The power supply cable mates with the smallest connector on the ADFM. Wiring assignments for the power cable are as follows:

	Pin	Color	Function
(+)	1	Red	+ DC
(-)	4	Black	- DC

2-3.3 Applying Power

Two key switches on the inner front panel control power to the ADFM. A third momentary key switch provides a reset function. Ensure that both power switches are in the “off” position, and the reset switch is not held in the “reset” position. Connect the appropriate power supply cables to the ADFM and the power source, if required. Ensure that the batteries are securely mounted in the ADFM and that the battery supply wiring harness is attached. Use the supplied switch-key to switch the appropriate power source switch(es) to the On-position, indicated by “1”; this will power-up the ADFM. If you intend to use both mains and battery power, ensure that both switches are on.

2-4 Built In Tests (BITs)

When power is first applied to the ADFM, an internal self-test will automatically be performed. Result messages will scroll on the LCD display, culminating in a display showing the ADFM firmware version number on the first line and a hexadecimal-coded error map on the second line. The software used to operate the ADFM will periodically report and reset the error code map, and to re-run selected tests. By interpretation and further fault isolation, it is possible to isolate a hardware problem to a least replaceable assembly (LRA) level. For a list of LRAs refer to Chapter 4-Table 4-1, page 4-6: List of Least Replaceable Assemblies.

2-4.1 Testing Interval

Routine execution of the built-in tests is not required during normal system operation. Execution of selected built-in tests from software is recommended quarterly or at each battery change, whichever is more frequent. The built-in tests should also be performed whenever a hardware problem with the ADFM is suspected. See Chapter 3 and the software manual for further details.

2-4.2 Test Record

The WinADFM software by default will create a log containing details of all ADFM operations, including the status of the error code map and the results of all built-in tests. No further test record is required unless specifically requested by Technical Support Personnel.

2-4.3 Power-UP BIT Procedure/Sequence

a. Switch power to the ADFM off.

b. Switch power on again; however, make sure at least ten minutes have passed since all power was switched off. The ADFM's LCD display should show firmware version and error code map followed by the "wake up message":

```
RD Instruments:
-------------------
Acoustic Doppler
Flow Meter
```

c. The ADFM's LCD display should begin displaying the results of the power-up BIT, as these tests are executed. The power-up BIT tests will take approximately one or two minutes to perform after which the LCD display will show the firmware version and BIT error code map (see Chapter 5 for details):

```
ADFM  Ver.    V6.xx
09000080
```

d. To repeat the power-up BIT tests you may turn and release the Reset key switch, located on the front panel of the Electronics Unit.

2-5 Final Preparations for Use

2-5.1 Measure Pipe or Channel Geometry

In order for the ADFM to measure flow accurately, it must have information about the pipe or channel in which it is installed. Refer to Figure 2-27 for a diagram of the channel geometries directly supported by the ADFM. The pipe/channel shape must be symmetrical about the vertical centerline. Application of the ADFM in pipes or channels of other geometries may be possible. Please contact MGD Technologies Inc. with specific details of your application for further information.

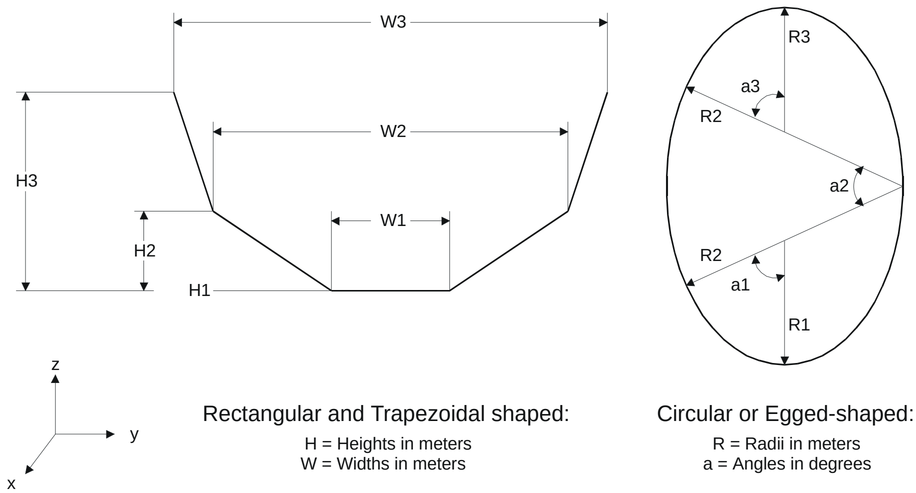

Figure 2-2. Pipe Geometry and Parameters

During installation, the following parameters need to be recorded, as they are needed by the software to estimate discharge:

- Cross-sectional geometry: For rectangular channels, the width (W) and the height (H) need to be recorded. For circular pipes/channels the, radii (R) and angles (a) need to be recorded. These parameters will be entered into software and used to estimate discharge. Note that for a circular channel only the Diameter (D) needs to be recorded.
- Normal distance from the surface of the transducer fifth beam to the invert of the pipe: Enter these dimensions into the “Zero Offset” box in the WinADFM setup screen.
- Level of silt in the pipe or channel should be entered into the “Bed Level” box in the WinADFM setup screen.

2-5.2 Prepare Installation Hardware

Installation hardware is available from MGD Technologies Inc. for a variety of channel shapes and sizes. Please contact MGD Technologies Inc. for further information, or if you desire assistance in applying the ADFM to your specific situation.

The ADFM transducer assembly includes three drilled and tapped mounting holes. To avoid damage to the transducer assembly and ceramics, these holes are the only locations that should be used to mount the transducer assembly to the installation hardware. These mounting holes are drilled and tapped for a metric size machine screw, size M6-1.0. Inserts are available to convert the existing holes from metric M6 to metric M3 and US standard #6-32 size threads.

Installation of the ADFM transducer assembly must also comply with the following parameters to maintain the accuracy of the final installation:

- Transducer must be installed in such a way that the vertical beam (beam 5) is oriented normal with respect to the pipe's or channel's invert. Note that the vertical beam is normal to the transducer's top surface.
- Transducer must not be rotated about the vertical Z-axis. A sighting device or similar should be used to minimize rotational misalignment.
- Transducer must be installed such that positive longitudinal flow direction is from the "non-cable" side of the transducer to the "cable" side. See Figure 2-38 below for further explanation of the flow direction.

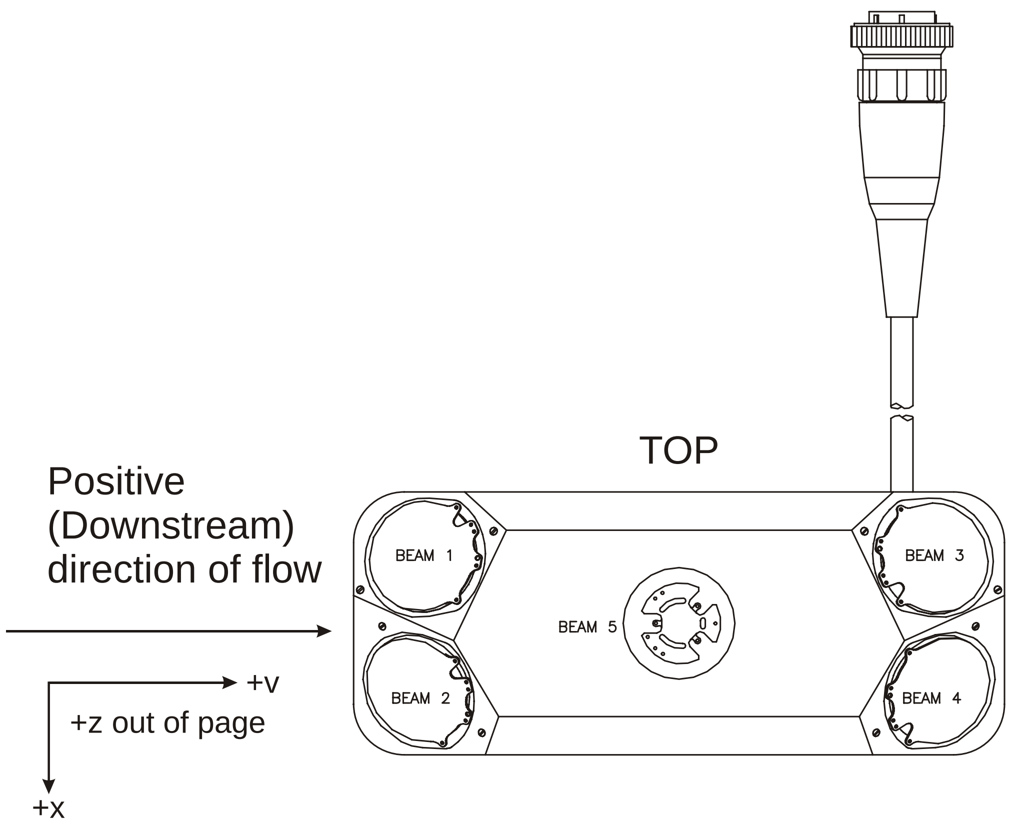

Figure 2-3. Transducer Orientation

2-5.3 Install Software and Configure Station File

Before the ADFM can be used in a specific application, it must be programmed for that application. This is most easily done using the WinADFM software. See Chapter 3 and the Software Manual for further details.

2-5.4 Installing and Deploying the ADFM

Detailed procedures for installing the ADFM in a specific application cannot be provided without detailed knowledge of the application. Please contact MGD Technologies Inc. if you desire information or assistance in your application. “Deployment” refers to the programming of an ADFM with the site, channel, profiling, and data logging characteristics desired at the site. Deployment is discussed in more detail in Chapter 3 and the software manual.

2-6 Packaging and Shipping the ADFM

Clean the Electronics Unit and transducer assembly with mild soap and water prior to packaging and shipment. **DO NOT** use abrasive agents or solvents as they will damage these surfaces. **MILD** chlorine bleach solutions may be used if odors persist or if disinfection of the unit is desired. Use caution to prevent water from entering the Electronics Unit housing while cleaning. Ensure that the unit is completely dry prior to packaging and shipment to avoid corrosion or other damage during shipment. The ADFM may be shipped with batteries installed, however, all key switches should be in the “off” position for shipment. Removal of batteries from the unit may be desirable to reduce the shipping weight.

2-6.1 Tagging For Service

If the instrument is to be shipped to MGD Technologies Inc. for service or repair, attach a tag to the instrument identifying the owner, address of owner, complete instrument model and serial number, and a description of the service required. Mark the container FRAGILE to ensure careful handling. In any correspondence, refer to the system by model and full serial number.

2-6.2 Packaging

The original factory packaging material should be stored for reuse in the event it becomes necessary to transport the ADFM. If the original packaging material is unavailable or unserviceable, materials identical or equivalent to those used in factory packaging are available through MGD Technologies Inc.

For repackaging with commercially available materials follow these instructions:

- Wrap Electronics Unit and transducer assembly separately in bubble wrap or other cushioning material.
- Use strong shipping container suitable for the weight of the ADFM. Shipping containers made of wood or plastic are prefer-

able, but corrugated shipping boxes of at least 200-lb. test may be used.

- Use a layer of shock-absorbing materiel, at least 25 mm (1 in) thick around all sides of the Electronics Unit and transducer assembly to firmly cushion and prevent movement inside the container. Special care must be taken to protect the transducer ceramics on the upper face of the transducer assembly from damage.
- Seal shipping container securely.
- Mark shipping container FRAGILE to ensure careful handling.
- In any correspondence, refer to system by model number and serial number.

Chapter
3

Software Operation

3-1 Introduction

The primary tool used to program, deploy, and operate the ADFM is the software program WinADFM. Additional utility programs are available if required for specific functions, however, their use is not required in normal operation. Most of these utilities are engineering tools used during development and testing of the ADFM. However, if you are experiencing a specific problem with an ADFM or data, you may be provided with one of these utilities and instructions for its use.

3-2 Computer Requirements

The following are requirements for the computer(s) used to interface with the ADFM.

Minimum Requirements:

- IBM Compatible 486 processor or better
- Windows 95
- VGA color or better display monitor
- Hard Drive (minimum 50 MB free disk space)
- Hard Drive data backup method
- 3.5" Floppy Drive
- Serial Port (1)
- Modem (telemetered sites only)

Suggestions:

- IBM Compatible Pentium processor
- Hard Drive (500 megabytes or larger capacity with fast access)
- Zip Drive (or other hard drive data backup system)
- Mouse

3-3 WinADFM

WinADFM is the recommended program for operating the ADFM. Please refer to the separate software manual for further information.

3-3.1 Related Files

ADFM Station File (“<siteid>.stn”)

This file contains the configuration information for a particular monitoring location. See the WinADFM software manual for further information.

ADFM Log File (“<siteid>.log”)

This is an ASCII file containing the results of all logged WinADFM operations for a particular site. See the WinADFM software manual for further information.

ADFM Chart Settings (“<siteid>.ch1”, “<siteid>.ch2”, “<siteid>.ch3”)

These files contain the chart settings for a particular site. See the WinADFM software manual for further information.

ADFM Group File (“<groupname>.sgr”)

This file contains a listing of ADFM station files contained within a group. See the WinADFM software manual for further information.

ADFM Data Files ("###MDDHH.xxx”) (downloaded from internal recorder):

Binary data files containing raw data ensembles as recorded by the ADFM and downloaded by software to a computer. The naming convention is as follows:

###MDDHH.xxx	###	ADFM serial number (labeled on rear of ADFM electronics chassis)
	M	Month data was downloaded (1=Jan,...,9=Sep, A=Oct, B=Nov, C=Dec)
	DD	Day of month data was downloaded from ADFM recorder
	HH	Hour of day data was downloaded from ADFM recorder (00 to 23)
	xxx	ADFM recorder deployment number (001 to 999)

Example:

102A1214.001	102	*ADFM* serial number *102*
	A	Downloaded from recorder on *October*
	12	Downloaded from recorder on October *12*
	14	Downloaded from recorder on October 12 at *2 PM*
	001	*Deployment* number *001* on ADFM recorder

ADFM Data Files ("rtYYMMDD.xxx") (data collected in real time):

Binary data files containing data measured by the ADFM and collected by software on a computer as the measurement occured. The naming convention is as follows:

rtYYMMDD.xxx	rt	Identifier for "Real Time" data
	YY	Year data was collected from ADFM
	MM	Month data was collected from ADFM
	DD	Day of month data was collected from ADFM
	xxx	Sequential real time data set collected

Example:

rt970206.003	rt	*Real time data*
	97	Data collected in 1997
	02	Data collected in February
	06	Data collected on the 6^{th} of the month
	003	The third real time data set of the day for this site

CSV (Comma Separated Value) Data File (###MDDHH_xxx.CSV")

Data files containing ADFM data converted to Comma Separated ASCII values for Date/Time, Depth, Velocity, and flow rate.

3-4 Using BBTALK

BBTALK is a dumb terminal emulator program. This IBM-compatible program can capture raw data files and help troubleshoot configuration problems. You can use *BBTALK* for serial or parallel communications in either an ASCII or BINARY mode. A binary-to-hexadecimal conversion feature lets you view and record the binary output data in a hexadecimal format. A LOG feature lets you record data to a disk file.

3-4.1 Running BBTALK

Access the drive/directory containing the *BBTALK* program. Type `BBTALK` at the DOS prompt. The program will load, and a blank communications screen will appear with the following menu at the bottom of the screen.

```
F1-? F2-Script F3-Log F4-ASCII F5- COM1:  9600,N,8,1 F6-Save END-BRK AltX-Exit
```

Figure 3-1. BBTALK Menu

3-4.2 BBTALK Help

BBTALK has a built-in help screen.

- Press `F1` at any time to display *BBTALK's* help menu.
- Press any key when done.

```
══════════ BBTALK v2.25 Help Screen ══════════
  Copyright (c) 1994-1995, RD Instruments
           All rights reserved.
 F1 - This screen
 F2 - Run script file
 F3 - Toggle logging data stream to disk
 F4 - Toggle HEX and ASCII display
 F5 - Setup serial port
                  ↑/↓ - Select Parameter
   <Space> or <Enter> - Change Setting
                <Esc> - Accept entry
 F6 - Save serial port configuration
 F8 - Clear data screen
 Alt-Fx - Run script file "ALT-Fx.SCR"
 <Ctrl-PgDn> - YModem Receive
       <End> - Send BREAK
                      ASCII Data
       COLORS:         HEX Data
                Communications Error
              AltX - Exit BBTALK
══════════ Press any key to continue ══════════
```

Figure 3-2. BBTALK Help Screen

3-4.3 Wakeup the ADFM

Wakeup is the process of establishing communication with the ADFM. Immediately after you apply power to the ADFM, it enters the STANDBY mode. Sending a BREAK signal from a terminal/program awakens the ADFM. When the ADFM receives a BREAK signal, it responds with the wake-up message. The ADFM is now ready to accept commands at the “>” prompt from either a terminal or computer program. Press End to send the wakeup command (BREAK) to the ADFM.

The ADFM wake-up (copyright) message should appear.

```
Broadband ADFM Version x.xx
RD Instruments (c) 1996-1998
All rights reserved.
>
```

If there is no response from the ADFM, check the communications setup in the SETUP MENU and the ADFM. Both setups must be the same.

NOTE. If the Caps Lock, Num Lock, or Scroll Lock keys are activated, this may interfere with the ability to send a valid Break signal when pushing the END key.

3-4.4 Communication Parameters

This menu sets the communications protocol between the ADFM and the computer.

a. Press F5 to view the SETUP MENU.

b. Use the Up/Down arrow keys to select the parameter to change.

c. Use the Enter or Space keys to change the parameter.

d. Press Escape to exit the SETUP MENU.

e. To permanently save this setup to the BBTALK.PTR configuration file, press F6. The configuration file is saved to the directory where *BBTALK* resides.

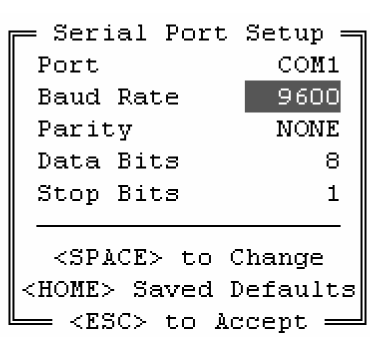

Figure 3-3. BBTALK Communication Setup Menu

3-4.5 BBTALK LOG Files

The LOG feature lets you record data to a disk file. You name the file (DOS convention) by pressing the F3 key. You can enable logging at any time. The help line shows the CAPTURE status. To use LOG, do the following steps.

a. Press F3 to enable the LOG function.

b. Enter the DRIVE (if other than current drive) and FILENAME.EXT. For example, type C:\ADFM\SAMPLE.TXT.

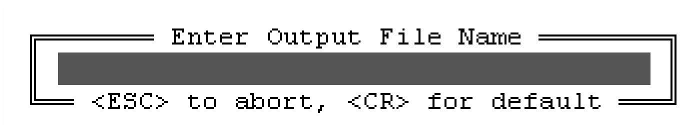

Figure 3-4. BBTALK Log File

c. If the file already exists, the program asks you if you want to overwrite the existing file.

d. All data sent to the screen will now be written to the file you specified. You can enable the CAPTURE feature at any time, even if the ADFM is already sending data.

e. To disable CAPTURE, press F3, and then press Enter without entering a file name.

NOTE. When a high baud rate is being used, LOG may lose some data.

Chapter 4

Maintenance

4-1 Introduction

This chapter describes basic maintenance requirements for the ADFM.

- How to replace or recharge the desiccant
- How to replace and recharge the system batteries
- How to change fuses
- How to change the mains supply voltage selection

CAUTION. Never open the Electronics Housing inside a corrosive atmosphere. Severe damage to the PCBs can occur. Damage may not appear right away, but will shorten the lifespan of all internal components.

4-2 Desiccant

Desiccant is used to dehumidify the electronics housing interior. The factory-supplied desiccant lasts a year. Remember that desiccant rapidly absorbs moisture from ambient room air.

Used desiccant bags may be dried at 250° for 14 hours. As a minimum, replace the desiccant bags (Table 4-16, item 08) whenever the electronics housing is opened, or you are preparing to deploy or store the ADFM for an extended time.

CAUTION. Do not open the desiccant bag. Contact with the silica gel can cause nose, throat, and skin irritation.

NOTE. Desiccant bags are shipped in an airtight aluminum bag to ensure maximum effectiveness. There is a moisture indicator inside the bag. If the moisture indicator is pink, do not use the desiccant bag until it has been dried. MGD recommends replacing the desiccant bag just before the deployment.

a. In a non-corrosive atmosphere, remove the top of the unit.

b. Unscrew the two screws securing the housing cover and open the cover.

c. The desiccant bag holder is attached to the front panel with cable ties. Remove the ties and replace the desiccant.

d. Use cable ties to attach the desiccant holder to the front panel.

4-3 Battery Replacement

The Electronics Unit contains two types of batteries: the system (alkaline lantern or lead acid) batteries and the real-time clock back-up battery.

> ⚠ **CAUTION.** Before attempting to replace existing batteries, be sure that mains power source is disconnected. It is advised that only qualified personnel attempt this replacement procedure.

4-3.1 Replacing the Alkaline Lantern System Batteries

The ADFM's internal batteries use four 6-volt alkaline lantern type batteries with a nominal capacity of 13 Ah each (see Table 4-16, item 03). The nominal voltage is 24V for all batteries connected in series, while the low voltage is 20V. They are also commonly available. MGD recommends purchasing spare Energizer™ alkaline lantern batteries.

> ⚠ **CAUTION.** If the Electronics Unit is connected to a mains power, for your own personal safety we recommend that you disconnect mains first before opening the Electronics Unit housing.

a. In a non-corrosive atmosphere, remove the top of the unit.

b. Unscrew the two screws securing the housing cover and open the cover.

c. Remove the battery cover by removing the four screws

d. Replace all four batteries with new batteries.

e. Replace the battery cover.

f. Test the system (see Chapter 5).

> ⚠ **CAUTION.** Do not short out battery leads when removing the batteries. High currents may flow during shorts, and fire or personal injury may result. THERE IS NO FUSE IN SERIES WITH THESE BATTERIES!

4-3.2 Replacing the Lead-Acid System Batteries

The ADFM's internal batteries are two sealed lead-acid type batteries, with a nominal capacity of 7 Ah each (see Table 4-16, item 04). The nominal voltage is 24V for both batteries connected in series, while the low voltage is 20V. These batteries can be re-charged (see below). They are also commonly available. MGD recommends purchasing spare batteries. That way, when the time comes to change the internal batteries, fully charged batteries can be quickly installed and the drained batteries can be taken to be re-charged.

> **CAUTION.** If the Electronics Unit is connected to a mains power, for your own personal safety we recommend that you disconnect mains first before opening the Electronics Unit housing.

a. In a non-corrosive atmosphere, remove the top of the unit.

b. Unscrew the two screws securing the housing cover and open the cover.

c. Unscrew the bolts securing metal bar and remove bar.

d. Disconnect the harness and reconnect new batteries.

e. Replace the metal bar and bolts.

f. Test the system (see Chapter 5).

> **CAUTION.** Do not short out battery leads when removing the batteries. High currents may flow during shorts, and fire or personal injury may result. THERE IS NO FUSE IN SERIES WITH THESE BATTERIES!

4-3.3 Recharging The Lead-Acid System Batteries

To recharge batteries, follow the instructions below.

> **NOTE.** Recommended charge is 1/20 of the rated capacity, which will maximize battery life and capacity.

The maximum charging current per manufacturer specification for these types of batteries is 3A at 20°C. For a 12-volt battery the charging voltage is 14.1 volts to 15.0 volts maximum. Please contact the specific battery manufacturer for more details if required. Longer battery life and higher capacity results if you charge batteries at a more moderate charging current rate. In general, a charging current of 1/20 of the rated capacity is recommended, which results in 0.6A for these batteries.

4-3.4 Replacing The Real Time Clock Backup Battery

The real-time clock (RTC) is designed to keep time when the power source is turned off. The backup battery is a single 3 volt, 250 mAh Lithium coin cell, and is located near the bottom left corner of the ADFM motherboard in the electronics housing (see Table 4-16, item 05).

a. In a non-corrosive atmosphere, remove the top of the unit. Open the front panel of the Electronic Housing.

b. With a small blade non-conductive screwdriver, gently lift and slip out the coin cell.

c. Replace with a new coin cell (Panasonic PR2330, or equivalent).

d. Test the system (see Chapter 5).

4-4 Fuse Replacement

The electronics chassis contains a mains supply fuse. The fuse is located on the front panel of the Electronics Housing.

⚠	**CAUTION.** Only fuses with the required rated current, voltage, and specified type should be used. Do not repair fuses or short circuited fuse-holders. To do so could cause a shock or fire hazard.

a. Disconnect the mains power cord.

b. In a non-corrosive atmosphere, remove the top of the unit.

c. Use a blade screwdriver to open the fuse holder.

d. Pull out the blown fuse, and replace the fuse. Use only the fuse specified for the selected mains supply voltage (see Table 4-16, item 10 or 11).

e. Make sure that the fuse holder is closed before reconnecting the mains power cord.

f. Test the system (see Chapter 5).

4-5 Changing Mains Supply Voltage

If you need to change the mains supply voltage selection from 230V to 115V or vice-versa, follow the procedure below.

CAUTION. Disconnect the mains power cord before attempting to change the voltage selection. Make sure you install a fuse appropriate for the selected mains supply.

a. Disconnect the mains power cord before attempting this procedure.

b. In a non-corrosive atmosphere, remove the top of the unit.

c. Locate plug P4 on the ADFM motherboard. Use the following table to determine the correct jumpers.

Voltage Selection	Jumper
115 VAC	P4.2 to P4.5
	P4.4 to P4.6
230 VAC	P4.5 to P4.6

d. Label the electronic housing with a label indicating the proper mains supply voltage.

e. Install a fuse appropriate for the selected mains supply (see Table 4-16, item 10 or 11).

f. Re-connect the mains power cord.

g. Test the system (see Chapter 5).

4-6 Replacement Parts

Table 4-16 is a listing of ADFM replacement parts, which include the Least Replaceable Assemblies (LRA), along with other parts such as fuses etc. When practical, you may use parts procured other than through MGD, if MGD is not listed as the manufacturer of these parts, and are considered by MGD to be generic. However, these parts must be direct equivalents to the parts listed. In particular, do not replace fuses with any other type than specified, although you may use a different manufacturer.

Table 4-1: List of ADFM Replacement Parts

Item	Description	Specification	Part Number	Mfgr
01	ADFM Electronics Unit	Assembly		MGD
02	ADFM Motherboard	PCB Assembly		MGD
03	Battery, Alkaline Latern	6 V, 13 Ah		Energizer
04	Battery, Lead Acid	12 V, 12 Ah	975-2000-00	Yuasa, or Power-Sonics
05	Battery, Lithium Coin Cell	3 V, 250 mA	PR2330	Panasonic
06	Cable, Mains Power			n/a
07	Cable, RS-232 Data	DB9-M to DB9-F	971-6092-00	n/a
08	Desiccant	bag	X1220	Mil-Pac
09	Display, LCD	4 x 16 characters	L161400J000	Seiko
10	Fuse, 115 VAC mains	250 mA, 250 V per IEC127-2/III	19195-250MA	Wickmann
11	Fuse, 230 VAC mains	125 mA, 250 V per IEC127-2/III	19195-125MA	Wickmann
12	Interface Board, Front Panel	PCB Assembly		MGD
13	Interface Board, Transducer	PCB Assembly		MGD
14	Modem	PCB Assembly		MGD
15	Recorder, PCMCIA	20 Mb		MGD
16	Transducer	Assembly		MGD
17	Transducer Cable			MGD

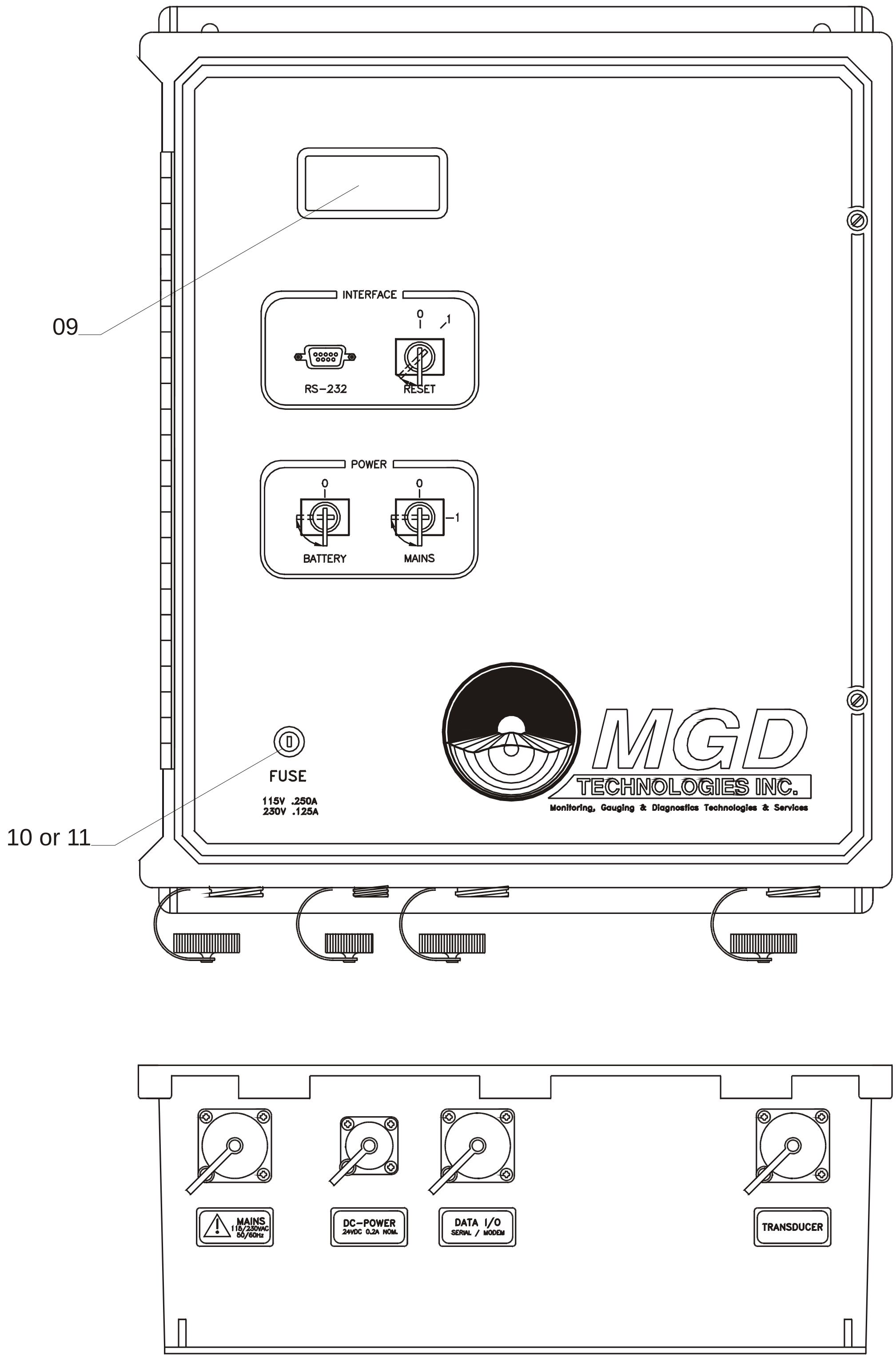

Figure 4-1. ADFM Electronic Housing (Exterior View) – Replaceable Parts Identification

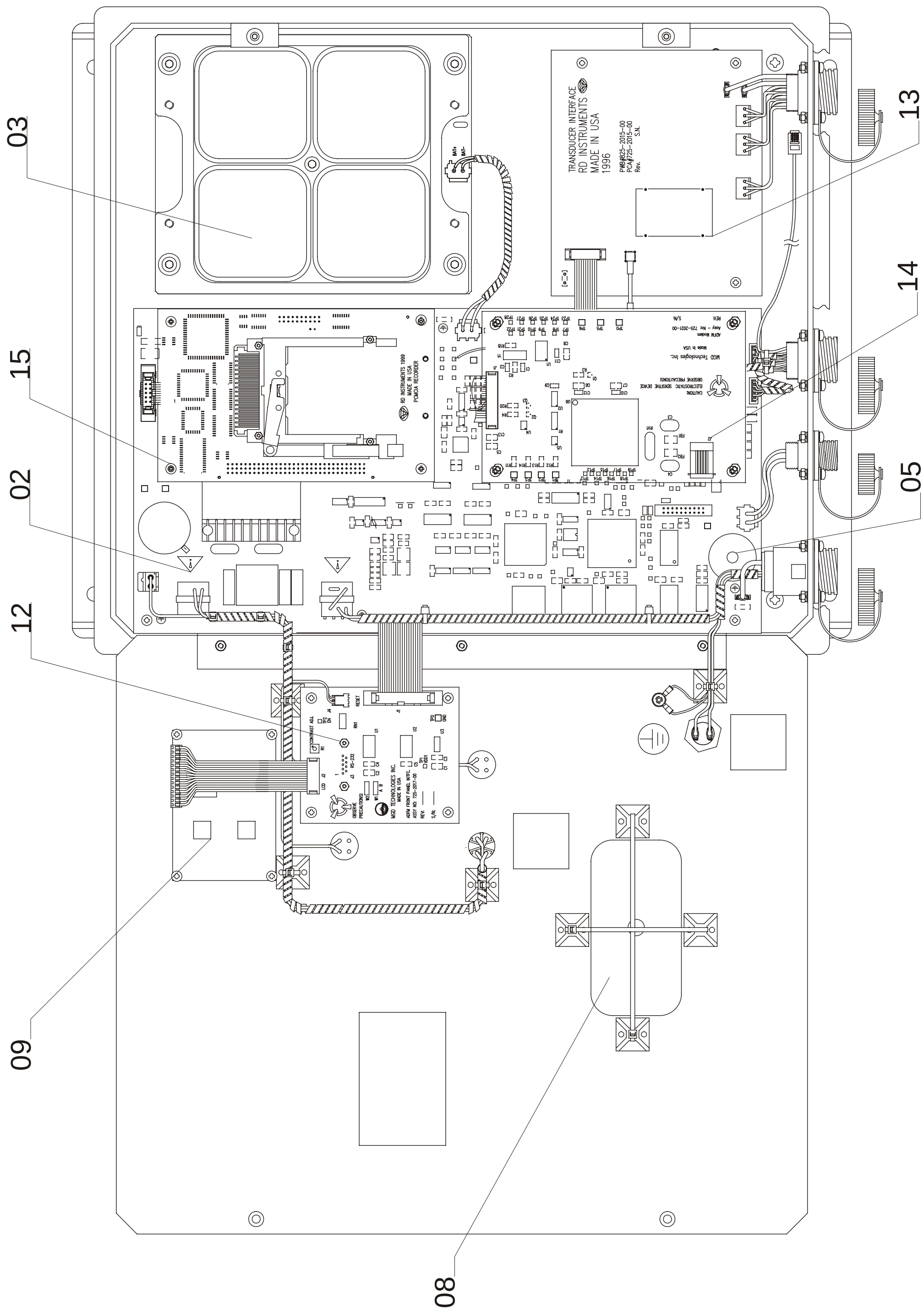

Figure 4-2. ADFM Electronic Housing (Interior View) – Replaceable Parts Identification

Chapter 5

ADFM Test Procedures

5-1 Introduction

This chapter explains how to test the ADFM using *BBTALK* and the *WinADFM* program. These tests thoroughly check the ADFM in a laboratory environment, but are no substitute for a practice deployment. You should test the ADFM:

- When you first receive the ADFM.
- Before each deployment or every six months.
- When you suspect instrument problems.
- After each deployment.

These test procedures assume all equipment is working. The tests can help you isolate problems to a major functional area of the ADFM. For trouble-shooting information, see Chapter 6.

NOTE. The built-in tests require you to immerse the transducer faces in water. If you do not, some of the tests may fail. Running the tests in air will not harm the ADFM.

5-2 Test Setup

Use the following steps to connect the ADFM system and to place the ADFM in a known state.

a. Connect a laptop computer to the RS-232 communication port.

b. Connect and apply power to the system as described in Chapter 2.

c. Place the ADFM transducer in approximately one foot of water.

5-3 Built-In Diagnostic Tests

The following describes how to execute an automatic self-test. In general, if the automatic self-test is successful, no further testing is required. However, if the automatic self-test is not successful, further fault isolation, utilizing individual Built-In Tests is necessary.

5-3.1 Automatic Built-In Test Test

The automatic Built-In Test (BIT) runs whenever the power is applied to the electronic housing or the reset button is cycled.

a. Switch power to the ADFM off.

b. Switch the power on again; however, make sure that at least one minute has passed since power was switched off. The computer screen will display [COLD Wakeup], and the ADFM's LCD display will show the "wake up message":

```
RD Instruments
-------------------
Acoustic Doppler
Flow Meter
```

c. The ADFM's LCD display will begin displaying the results of BIT as these tests are executed. The BIT tests will take approximately one or two minutes to perform after which the computer screen will display the wake up message:

```
Broadband ADFM Version 6.xx
RD Instruments © 1991-94
All rights reserved.
```

d. To repeat the BIT tests you may turn and release the Reset key switch, located at the front panel of the Electronics Unit.

e. To wake up the ADFM without performing the BIT, send a BREAK from *BBTALK*, by pressing the <END> key. The above wake up message will appear on the computer screen in approximately one second; the LCD will not display this message.

5-4 Using BBTALK to Test the ADFM

BBTALK allows you to send direct commands to the ADFM. You may use the following commands to further test the system.

5-4.1 Diagnostic Tests

The diagnostic test checks the major ADFM modules and signal paths. We recommend you run this test before a deployment. If any test fails, call MGD for further troubleshooting information.

a. Start *BBTALK*. Press the `End` key to wake the ADFM.

b. Type `CP` to clear the fault log.

c. Type `PC`. A message similar to the following should appear.

```
>pc
Transducer Communications:                   PASS
Recorder BIT (RT ):                          PASS
Modem (MO ):                                 PASS
System Voltages (PT2):                       PASS
CPU RAM (PI ):                               PASS
Timing Card RAM (PI ):                       PASS
Demodulator RAM (PI ):                       PASS
Checksum Code/Tables (PT8):                  PASS
Receive Test (PT3):                          PASS
Transmit Test (PT4):                         PASS
Electronics Wrap Test (PT5):                 PASS
LPF Bandwidth Test (PT6):                    PASS
Clock Interrupt (PI ):                       PASS
Error Log:
 Power Loss
 Auto Restart Occurred
 Transducer Communications Error
Self Tests Complete
```

Many users tell us their ADFM reports a FAIL condition during the self-tests that check the ADFM's "electronics wrap test." In most cases, the cause of the failure is external interference. A "noisy" environment, such as in a lab usually causes this external interference. You can take a few simple steps to find out if the FAIL condition is being caused by external interference or by a problem with the ADFM.

The following procedure explains how to conduct the PC test to reduce the likelihood of a false failure.

a. Turn off any nearby equipment (monitors, radios, etc.) that is not needed to conduct the test.

b. The electronic housing case should be closed to help shield the circuit boards from external electronic "noise."

c. The ADFM transducer head must be immersed in water. Ensure there are no air bubbles on the transducer faces.

d. If the transducer is immersed in a bucket of water that is resting on the floor, noise can be coupled into the ADFM. As such, you should shield the bucket from the floor by inserting a piece of hard foam between the bucket and the floor.

e. If possible, you may also want to move the ADFM to a different room, or at least to a different part of the lab to see if the fail condition goes away.

f. If after following the above procedure, your ADFM still fails the receive tests, contact MGD for assistance.

5-4.2 Receive Path Test

This test runs a through test on the ADFM's receive path electronic circuits.

a. Start *BBTALK*. Press the `End` key to wake the ADFM.

b. Type `CP` to clear the fault log.

c. Type `PT3`. A message similar to the following should appear.

```
>pt3

Correlation Magnitude:

               Lag  Bm1  Bm2  Bm3  Bm4  Bm5
                 0  255  255  255  255  255
                 1  206  212  207  206  212
                 2  103  118  107  105  119
                 3   31   47   33   33   49
                 4    4   15    9    6   16
                 5    2    3    7    3    7
                 6    2    2    9    1    5
                 7    2    2    6    1    4

  High Gain RSSI:    45   47   44   42   47

  DAC Sin:   182
  DAC Cos:   183
  Duty:       50   50,    LPF:  0

Receive Test Results = $00000000 ... PASS
```

d. Observe the High Gain RSSI values. They should be between 40 to 57 counts with the transducer connected.

e. Disconnect the transducer from the electronic housing by disconnecting the transducer cable.

f. Type `PT3`. A message similar to the following should appear.

```
>pt3

Correlation Magnitude:

               Lag  Bm1  Bm2  Bm3  Bm4  Bm5
                 0  255  255  255  255  255
                 1  192  196  198  192  194
                 2   70   75   88   76   73
                 3    9   11   27   26   11
                 4   16   15   10   26   17
                 5   12   15    6    9   13
                 6   10   11   10   15    8
                 7    9    8   10   19    7

  High Gain RSSI:    21   21   20   21   21

  DAC Sin:   186
  DAC Cos:   187
  Duty:       59   50,    LPF:  0

Receive Test Results = $00000000 ... PASS
```

g. Observe the High Gain RSSI values. They should be between 20 to 25 counts with the transducer disconnected.

h. Leave the transducer cable disconnected if you want to run the next test.

5-4.3 Transmit Test

This test runs a through test on the ADFM's transmit path electronic circuits.

a. Start *BBTALK*. Press the `End` key to wake the ADFM.

b. Type `CP` to clear the fault log.

c. Type `PT4`. A message similar to the following should appear.

```
>pt4

----------- BEAM 1 -----------
IXMT    =      3.1 Ml Amps peak
VXMT    =      4.1 Volts peak
RXMT    =   1335.6 Ohms
Transmit Test Results = $40 ... PASS
----------- BEAM 2 -----------
IXMT    =      3.1 Ml Amps peak
VXMT    =      4.1 Volts peak
RXMT    =   1335.6 Ohms
Transmit Test Results = $40 ... PASS
----------- BEAM 3 -----------
IXMT    =      3.1 Ml Amps peak
VXMT    =      4.1 Volts peak
RXMT    =   1335.6 Ohms
Transmit Test Results = $40 ... PASS
----------- BEAM 4 -----------
IXMT    =      3.1 Ml Amps peak
VXMT    =      4.1 Volts peak
```

```
RXMT    =   1335.6 Ohms
Transmit Test Results = $40 ... PASS
```

d. Observe the RXMT values. They should be above 1300 ohms with the transducer disconnected.

e. Re-connect the transducer to the electronic housing by connecting the transducer cable.

f. Type `PT4`. A message similar to the following should appear.

```
>pt4

----------- BEAM 1 -----------
IXMT    =     30.9 Ml Amps peak
VXMT    =      3.4 Volts peak
RXMT    =    109.7 Ohms
Transmit Test Results = $0 ... PASS
----------- BEAM 2 -----------
IXMT    =     30.6 Ml Amps peak
VXMT    =      3.4 Volts peak
RXMT    =    111.3 Ohms
Transmit Test Results = $0 ... PASS
----------- BEAM 3 -----------
IXMT    =     30.9 Ml Amps peak
VXMT    =      3.4 Volts peak
RXMT    =    109.7 Ohms
Transmit Test Results = $0 ... PASS
----------- BEAM 4 -----------
IXMT    =     30.9 Ml Amps peak
VXMT    =      3.4 Volts peak
RXMT    =    109.7 Ohms
Transmit Test Results = $0 ... PASS
>
```

g. Observe the RXMT values. They should be approximately 109 ohms with the transducer connected.

5-4.4 Sensor Test

This test checks the internal ADFM sensors (temperature and depth).

a. Start *BBTALK*. Press the `End` key to wake the ADFM.

b. Type `CP` to clear the fault log.

c. Type `PA1`) This command lets you view sensor data and scale factor calculations while the ADFM is operating.

```
>pa1

Press any key to quit sensor display ...

Transducer Temp   Depth(mm)
  21.47øC            0
  21.47øC            0
```

d. Verify these readings are present and correct.

5-4.5 Modem Test

This test checks the modem operation.

a. Start *BBTALK*. Press the `End` key to wake the ADFM.

b. Type `CP` to clear the fault log.

c. Type `MP1` to turn the modem power on.

d. Type `MO`.

e. Verify these readings are present and correct.

```
>mp1
>mo
Modem is OK
Modem state/connect status = COMMAND/NOT CONNECTED
Primary Port = RS-232
```

f. Type `MP0` to turn the modem power off.

g. Type `MO`.

h. Verify these readings are present and correct.

```
>mp0
>mo
Modem is NOT OK
Modem state/connect status = OFF/NOT CONNECTED
Primary Port = RS-232
>
```

5-4.6 Recorder Test

This tests the recorder — it does not destroy any data.

a. Start *BBTALK*. Press the `End` key to wake the ADFM.

b. Type `CP` to clear the fault log.

c. Type `RT`.

d. Verify these readings are present and correct for your system.

```
>rt

Recorder Message...  0  1 14  0  0

RAM --------------PASS
Cards Found ------   1
Memory Found -----  20 MB
Write/Read -------PASS
Block Copy -------PASS
Recorder NOT Erased

Recorder BIT...PASS
>
```

5-5 Using WinADFM to Test the ADFM

WinADFM can be used to test the ADFM. Figure 5-18 shows the Operate dialog window. The ADFM can be tested for proper communication, bench test the system to ensure the system electronics are operating properly, and field-test the system after it has been installed.

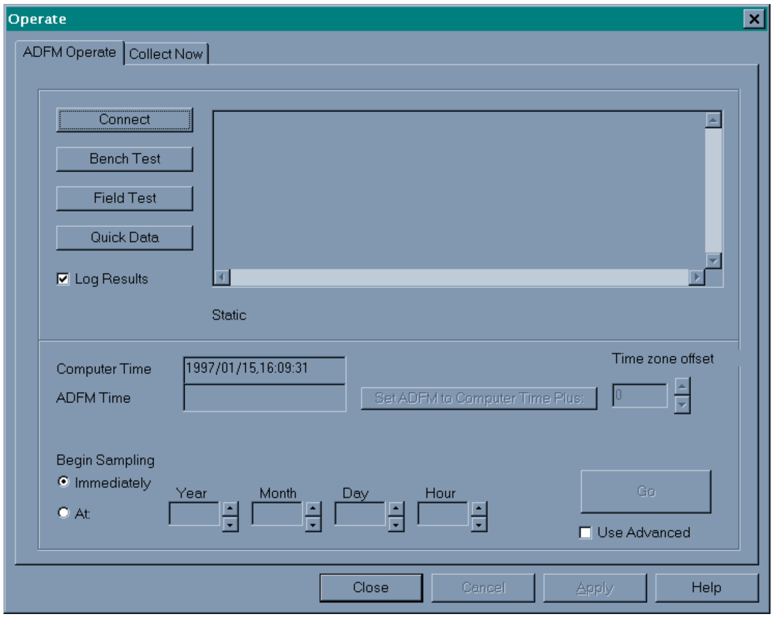

Figure 5-1. WinADFM Operate Dialog Window

The tests are listed in the top half of the window next to the output display. Results of each test are displayed in the terminal screen to the right of the buttons. Test results are recorded in the station's Log File. If checked, the log file keeps a record of all communication between the computer and the ADFM once communications have been established.

5-5.1 Connect

This test establishes communications and determines if the ADFM wake-up message contains any errors. Determines if the system is "ready". This test is for either serial (RS-232) or modem communications between the ADFM and a laptop. The system will return an error declaration (Communication Error) if communications are not obtained.

5-5.2 Bench Test

This test determines if all the required ADFM systems are present and functioning. The bench test does the following.

- Establishes communications and determines if the ADFM wake-up message contains any errors. Determines if the system is "ready".

- Lists the ADFM's serial number and the transducer and electronics firmware versions.
- Determines if an internal recorder is present. Performs a "Recorder Test" and returns an "OK" or an error declaration.
- Determines if a modem is present. Performs a "Modem Test" and returns an "OK" or an error declaration.
- Performs a "Systems Test" and returns an "OK" or an error declaration.
- Performs a Look-up Table "Checksum Test" and returns an "OK" or an error declaration.
- Determines the value of three operating voltages in the ADFM.
  - Battery Voltage,
  - VDD1 Voltage (logic),
  - Transducer Voltage.

5-5.3 Field Test

This test performs internal ADFM system checks that should be performed after installation. This test does the following.

- Establishes communications and determines if the ADFM wake-up message contains any errors. ADFM is "ready".
- Determines if the receive path is operating properly and returns a Pass or Fail with an error. This test will fail if the transducer is not connected to the electronics case.
- Determines if the transmit path is operating properly and returns a Pass or Fail with an error.
- Determines if the electronics signal-processing path is operating properly and returns a Pass or Fail with an error. This test will fail if the transducer is not underwater.

NOTES

Chapter
6

ADFM Troubleshooting

6-1 Introduction

This chapter describes how to isolate faults. The provided information below assumes that faults are isolated with a large degree of certainty to a least replaceable assembly (LRA) level only. Considering the complexity of the ADFM it is MGD Technologies Inc.'s intention to provide as much information as it seems practical for field repair. Fault isolation to the component level is beyond the scope of these instructions.

The time to repair the system in the field will be minimized if an entire replacement unit is available, that is a transducer, an Electronics Unit, and a transducer cable. For efficient field service, MGD Technologies Inc. strongly advises the availability of at least the listed LRAs, but an entire replacement system is recommended (a LRA is either a printed circuit board assembly or a entire module). LRA's are listed for completeness in Chapter 4, including the ordering numbers and other replacement parts and their ordering numbers.

Table 6-1: List of Least Replaceable Assemblies

LRA:	Description:
Front Panel Interface	Front panel interface board
LCD	The front panel LCD display unit.
Modem Interface	Modem interface board, not including the Modem.
Modem	The fax/data Modem unit.
Motherboard	The Electronics Unit motherboard.
Recorder	PCMCIA-Recorder Board.
Transducer	The entire transducer head, which includes transducer electronics, transducer housing, transducer ceramic assemblies, and cable.
ADFM Motherboard	The entire ADFM Motherboard assembly, excluding the Modem and Recorder and its associated components.

6-2 Equipment Required

Special test equipment is not needed for troubleshooting (fault isolation). A list of equipment required for the performance tests is listed below. Any equipment satisfying the critical specification listed may be used.

Table 6-2: Required Test Equipment

Required Test Equipment	Critical Specification
Digital Multi-Meter	3 ½ digit
	DC-Voltage Range: 200.0 mV, 2.000V, 20.00 V, 200 .0V
	DC-Voltage Resolution: 100 uV, 1 mV, 10 mV, 100 mV, 1 V respective
	DC-Voltage Accuracy: ± 1%
	AC-Voltage Range: 200 V, 450 V
	AC-Voltage Resolution: 10 mV @ 20 V range
	AC-Voltage Resolution: 1 V @ 450 V range
	AC-Voltage Accuracy: ± 2%
	Resistance Range: 200, 2 k, 20 k, 200 k, 20 Mohm
	Res.-Resolution: 0.1, 1.0, 10, 100, 1k, 10k respective
	Res.-Accuracy: ± 2% @ 200 Ohm to 200 kOhm
	Res.-Accuracy: ± 5% @ 20 Mohm

6-3 Power On Fault Isolation

Symptom:	**No wake up message at LCD display or computer screen.**
Possible Cause:	Power
What to Do:	Refer to “Built-in Test is Not Executing,” page 6-6.

Symptom:	**No wake up message at LCD, but computer screen displays wake up message when a BREAK is sent, or when a manual Reset is applied (Reset Switch).**
Possible Cause:	LCD. Front Panel Interface Board. Cable connection between LCD and front panel. Cable connection between Front Panel Interface Board and ADFM Motherboard. ADFM Motherboard.
What to Do:	Replace LCD. Replace Front Panel Interface Board. Replace ADFM Motherboard.

Symptom:	**No wake up message at computer screen, but LCD displays wake up message and completes BIT.**
Possible Cause:	RS-232 connection. Computer’s communications port set up wrong. Front Panel Interface Board. ADFM Motherboard.
What to Do:	Troubleshoot cabling. Run BBTEST to set up computer’s COM-port. Replace Front Panel Interface Board. Replace ADFM Motherboard.

6-4 Fault Isolation

Symptom:	**“Transducer not found”**
Possible Cause:	Transducer Cable. Transducer Cable Connector. Cabling between Motherboard and Transducer Connector of Electronics Unit. Transducer.
What to Do:	Refer to “BIT Determines a Problem Associated with the Transducer,” page 6-10.

Symptom:	**“Recorder not found”**
Possible Cause:	Recorder cable assembly. Recorder Assembly. ADFM Motherboard.
What to Do:	Check recorder cable connection to motherboard. Replace Recorder Assembly. Replace ADFM Motherboard.

Symptom:	**Recorder found but not recording data correctly.**
Possible Cause:	Recorder Assembly.
What to Do:	In BBTALK type "R?" for the recorder menu. Next type "RT" followed by a CR to perform a non-destructive recorder diagnostics test. The results should look like "0 1 14 0 0 ". The 1st, 4th, and 5th digits should be zero. A non-zero number in one of these digits indicates a failure. The 2nd digit is the number of PCMCIA cards in the recorder (1 or 2). The 3rd digit is the hexadecimal (h14=20, or ha=10) representation of the number of megabytes of recorder memory installed.

Symptom:	**"Modem Not Found"**
Possible Cause:	Modem Interface Board. Modem. ADFM Motherboard
What to Do:	Check Modem Interface Board connections to motherboard and to Modem. Replace if necessary. In BBTALK type "MT" followed by a CR. Then type "AT" followed by a CR. AN "OK" should be displayed; if not the Modem may be defective. If none of the above works the ADFM Motherboard may need replacement.

Symptom:	**Modem found but does not dial out.**
Possible Cause:	Modem. Phone Line. ADFM Motherboard.
What to Do:	In BBTALK type "MT" followed by a CR. Then type "AT" followed by a CR. AN "OK" should be displayed; if not the Modem may be defective. If successful in (2), type "ATDT1" followed by CR. If the message "No Dial Tone" appears the phone line, or phone connections may be defective. If none of the above works the ADFM Motherboard may need replacement.

Symptom:	**Ancillary Data VXDR, VDD1, and VDC are outside the range listed in section "Maintenance and Troubleshooting".**
Possible Cause:	Batteries or Power Supply. ADFM Motherboard.
What to Do:	Replace batteries. Check power supply.
	Replace Motherboard. Refer to section "Least Replaceable Assembly Fault Isolation," page 6-6, and "Power," page 6-7 for further information and trouble shooting.

Symptom:	**Transmit Test Failure**
Possible Cause:	Cabling between the Motherboard and the Electronics Unit's rear panel Transducer Connector. Transducer Cable or connectors. ADFM Motherboard.
What to Do:	Refer to section "Least Replaceable Assembly Fault Isolation," page 6-6.

Symptom:	**"Loop Test Failure". An occasional loop test failure may be normal since this is a statistical test. If the percentage of loop test failures is large (>10%) a problem may have arisen.**
Possible Cause:	Transducer not connected properly, or defective. High interference source. ADFM Motherboard.
What to Do:	Refer to section "Least Replaceable Assembly Fault Isolation," page 6-6.
	Eliminate interference source[1], or shield transducer environment. From BBTALK type "PT3" followed by a CR. The Correlation Magnitude at Lag 0 should be 255, at Lag 7 it should be typically < 20. Also, the Amplitude should be typically < 65. Otherwise it may indicate a high source of interference.
	Replace Motherboard.

Symptom:	**Any RAM Test failure.**
Possible Cause:	ADFM Motherboard.
What to Do:	Replace Motherboard.

Symptom:	**Clock Interrupt failed.**
Possible Cause:	ADFM Motherboard.
What to Do:	Replace Motherboard.

[1] It is recommended to record the values for Correlation Magnitude, Amplitude, and the results of the transmit test for later reference.

6-5 Least Replaceable Assembly Fault Isolation

The following procedure is intended to assist fault isolation in cases where:

- The Built-in-Test (BIT) can not be executed (no ADFM Wake-Up for example) or
- The BIT determines an ADFM Transducer problem

It is not necessary to follow this procedure for routine maintenance. However, the Built-In Tests may be executed on a routine basis.

CAUTION. The following servicing instructions are for use by service-trained personnel only. To avoid dangerous electric shock, do not perform any service unless qualified to do so. Please read section "GENERAL WARNINGS AND CAUTIONS" for more important information.

For the following procedure the top cover of the ADFM Electronics Unit must be removed from the chassis. This exposes the Electronics Unit's circuitry. Especially if mains power is used to power the ADFM, dangerous voltages which may cause personal injury due electrical shock are present at various location on the board, in particular where marked with a lightning bolt located inside a triangle.

CAUTION. The ADFM contains Electro Static Sensitive Devices. You must take accepted ESD prevention measures BEFORE OPENING THE ADFM ELECTRONICS UNIT.

The circuitry contains electro-static sensitive devices throughout the ADFM Electronics Unit. To prevent electro-static discharge (ESD) to these components, you must ground the Electronics Unit as well as your self. Use an ESD wrist strap (or other accepted means) to ground your self. Please keep in mind that even if an ESD has occurred the ADFM may still work, but its reliability may be seriously impaired.

6-5.1 Built-in Test is Not Executing

If the built-in test (BIT) can not be executed, most likely it is caused by one of the following:

- Faulty Communication
- No Power or a faulty ADFM power supply

Communication

If the built-in test can not be executed because of a communication problem between the host computer and the ADFM, or at any other time communication can not be established, the following procedure may help you to isolate the problem.

a. Verify that the internal or external power sources are properly connected to the ADFM, and sufficient to supply it.

b. Verify that the computer's serial port is functioning normally. With Windows 95, go to **Start**, **Settings**, **Control Panel**. Double click **System**, go to the **Device Manager** tab and select **Ports** to determine if the computer's serial port is properly operating. Verify line continuity on the RS-232 Serial Communications Cable.

c. Using *BBTALK*, located in the C:\WinADFM root directory, send a break to the ADFM using the <end> key. Make sure that the computer port is set up correctly for port setting, baud rate, parity, number of data-bits and number of stop-bits by pressing the F5 key while in *BBTALK*. The correct parameters are the COM port you are using (typically COM1), 9600, none, 8, 1. Sending a break will establish serial communications between the ADFM and the computer. The wake-up message, and a series of built-in test results should be displayed at the Electronics Unit's LCD (please refer to the self-test description in Chapter 5).

d. If remote communications can still not be established, assert a manual reset at the ADFM Electronics Unit by turning the keyed switch labeled "RESET" to the "1" position; release the switch. This should start the built-in test. The wake-up message, and a series of built-in test results should be displayed at the Electronics Unit's LCD (please refer to the self-test description in Chapter 5).

If the above procedure is not successful, one possible answer is that the Electronics Unit's motherboard is faulty, and may have to be exchanged. If all tests are successful (i.e., the computer screen produces normal, legible results), however, at no time does the LCD display showed any information, or the display was scrambled, the ADFM's LCD display or the front panel interface may be faulty, and may require replacement. It may, however, be the ADFM power supply that is at fault.

6-5.2 Power

If the built-in test can not be executed locally or remotely, nor any other type of communication is possible with the ADFM, follow the procedure below to assist you to isolate the problem.

a. If you tried to use internal batteries to power the ADFM you may alternatively try mains power or DC power if possible. If you are successful, a faulty battery switch, or its wiring most likely causes the problem. Check also the internal batteries' wiring harness for good connection at the battery terminals, and the motherboard battery connector.

NOTE. MGD Technologies Inc. recommends replacing the ADFM Electronics Unit unless the problem is obvious and can be safely repaired in the field.

b. If mains power is used for supplying the ADFM with power, check if your mains outlet has the proper voltage.

   1. Check if the Mains Power Switch at the front panel is in the On-position (“1”-position). You have to use the supplied key to rotate the switch.

   2. Check the mains fuse. The mains fuse is located on the front panel of the ADFM electronic chassis. Remove the mains power cord, and gently prey open the fuse drawer, and check the fuse.

CAUTION. Replace the fuse only with the specified fuse type, and fuse rating. Do not short circuit the fuse or fuse holder, as this presents a fire hazard. PLEASE READ THE WARNINGS AND CAUTIONS AT THE BEGINNING OF THIS MANUAL, AND THE BEGINNING OF THIS SECTION.

c. If an external DC-supply is used to supply the ADFM check if your external supply is functioning, and is able to supply the proper voltage to the ADFM. Proper DC voltage is 12 to 26 VDC. Check if the Battery Switch at the front panel is in the On-position (“1”-position). You have to use the supplied key to rotate the switch.

If the above procedure is not successful in establishing communications with the ADFM, most likely the problem lies within the ADFM’s Electronics Unit. You may have to remove the Electronics Unit’s top cover for further fault isolation.

CAUTION. You must obey all warnings and cautions regarding power and ESD. Please read these warnings at the beginning of this manual, and the beginning of this section.

Regardless of which type of power you are using you can measure the ADFM’s Electronics Unit’s internal voltages at the test points (TP) listed in Table 6-39. If you are facing the front panel, all listed test points are located at the lower left corner of the ADFM motherboard. Also the test/reset switch labeled “S1” is located at these test points.

d. Once you applied power to the system and switched the appropriate power switch into the On-position (“1”-position), you should be able to measure the unregulated (raw) supply voltage VPWR+ at test point TP7. If you are able to measure VPWR+, the power supply connection is OK. You should be able to measure this voltage regardless which type of power you are using, or regardless of any combination of power you are using.

e. You also should be able to measure VDD2 and VDD3 at test point TP2 and TP3 respective.

f. Depress, and release switch S1, and measure the remaining listed voltages.

Table 6-3: List of Test Points

Test Point:	Label:	Description:	Voltage:
TP0	GND	Electrical Ground	0 V
TP1	VDD1	Main supply of electronics	5.0 ± 0.15 VDC
TP2	VDD2	Nonvolatile electronics supply	5.0 ± 0.15 VDC
TP3	VDD3	Auxiliary supply	16.0 ± 1.50 VDC
TP4	VCC	Receiver supply	5.0 ± 0.15 VDC
TP5	VR1	Reference voltage	2.50 ± 0.015 VDC
TP6	VXMT	Transmitter/Transducer supply	5.0 ± 0.15 VDC
TP7	VPWR+	Raw power supply	28 ± 3.0 VDC @ Mains Vbatt - 2 VDC @ DC

If the above test is not successful you may have to replace the Electronics Unit, or the Electronics Unit's motherboard.

g. If the above voltages can be measured following the procedure above, and communication can still not be established successfully, the problem may still be a faulty communication line, or a faulty Electronics Unit motherboard.

6-5.3 BIT Determines a Problem Associated with the Transducer

The built-in test (BIT) is not able to isolate in all instances the problem exactly. If, with help of BIT you isolated the fault to be within the transducer or the Transmit Test failed, the problem may be associated with the following items.

- Any connection between the ADFM motherboard and the transducer cable
- A faulty transducer

To check any connection between the transducer and the ADFM Electronics motherboard, other than the transducer cable, the Electronics Unit's top cover has to be removed.

> ⚠ **CAUTION.** You must obey all warnings and cautions regarding power and ESD. Please read these warnings at the beginning of this manual, and the beginning of this section.

To check these connections, inspect for proper seating of all connections on the ADFM Electronics Unit's motherboard located in the ADFM Electronics Unit's Chassis. Do not alter the connections made on the motherboard for a reason other than to re-establish a faulty connection.

Appendix

A

ADFM System Overview

A-1 Introduction

The ADFM consists of two units: the Electronics Unit and the transducer. Both Units are described below to a detail necessary for an understanding of their function, and as an aid for troubleshooting.

A-2 Electronics Unit Circuit Description

The following description refers to Figure A-17. The legends used are spelled out more precisely in Table A-18.

A-2.1 Power Supply System

The power supply supplies the ADFM Electronics Unit and the ADFM transducer with power. It is designed to minimize energy consumption, by employing low power circuits, and power strobing of functional circuit modules. In addition, a highly efficient switching regulator generates the ADFM's five-volt main power supply.

The necessary supply voltages are derived from mains, an external DC-supply, or an internal 24-volt supply. Any combination of supplies is also possible. The highest DC-voltage in the system will determine which power source will supply the ADFM. The mains supply will generate approximately 28 VDC. Therefore, if an internal battery is installed (24 VDC) and mains is connected, the ADFM will be supplied by the mains voltage, when the mains power switch is in the "On" position.

Mains enters the system through the power entry module (MAINS PWR ENTRY), which provides the voltage selector switch, the mains fuse, and electro-magnetic interference (EMI) filtering. The mains power switch located at the front panel allows On/Off control of the mains power. A power transformer changes the mains voltage level at the primary winding, which can be configured to accept either 115 or 230 volts ac, to about 20 VAC at the secondary winding. The voltage is rectified, and filtered at the power filter (PWR FILTER). External DC-supply voltage and internal batteries are connected through diodes. A battery power switch located at the front panel is common to both DC supplies. The DC supplies and the rectified mains supply are connected together at the power filter.

This unregulated DC supply voltage is connected to the auxiliary regulator (AUX. REG.), which pre-regulates the supply to about 16 volts (VDD3); it also produces a regulated 5 volts supply (VDD2). These voltages are present as long as mains, or the internal/external DC-sources are connected. The main power control (MAIN PWR CONTROL) enables the DC/DC switching regulator (DC/DC-CONV.) under CPU control. It enables the main 5-volt power (VDD1) to the Electronics Unit; VDD1 supplies the CPU, the timing generator circuitry, bus interface logic, part of the off-board I/O, the recorder, and the front panel interface. VDD2 supplies volatile memory (RAM), volatile configurable logic circuits, and the real time clock (RTC) with standby power. In addition, the RTC is also backup-powered by a 250 mAh Lithium coin cell, which maintains its calendar and alarm settings if all power is off.

To save power also when the Electronics Unit is “awake”, that is if VDD1 is switched on, additional power management is provided. The CPU can enable power via the receiver power strobe switch (RCV PWR STROBE) to the receiver portion of the ADFM, which includes the receiver amplifier (RCV-AMP), the mixers, the low pass filters (LPF) the limiting amplifiers (LIMITER), and the data acquisition circuitry (FIFO, CORRELATOR) as its main components. Also the 2.50-volt reference voltage VR1 is controlled by the same switch. The CPU controls also the transducer power strobe switch (XDCR PWR STROBE), which enables a 7.9-volt regulator. After additional filtering and power supply decoupling, it supplies the transducer and transmit amplifier (XMT-AMP) with power.

To increase reliability and reduce power consumption, all power strobes and controls are solid state devices.

A-2.2 Receiver

The transducer output signal (RCV-SIG) is routed to the receive coupling transformer (RCV-XFMR) that provides isolation and impedance matching. The signal is further amplified and bandwidth limited by a high gain selective log-amplifier (RCV-AMP) circuitry. The amplified receive signal is fed to a frequency mixer, where the signal is mixed multiplicatively with the local oscillator (LO) frequency. The desired base band signal, which is the difference frequency of the receive signal and the local oscillator frequency, is obtained by passing the mixer output signal through a low pass filter. The base band signal contains now the entire Doppler spectrum without the carrier signal.

The mixer is a quatrature mixer, where an in-phase (I), and a quatrature signal (Q) is obtained. Both signals are needed for the correlator, which performs the basic digital signal processing. The I and Q-signals are buffered with a first-in/first-out buffer (FIFO). The signal’s echo strength, also named relative signal strength (RSSI) is also low pass filtered and digitized.

The receiver power supply is under CPU control, and is powered by VCC. Bi-directional digital bus transceivers provide the system bus interface where the pre-processed data from the receiver are available for post processing by the CPU.

A-2.3 Timing Generator

The timing generator (TIMING-GEN) generates all signals needed for the transmitter and receiver, such as the transmit signals, transmit enable, and the local oscillator quatrature signal for the mixer.

The transmitter amplifier (XMT-AMP) is considered part of the timing generator. It is a power driver, which buffers the logic level signal generated by the timing generator, and drives the transmitter output transformer (XMT-XFMR). The transmit transformer provides isolation between the Electronics Unit of the ADFM and the transducer; it connects to the transducer transmit input via a IS-barrier (optional). The transmit current is monitored by a current transformer (CURR-XFMR). Its’ output signal is scaled and digitized, and is part of the ADFM’s build in self test (BIT).

The timing generator interfaces to the system bus through bi-directional digital bus transceivers. All timing generator setups are fully programmable, and are downloaded by the CPU to the timing generator’s own RAM. The CPU is able to read back the timing setup data, the digitized current sense data, as well as for monitoring purposes the unregulated DC input voltage (VDC), the transmit voltage (VXMT), and the main 5 volt supply (VDD1).

A-2.4 Central Processing Unit

The central processing unit (CPU) is not shown in detail in the block diagram. The major CPU components are the micro processor unit (MPU), random access memory (RAM) for data storage, read only memory (ROM) for program storage, a real time clock (RTC) to keep time and date, a address decoder, and a CPU supervisor.

The MPU is a power efficient 68000-based HCMOS processor. It provides all housekeeping functions for the ADFM, as well as post processing of the Doppler data, data formatting for data-I/O, and the user command input interface.

The ROM is configurable in size (128 to 512 k-words), uses Flash or EPROM, and is typically factory set to 512 k-words Flash. The RAM is supplied by VDD2, which provides non-volatility, as long as either a DC power, or mains is supplying the ADFM, that is the RAM contents is maintained during the sleep mode (power down mode). RAM contents are lost if none of these sources are present.

The RTC keeps time and date, including leap year. When the RTC's programmed alarm compares with the current time and date, its alarm function generates an interrupt, which in turn wakes the CPU up from an asleep mode (power down mode). It also keeps time for time between ensembles and time between pings for example. The RTC's memory is backed up by a 250-mAh Lithium coin cell for up to 3 years, even if external and internal power sources are not present. However, it is recommended to change the backup battery at least every 2 years.

The address decoder provides all enables and controls for all CPU functions, bus interface enable, timing generator enable and control, receiver enable and control, off-board enable and control (serial interfaces such as RS-422, RS-232), and power supply controls. Interrupt priority encoding and bus-ready control (wait state generator) are also functions of the decoder.

The CPU supervisor monitors power, and generates an un-maskable interrupt for the MPU to signal a power fail. The CPU is able to shut down in a controlled manner. If the supply voltage should fall any further, the supervisor generates a system reset. Further more, it protects RAM and RTC from an erroneous writes during power down or power fail events. When the system is in sleep mode a RTC interrupt sets a supervisor register, which in turn switches the main 5 volt power on (VDD1). The MPU is able to interrogate the source of the interrupt, and will proceed according its instructions.

The CPU interfaces to the system bus through bi-directional digital bus transceivers. Since all of the functional modules are isolated by these transceivers (as described above), fault isolation of this complex system is possible; it would be very difficult, if not impossible in an un-isolated bused system.

A-2.5 User Interface

Several user interfaces are integrated into the ADFM. In particular these are a RS-232 serial data interface, a 9600 baud data Modem, and a LCD display. A solid state recorder is also built into the ADFM. The Modem and serial interface allows the operation of the ADFM without restrictions. However, the host terminal or host computer must be able to send a Break signal width a minimum duration of 400 ms. The Modem must be able to send a Break signal with a minimum duration of 300 ms.

The RS-232 serial data interface is located at the front panel of the ADFM. It is intended for local operation of the ADFM. This single ended interface allows maximum baud rate of 19.2 k-Baud over a distance of 15 meters. Longer distances may be possible at lower data rates. Handshake lines are not available.

The front panel LCD displays the ADFM operating status. Self-test results are indicated as well.

A-3 Transducer Electronics Circuit Description

The following description refers to Figure A-29. The legends used are spelled out more precisely in Table A-210.

A-3.1 Multiplexer

Prior to a ping, the transducer micro controller (XDCR-CTL) selects a beam via a solid state transmit and receive multiplexer, which is part of the transmit/receive switch (T/R-Switch), and the pre-amplifier (PA) respective. The specific beam number the XDCR-CTL selects is set up by the ADFM's Electronics Unit via a half duplex serial communication port (SDIN, and SDOUT) between the Electronics Unit and the transducer controller.

A-3.2 Transmit Path

The transmit signal, generated by the ADFM's Timing Generator, arrives at the transducer electronics terminals labeled XMT. It passes through the transmit coupling transformer (XMT), which provides isolation and impedance matching. The signal then is mutilplexed to one of five beams via the prior selected T/R-Switch, which also isolates and protects the pre-amplifier (PA) during transmit. At the end of transmit the transmit multiplexer is deselected, but the appropriate PA remains selected.

A-3.3 Receive Path

The echo from the water is received through the same selected transducer, band-pass filtered, and amplified by the prior selected pre-amplifier (please notice, only one pre-amplifier is selected at any given time). The PA's output signal is buffered by a buffer amplifier (BUFF) that is common to all five channels. The buffer amplifier provides decoupling and impedance matching. The signal eventually is converted to a differential signal by a wide-band signal transformer, and is available at the transducer terminals, labeled RCV-SIG. After the signal is received, the transducer controller deselects the pre-amplifier.

A-3.4 Temperature Interface

The transducer's ambient temperature is sensed by an accurately linearized termistor (T_SENSE). The termistor's temperature dependent output voltage is connected to an amplifier (S_AMP), where it is scaled, and buffered. The transducer then digitizes the scaled buffered output voltage. The result is available for the ADFM's Electronics Unit via the serial interface port. Since the temperature signal (TEMP) is ratiometric to the temperature sensor's supply voltage, the transducer controller also digitizes the sensor's supply voltage.

A-3.5 Transducer Power Supply

The transducer power supply terminals are labeled VXDR. The supply voltage is lowpass filtered and regulated by a low-dropout linear voltage regulator (PWR-REG). The 5.0-volt output VAA1 of the regulator is the primary supply for all transducer modules. A 2.50-volt reference voltage VREF provides all bias voltages needed for the pre-amplifier and the buffer stage. For build-in self-test purposes, it is also provided to the transducer controller's A/D-converter. To save energy, the temperature sense circuitry and its scaling amplifier are power strobed, that is, power is only provided when a temperature measurement is needed. A solid state switch (T-EN) connects VAA1 to the power supply of the temperature circuitry under the controller's command.

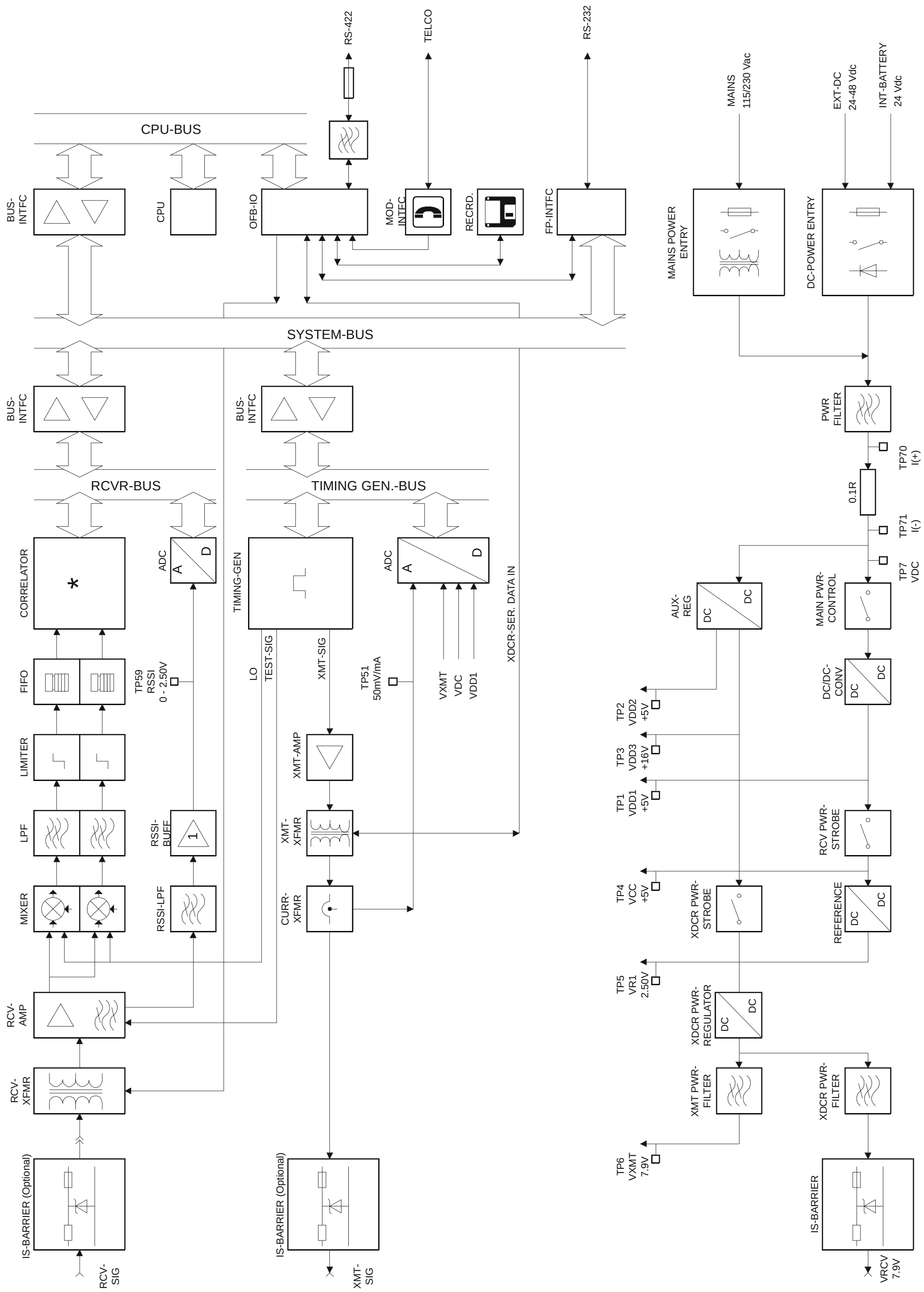

Figure A-1. Electronics Unit Block Diagram

Table A-1: Electronics Unit Block Diagram Legend

Block Diagram Legend	Description
ADC	Analog to Digital converter
AUX. REG.	Auxiliary regulator
BUS-INTFC	Bus interface circuit
CORRELATOR	Correlator, digital signal processor
CPU	Central processing unit
CURR-XFMR	Current sense transformer
DC PWR ENTRY	DC power entry circuit
DC/DC-CONV.	DC/DC switching regulator
FIFO	First In - First Out Register
FP.-INTFC	Front panel Interface
LIMITER	Amplitude Limiter
LO	Local oscillator frequency signal
LPF	Lowpass filter
MAIN PWR CONTROL	Main power control of system
MAINS PWR ENTRY	Mains power entry circuit
Mixer	Frequency mixer
MOD.-INTFC	Modem interface and Modem
OFB-I/O	Off board input/output device
PWR FILTER	Filter for mains and DC-power supply
RCV PWR STROBE	Power control of on-board receiver functions
RCV-AMP	Receiver amplifier
RCV-XFMR	Receive channel input coupling transformer
RECORDER	Solid state recorder for data storage
REFERENCE	Reference voltage
RSSI	Relative signal strength indicator
TEST-SIG	Test signal
TIMING-GEN	Timing generator
TP(xx)	Test points
XDCR PWR FILTER	Transducer power supply filtering
XDCR PWR REGULATOR	Transmitter and transducer supply voltage regulator
XDCR PWR STROBE	Power control of transmitter power and transducer supply voltage
XDCR-SER. DATA IN	Serial data signal from electronics to transducer
XDCR-SER. DATA OUT	Serial data signal from transducer to electronics
XMT PWR FILTER	Transducer power filter
XMT-AMP	Transmitter amplifier
XMT-SIG	Transmit signal waveform
XMT-XFMR	Transmitter output transformer

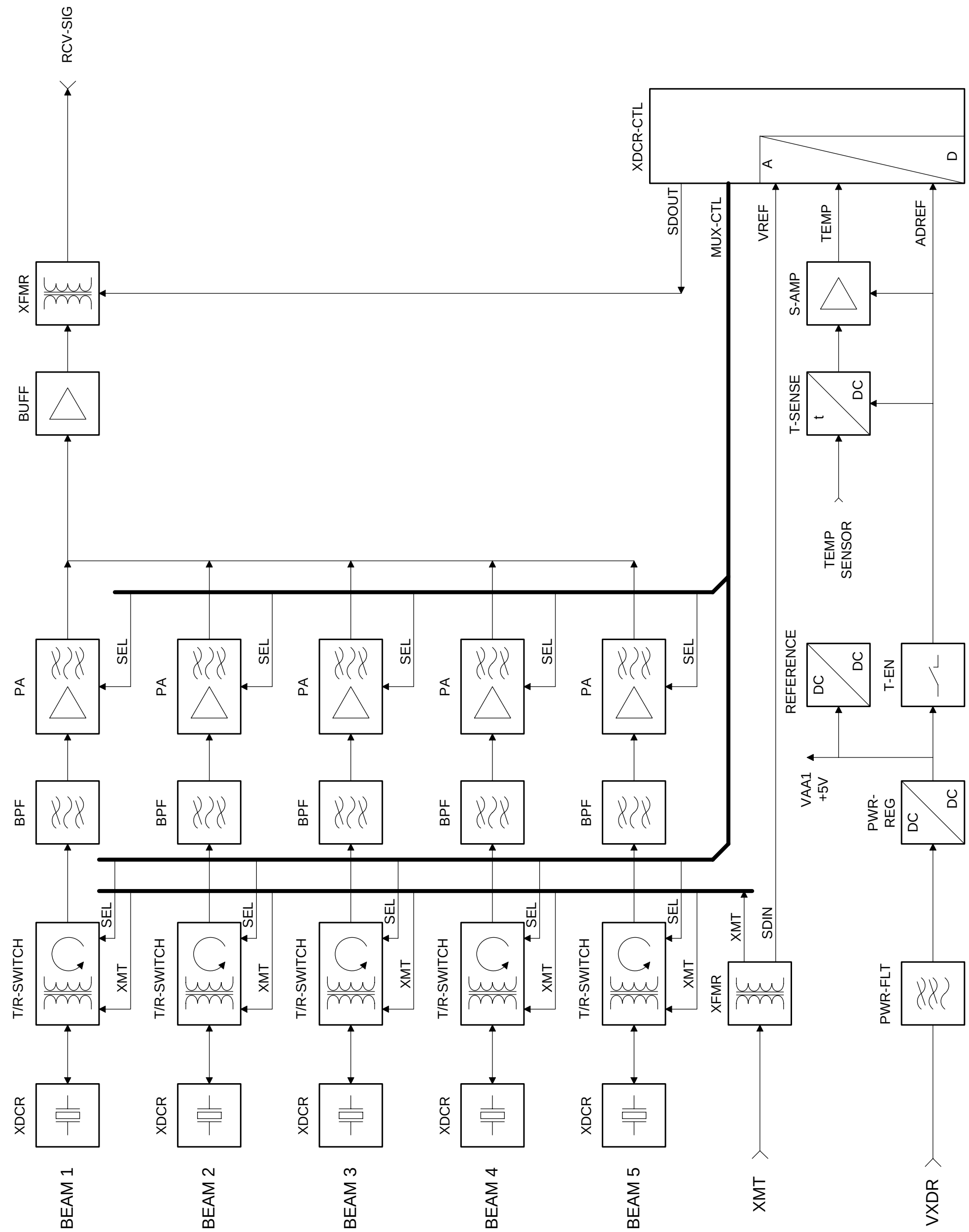

Figure A-2. Transducer Block Diagram

Table A-2: Transducer Block Diagram Legend

Block Diagram Legend	Description:
XDCR	Transducer element, or beam
T/R-SWITCH	Transmit/Receive Switch
BPF	Bandpass filter
PA	Pre-Amplifier
BUFF	Buffer amplifier
XFMR	Transformer
XDCR-CTL	Transducer controller
PWR-FLT	Transducer power supply input filter
PWR-REG	Transducer power supply regulator
REFERENCE	Reference
T-EN	Temperature interface power strobe
T-SENSE	Temperature sensor
S-AMP	Temperature scaling amplifier
MUX-CTL	Multiplexer control
XMT	Transmit signal
SDIN	Transducer serial data input from Electronics Unit
SDOUT	Transducer serial data output to the Electronics Unit
VXDR	Transducer supply input voltage
RCV-SIG	Transducer output signal
TEMP	Scaled temperature sensor signal
VAA1	Regulated transducer supply voltage
ADREF	Analog/Digital converter reference

Appendix

B

Specifications

B-1 Physical Specifications

The ADFM consists of a transducer assembly placed in the flow connected to a controlling set of electronics by a waterproof cable. The transducer assembly is designed to be intrinsically safe (IS) compliant. An optional IS zener diode barrier may be mounted in an electronics assembly for interface to the transducer. The electronics can record data in a stand-alone mode, output data real-time via modem or serial communications, or do both. External AC, DC, or internal alkaline batteries power the system.

The ADFM Velocity Profiler™ transducer assembly (shown in Figure B-12) contains four individual velocity transducers that use piezoelectric ceramics for emitting and receiving acoustic signals. These four transducers measure velocity throughout the depth of flow. A fifth transducer is mounted in the center, pointed vertically, to measure the depth of flow. The transducer assembly casing is manufactured of plastic to provide years of corrosion free service.

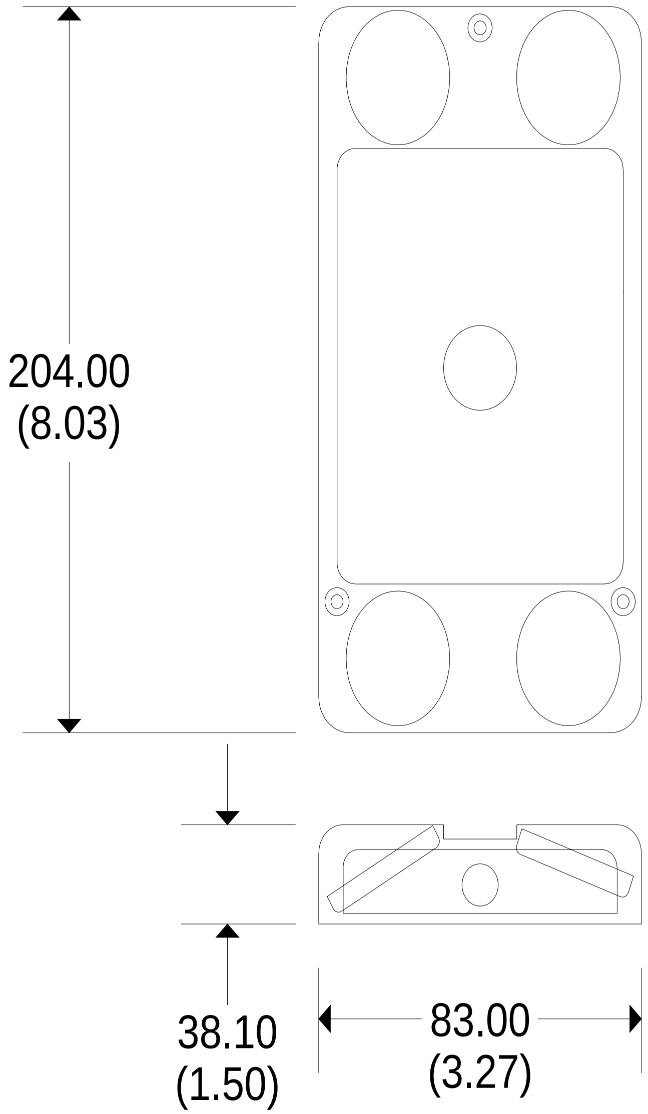

Figure B-1. ADFM Transducer Dimensions

The field housing contains the signal processing system (Figure B-23). The housing contains all signal processing boards, the battery supply, and available options – a modem for telemetry, solid state memory for stand alone operation, and IS zener diode barriers. An RS-422 and 232 serial interface is standard, as is a 4 line by 16 character LCD for quick determination of the system's status. The field housing is compliant with IP 67 (equivalent to NEMA 6P) and is suitable for mounting in a manhole.

NOTE. All Dimensions are in millimeters (in.).

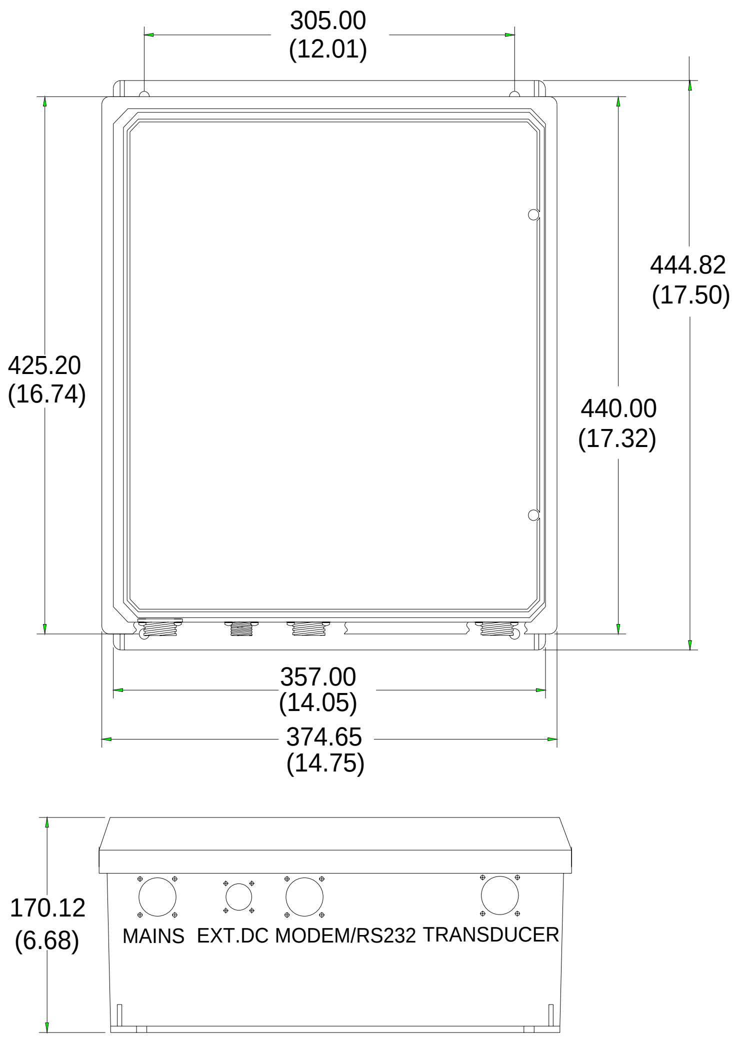

Figure B-2. ADFM Field Housing Dimensions

B-2 Performance Specifications

NOTE. All specifications shown are in Imperial units.

B-2.1 Measurement Precision

Flow Accuracy	2% of reading

Velocity

Horizontal Velocity Range	± 30.0 ft/s
Depth Cell Size	2 to 12 in. – user selectable
Vertical Profiling Range	Up to 20 ft., for particle concentrations of 50 to 1000 ppm
Accuracy	1.0% ± 0.01 ft/s of reading

Water Level

Measurement Range	4.7 in. to 20 ft
Accuracy	0.5% ± 0.2 in. of reading

B-2.2 Packaging and Environmental

Transducer

Operating Temperature	23 to 95° F
Housing Material	Plastic – corrosion resistant stainless steel optional
Static Pressure	250 psi Nominal (~17 atmospheres, ~550 feet)
Weight	2.2 lb

Electronics Unit

Operating Temperature	-15 to 125° F
Storage Temperature	-65 to 160° F
Packaging	IP 67 (NEMA 4X) compliant
Weight	30 lb.

Transducer Signal Cable

Operating Temperature	-40 to 125° F
Physical	Polyethylene jacket.
Static Pressure	45 psi
Length	50 ft std. (up to 150 ft optional)
Minimum Bend Radius	0.5 ft.
Weight	0.08 lb/ft nominal
Outer Diameter	0.5 in. nominal

Acoustic Frequency

Frequency	1.23 MHz

B-2.3 Data Management

ADFM Velocity Profiler™ Data Output

Q, V, D	Discharge, average velocity, depth
Velocity	Velocity profile data per beam and bin (velocity data relative to the acoustic beam's coordinate system)
Echo Intensity	Echo intensity data (relative backscatter intensity) per beam and bin
Data Qualifier	Profile data quality indicator (Correlation magnitude, %-Good) per beam and bin
Temperature	Transducer temperature output over a range of $20 \leq T \leq 125°$ F
Sound Speed	One output for speed of sound data
Leader	Outputs of general leader information (time, data, record number, etc.), and for vertical beam data

ADFM Velocity Profiler™ Software

WinADFM software for Windows '95

Data Storage (optional)

Storage Capacity	20 Mbytes

Data Interfaces

Data I/O	- RS-232; - RS-422; - Modem port (optional) - 4-20 mA (optional)

B-2.4 Power and Frequency

Power

External AC	230 ± 10% VAC 115 ± 10% VAC 50/60 Hz
External DC	24 VDC - 12 VDC absolute minimum; 36 VDC absolute maximum
Internal Battery Voltage	24 VDC nominal
Internal Battery Capacity	13 Ah @ 75° F - Alkaline 7 Ah @ 75° F - SLA
Battery Life @ 15 minute sampling interval	Alkaline - 22 weeks SLA - 7 weeks

4250 Area Velocity Flow Meter

Installation and Operation Guide

TELEDYNE ISCO
A Teledyne Technologies Company

Part #60-3253-042 of Assembly #60-3254-012
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Revision X, July 29, 2008

Foreword

This instruction manual is designed to help you gain a thorough understanding of the operation of the equipment. Teledyne Isco recommends that you read this manual completely before placing the equipment in service.

Although Teledyne Isco designs reliability into all equipment, there is always the possibility of a malfunction. This manual may help in diagnosing and repairing the malfunction.

If the problem persists, call or e-mail the Teledyne Isco Technical Service Department for assistance. Simple difficulties can often be diagnosed over the phone.

If it is necessary to return the equipment to the factory for service, please follow the shipping instructions provided by the Customer Service Department, including the use of the **Return Authorization Number** specified. **Be sure to include a note describing the malfunction.** This will aid in the prompt repair and return of the equipment.

Teledyne Isco welcomes suggestions that would improve the information presented in this manual or enhance the operation of the equipment itself.

Teledyne Isco is continually improving its products and reserves the right to change product specifications, replacement parts, schematics, and instructions without notice.

Contact Information

Customer Service

Phone:	(800) 228-4373	(USA, Canada, Mexico)
	(402) 464-0231	(Outside North America)
Fax:	(402) 465-3022	
Email:	IscoCSR@teledyne.com	

Technical Service

Phone:	(800) 775-2965	(Analytical)
	(800) 228-4373	(Samplers and Flow Meters)
Email:	IscoService@teledyne.com	

Return equipment to: 4700 Superior Street, Lincoln, NE 68504-1398

Other Correspondence

Mail to:	P.O. Box 82531, Lincoln, NE 68501-2531
Email:	IscoInfo@teledyne.com
Web site:	www.isco.com

Revised September 15, 2005

General Warnings

Before installing, operating, or maintaining this equipment, it is imperative that all hazards and preventive measures are fully understood. For information about general safety practices, turn to Appendix C *General Safety Procedures*. While specific hazards may vary according to location and application, take heed of the following general warnings:

⚠ WARNING

Avoid hazardous practices! If you use this instrument in any way not specified in this manual, the protection provided by the instrument may be impaired.

⚠ AVERTISSEMENT

Éviter les usages périlleux! Si vous utilisez cet instrument d'une manière autre que celles qui sont specifiées dans ce manuel, la protection fournie de l'instrument peut être affaiblie; cela augmentera votre risque de blessure.

Hazard Severity Levels

This manual applies *Hazard Severity Levels* to the safety alerts, These three levels are described in the sample alerts below.

⚠ CAUTION

Cautions identify a potential hazard, which if not avoided, may result in minor or moderate injury. This category can also warn you of unsafe practices, or conditions that may cause property damage.

⚠ WARNING

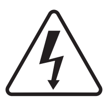
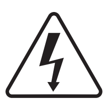
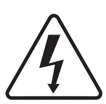
Warnings identify a potentially hazardous condition, which if not avoided, could result in death or serious injury.

⚠ DANGER

DANGER – limited to the most extreme situations to identify an imminent hazard, which if not avoided, will result in death or serious injury.

Hazard Symbols

The equipment and this manual use symbols used to warn of hazards. The symbols are explained below.

Hazard Symbols	
Warnings and Cautions	
	The exclamation point within the triangle is a warning sign alerting you of important instructions in the instrument's technical reference manual.
	The lightning flash and arrowhead within the triangle is a warning sign alerting you of "dangerous voltage" inside the product.
Symboles de sécurité	
	Ce symbole signale l'existence d'instructions importantes relatives au produit dans ce manuel.
	Ce symbole signale la présence d'un danger d'électocution.
Warnungen und Vorsichtshinweise	
	Das Ausrufezeichen in Dreieck ist ein Warnzeichen, das Sie darauf aufmerksam macht, daß wichtige Anleitungen zu diesem Handbuch gehören.
	Der gepfeilte Blitz im Dreieck ist ein Warnzeichen, das Sei vor "gefährlichen Spannungen" im Inneren des Produkts warnt.
Advertencias y Precauciones	
	Esta señal le advierte sobre la importancia de las instrucciones del manual que acompañan a este producto.
	Esta señal alerta sobre la presencia de alto voltaje en el interior del producto.

4250 Flow Meter

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Section 2 Programming

Section 3 Installation

Section 4 Options and Accessories

Section 5 Maintenance and Service

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Appendix C General Safety Procedures

Appendix D Material Safety Data Sheets

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4250 Flow Meter

Section 1 Introduction

This section of the instruction manual provides a general introduction to the 4250 Area Velocity Flow Meter. It includes a description of the flow meter, an explanation of how the unit operates, and technical specifications.

Manual Organization – This manual provides the information necessary to operate, maintain, and perform minor service on the 4250. The manual is organized into five sections:

Section 1 – Introduction, operation, and specifications.

Section 2 – Keypad operation and programming for the flow meter.

Section 3 – Installation and options application-specific to the 4250

Section 4 – Options and accessories available for all 4200 Series Flow Meters

Section 5 – Routine maintenance and minor service

Following Section 5 are appendices covering replacement parts and accessories, programming worksheets, safety information, and material safety data sheets.

Figure 1-1 The 4250 Area Velocity Flow Meter

1.1 Description

The 4250 Area Velocity Flow Meter uses a sensor with two different sensor systems submerged in the flow stream. This probe is called the area-velocity (or AV) probe. It contains a pressure transducer to measure level and a pair of ultrasonic transducers to measure velocity. The flow meter then calculates flow based on the cross-sectional area of the flow stream and its velocity. You need only enter the dimensions of the flow channel. If you want, you can also use the 4250 with a primary measuring device, as it has built-in standard level-to-flow conversions that cover most open channel flow measurement situations. You can enter an equation, or sets of data points that plot a user-derived flow profile for a flow stream. You can enter either velocity data points or level/flow rate data points. The 4250 supports Flowlink, Teledyne Isco's data acquisition, storage, and retrieval software.

Using Flowlink, the 4250 has enough memory to store 40,000 data readings. The optional 4200T Modem with speech capability is available to transmit stored data over telephone lines.

1.2 Compatible Equipment

The 4250 Flow Meter may be used with the following equipment:

Manufactured by Teledyne Isco:

- 3700 Series Sequential, Composite and Refrigerated Samplers
- 6700 Series Portable and Refrigerated Samplers
- GLS Compact Portable Sampler
- 4-20 mA Output Interface
- Tipping Bucket Rain Gauge
- High-Low Alarm Relay Box

Non-Isco Equipment:

- IBM Personal Computer or compatible clone with Isco Flowlink software
- Laptop Computer with Isco software
- YSI 600 Multi-Parameter Sonde

Optional Accessories:

- 4200T Modem - Speech-capable, with connector and cable
- D.O. (dissolved oxygen), pH, and temperature parameter probes
- Extension Cable (Vented) for the AV sensor, length of 25 feet. (Maximum distance between sensor and flow meter with extension cables is 75 feet.)
- Quick-Disconnect Box for AV sensor (Increases maximum distance between flow meter and sensor to 1000 feet.)
- Isco Flowlink Software for data acquisition, storage, and management
- Mounting rings for the AV sensor

1.3 Flow Meter Operation

When measuring flow rate, the 4250 is normally used with an open channel and calculates flow rate from a combination of measured level, stream velocity, and channel cross-sectional area. This is the only method of flow measurement that can measure submerged, full pipe, surcharged, and reverse flows, and it renders a primary measuring device unnecessary. The flow meter provides standard or optional flow-related output signals to be used for:

- Flow-proportional sampler pacing and enabling
- Transmitting level and flow data to an external device on a serial communications loop
- Data transfer to a remote location through a modem
- Control of an external 4-20 mA device
- Data transfer by a laptop computer

The 4250 contains microprocessor-controlled circuitry to calculate level and flow rates from the output produced by the area-velocity sensor, store user programming instructions, operate the display, and drive the internal plotter. An alphanumeric liquid crystal display (LCD) shows current total flow, level, and flow rate information. It also prompts you during initial setup or subsequent program changes. An internal plotter provides a hard copy printout of the information computed, plots level or flow rate, and generates reports. Connectors for other equipment used with the 4250 are on the right side of the flow meter's case.

1.4 Area Velocity Sensor Operation

The AV sensor is mounted beneath the surface of the flow stream and measures liquid level by responding to changes in hydrostatic pressure against a solid state pressure transducer. It measures average velocity ultrasonically by using the **Doppler effect**. This principle states that the frequency of a sound (or other wave) passed from one body to another is relative to both their motions. As the two approach each other, the frequency increases; as they recede, the frequency decreases. The motion of the bodies relative to each other is added to or subtracted from the frequency of the wave. A familiar example is this: You are in a car at a railroad crossing waiting for a train. As the train approaches, it sounds its whistle in warning. The whistle sounds a certain pitch to you. As the train passes through the crossing, the pitch drops noticeably. The transmitted frequency, of course, is always the same, but the Doppler effect will make it seem higher or lower to you because of the movement of the train toward or away from you.

1.4.1 Velocity Measurement

The probe's ultrasonic transducer transmits a high-frequency pulse into the flow stream. Bubbles and particles carried by the stream reflect the pulse back to the receiving transducer. The reflected pulse will have a different frequency, depending on whether the bubbles or particles are moving away from or toward the sensor.

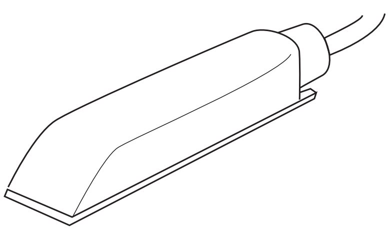
This frequency difference is converted by the flow meter into a velocity reading, and the reading can indicate either forward or reverse flow.

1.4.2 Pressure Transducer Operation

The pressure transducer in the area-velocity sensor contains a resistance bridge on a silicon diaphragm. Pressure against one side of this diaphragm causes it to flex slightly. The other side of the bridge is referenced through a small tube to atmospheric pressure. Flexing the chip causes the resistors on one side of the bridge to stretch, while the resistors on the other side compress. The result is an unbalance in the current across the bridge that is proportional to the increase in pressure caused by a rising level in the flow stream. This bridge is fed from a constant-voltage source, so any change in its output is a result of hydrostatic pressure against the transducer.

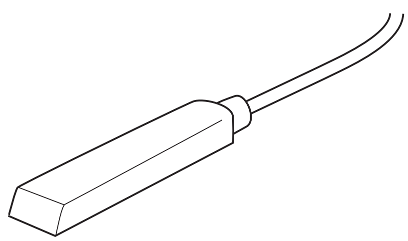
1.5 Three Sensors Available

Teledyne Isco offers three types of AV sensor for use with the 4250. The **10-foot standard** unit is intended for operation in depths from 1 inch to 10 feet maximum. The **30-foot standard** unit is capable of operation to depths as great as 30 feet. The difference is in the sensitivity of the pressure transducer used inside. The two are not interchangeable. You must select the appropriate unit based on the maximum anticipated depth in your flow stream.



Standard and Extended Range Sensors

Figure 1-2 Standard Area Velocity Probe



The third type of area-velocity sensor is the low-profile probe. This probe is streamlined for use in shallow flows and small pipes, in depths as low as 1 inch (25 mm).

The area-velocity sensor is designed to avoid accumulating debris that could affect readings. In rare instances, however, debris may accumulate inside the opening containing the pressure transducer and cause it to give false readings. In such cases, you may need to remove the probe and clean it.

Figure 1-3 Low-Profile Area Velocity Probe

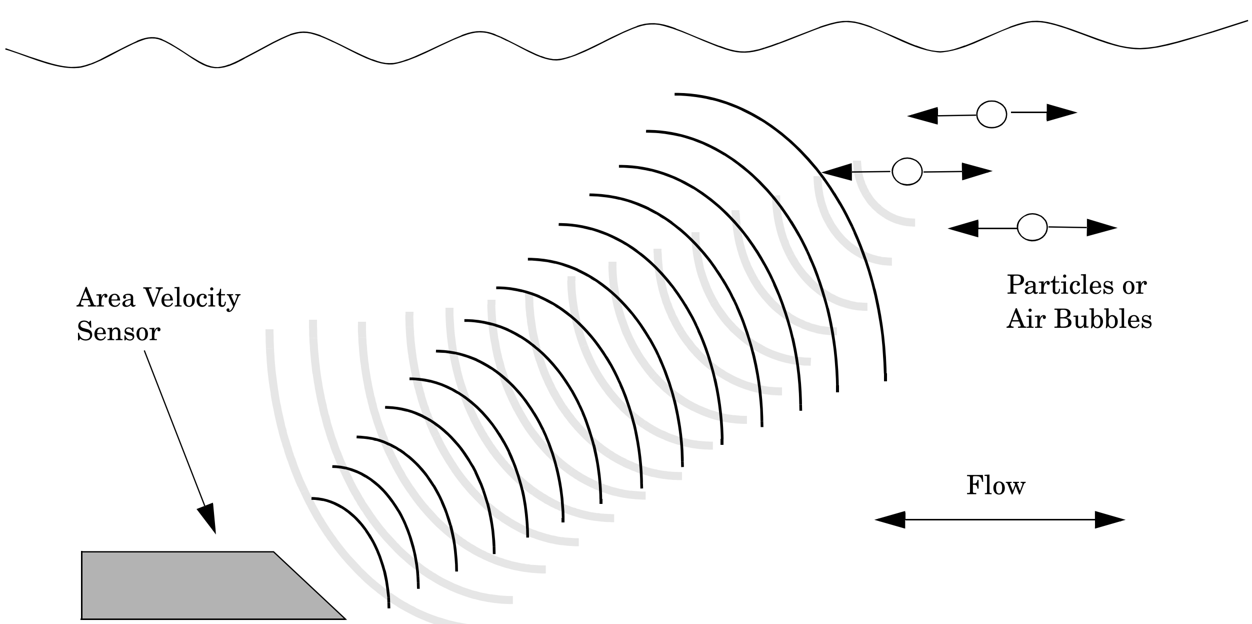


Figure 1-4 Operation of the Area Velocity Sensor

⚠ CAUTION

If you disassemble the AV sensor for cleaning, do not touch the exposed metal diaphragm inside the probe with either tools or your fingers. The diaphragm is very fragile. Deforming it even slightly may place a permanent offset on the transducer, ruining it (and the rest of the sensor). Use only gently running water to clean the probe.

See Section 5 for information on cleaning the pressure transducer. The velocity sensing circuitry is sealed inside the housing and is not serviceable.

1.6 Software Upgrades

4200 Series Flow Meters can be upgraded without being returned to the factory or having the EPROM replaced. With Flash memory, software updates can easily be installed in the field with a disk, a computer, and a cable. Flash update instructions can be found in Section 5 Maintenance. For more information about installing software upgrades in the 4250 Flow Meter, contact your Teledyne Isco representative or call the factory.

1.7 Controls, Indicators, and Connectors

The controls, indicators, and connectors of the 4250 Flow Meter are listed in Table 1-1, and their functions are briefly described. Refer to Figure 1-5 for a view of the controls and indicators, and Figure 1-6 for a view of the connectors and their pin functions.

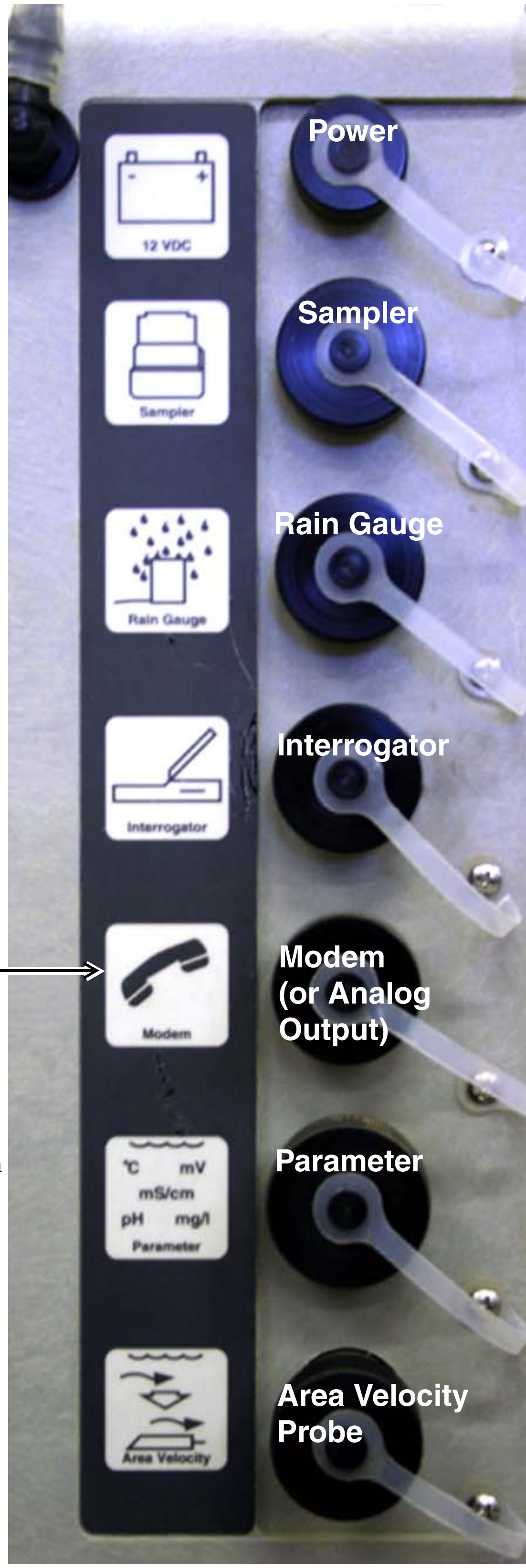
1.8 Technical Specifications

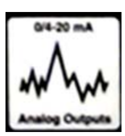
The technical specifications for the 4250 Flow Meter are found in Tables 1-2, 1-3, and 1-4. The anticipated longevity for a roll of paper used in the internal plotter is shown for various chart speeds in Table 1-5.

☑ Note

Various options and accessories used with the 4250 are described throughout the manual. For convenience, the part numbers for these items are listed on the Accessory Parts List found at the back of Appendix A Replacement Parts List. Part numbers for equipment not listed on this sheet are available from the factory.

Figure 1-5 4250 Controls and Indicators





A = Channel 1 (-) Red
B = Channel 3 (+) Green
C = Channel 1 (+) White
D = Channel 2 (-) Brown
E = Channel 3 (-) Black
F = Channel 2 (+) Blue

Pin	Function
A	Ground
B	12V
A	12V
B	Ground
C	Flow Pulse Output
D	Bottle Number Input
E	Event Mark Input
F	Inhibit/Enable Output
A	12V
B	Ground
C	SDO
D	Rain Gauge Input
A	12V
B	Ground
C	Sense Line
D	SDO
E	SDI
F	Analog Output Pulse
B	Tip
C	Ring
A	12V
B	Ground
C	Input Signal (+)
D	Temp (-)
E	Temp (+)
F	Switched 12V
G	Input Signal (-)
A	12V
B	Ground
C	Level (+)
D	Level (-)
E	Rcv (-)
F	Rcv (+)
G	Xmit (+)
H	Xmit (-)

Figure 1-6 4250 Side View Showing Connectors and Pin Functions

Table 1-1 4250 Controls, Indicators, and Connectors

CONTROLS	SETTINGS	FUNCTION
ON/OFF	On - Off	Turns the flow meter on and off. Internal memory is protected with a standby battery. See **Section 2.**
Keypad	Momentary Switches	24-key. 4 column matrix - Program flow meter through series of key-strokes prompted by messages on the display. Certain keys perform specific functions, (printing reports or entering program choices into memory). Arrow keys move through menus. Number keys enter numeric values.See **Section 2.**
INDICATORS	**READING**	**FUNCTION**
Display	Multi-function	2-line, 40 characters per line, liquid crystal display (LCD.) Prompts you through program procedure; displays total flow,. present flow rate and level. May also display parameter readings, if sensors present.
Internal Plotter	Various	Provides hard copy of total flow, level or flow rate variation over time; provides sampling information and a printout of the program. Prints reports. Generates up to 3 different linear data plots. Chart characters and plots are generated on plain paper roll with an ink ribbon.

Table 1-1 4250 Controls, Indicators, and Connectors (Continued)

CONNECTOR	TYPE	FUNCTION
12 VDC	2-pin male M/S	Connects 12 VDC power to flow meter
Sampler	6-pin male M/S	Connects flow meter to sampler; provides flow pulse to sampler; receives sampler bottle number, composite sample and event mark signal.
Rain Gauge/ YSI 600 Sonde	9-pin female M/S (Custom)	Connects flow meter to a Isco Rain Gauge or YSI 600 Multi-Parameter Sonde. Also provides output to High Low Alarm Relay Box.
Interrogator	6-pin female M/S	Provides serial data in/out and power. Can also be used with 4-20 mA Output Interface.
Modem (optional)	5-pin male M/S	Connects flow meter to telephone line for remote data transmission. This connector will only be present on units that have the optional modem installed.
Analog Output (optional)	6-pin male M/S	Provides analog data output from the flow meter to external, non-Isco control and recording devices.
Parameter	7-pin female M/S	Connects flow meter to parameter sensor: temperature, pH, or D. O. Note that you can only have temperature and one parameter (pH or D. O.) at the same time.
Area Velocity Sensor	9-pin custom special connector	Connects flow meter to area-velocity sensor. Also provides connection for internal vent tube from sensor.

Table 1-2 4250 Technical Specifications

Physical and Electrical	
Size	16" high × 11 1/2" wide × 10 1/2" deep (40.6 × 29.2 × 26.7 cm) (without power source attached).
Weight	17 lb. 4 oz. (7.8 kg)
Material	High-impact molded polystyrene structural foam.
Type	Self-certified NEMA 4X Enclosure.
Display Type	2-line, 40 character/line alphanumeric dot matrix liquid crystal.
Power	12 to 14 VDC; 14 mA average at 12.5 VDC (printer set at 1" per hour, 1 minute level reading interval, 5 minute velocity reading interval.)
Typical Battery Life	(Standard 4 Ampere-hour nickel-cadmium battery.) 8 to 11 days with printer set at 1" per hour, 1 minute level reading interval, 5 minute velocity reading interval. 15 days with printer turned **off**.
Operating Temperature	0 to 140°F (–18 to 60°C).
Storage Temperature	–40 to 140°F (–40 to 60°C).
Additional Power Required for Optional Equipment	
Modem	60 mA maximum during operation; 0.1 mA maximum standby.
High-Low Alarm Relay Box	10 mA standby, typical; 190 mA - both relays operated.
Internal Printer	
Chart Speeds	Off, 1/2, 1, 2, or 4 inches per hour.
Ribbon	19.7 ft. (6 m) black nylon - replaceable.
Operating Speed	1.5 lines per second at 68° F. (20° C).

Table 1-2 4250 Technical Specifications

Character Size	0.09" high × 0.07" wide (2.4mm × 1.7 mm), 12 pitch.
Printer Recording Span Chart Resolution Display Resolution	User-selected from 1/4 ft. (3.6 cm) to over 30 ft. (9.1 m) with multiple over-ranges. 1/240 of selected recording span 0.001 ft. (0.3 mm)
Paper	4.5" wide × 65 ft. (11.4 cm × 19.8 m) plain white paper, replaceable.
Printer Reliability	2.5 million lines MCBF (mean cycles before failure).
Reports Printed	Program selections, interval activity reports, flow meter history.
Printer Recording Modes	Level, flow rate, rainfall, temperature, velocity, pH (or) D. O.; includes totalized flow, sampler events,
Plotted Linear Data	3 different linear plots can be printed at the same time.
Flowlink Data Storage and Retrieval System	
Memory Partitions	Maximum of 6 user-defined memory partitions for level or event storage.
Data Storage	Rate of data storage user-selected in 1, 2, 5, 10, 15, 30, 60, or 120 minute intervals.
Baud Rates	Serial connection - 300, 1200, 2400, 4800, or 9600 baud. Serial connection with the optional internal modem - 2400 baud.
Storage	80,000 bytes, apportioned per reading as follows: flow = 4 bytes, level = 2 bytes, sample = 4 bytes, pH or D. O. = 1 byte)
Level Data	Level readings are stored as a 16-bit number representing .1mm (0.0394 inch); effective range is 0–65279 meters.

Table 1-3 Technical Specifications for the Standard AV Sensor

Weight Standard Range Extended Range	2.1 lbs (.96 kg) 3.9 lbs (1.8 kg)
Sensor Dimensions	Length: 6.6 inches (6.8 cm) Width: 1.6 inches (4.1 cm) Height: 1.2 inches (3.0 cm)
Nose Angle	35° from horizontal
Cable Length Standard Range Extended Range	25 ft (7.6 m) 50 ft (15.2 m)
Materials	Sensor: Polybutadiene-based polyurethane, stainless-steel Cable: Polyvinyl chloride (PVC) chlorinated polyvinyl chloride (CPVC)
Operating Temperature	32° to 160°F (0° to 71°C)
Level Measurement Method	Submerged pressure transducer mounted in the flow stream
Transducer Type	Differential linear integrated circuit pressure transducer
Level Measurement Range Standard Range Extended Range	 0.05 to 10.0 ft (0.015 to 3.05 m) 0.05 to 30.0 ft (0.015 to 9.14 m)

Table 1-3 Technical Specifications for the Standard AV Sensor (Continued)

Maximum Allowable level Standard Range Extended Range	 20 ft (6.1 m) 40 ft (12.2 m)
Level Measurement Accuracy Standard Range Extended Range	 0.033 to 5.0 ft: ± 0.008 ft/ft (0.01 to 1.52 m: ± 0.008 m/m) >5.0 ft: ± 0.012 ft/ft (>1.52 m: ± 0.012 m/m) 0.05 to 15.0 ft: ± 0.03 ft (0.015 to 4.57 m: ± 0.009 m) 0.05 to 21.0 ft: ± 0.09 ft (0.015 to 6.40 m: ± 0.027 m) 0.05 to 30.0 ft: ± 0.30 ft (0.015 to 9.14 m: ± 0.090 m) @77°F (25°C). Includes non-linearity, repeatability, and hysteresis. Does not include temperature coefficient.
Compensated Temperature Range	32° to 100°F (0° to 38°C)
Temperature Coefficient Standard Range Extended Range	 0.05 to 4.0 ft: ± 0.005 ft/°F (0.015 to 1.22 m: ± 0.0027 m/°C) 4.0 to 10.0 ft: ± 0.007 ft/°F (1.22 to 3.05 m: ± 0.0038 m/°C) 0.05 to 30.0 ft: ± 0.008 ft/°F (0.015 to 9.14 m: ± 0.0044 m/°C) Maximum error over compensated temperature range, per degree of temperature change.
Velocity Measurement Method	Doppler Ultrasonic
Frequency	500 kHz
Typical minimum depth for velocity measurement	0.25 ft (75 mm)
Range	-5 to +20 ft/s (-1.5 to +6.1 m/s)

Table 1-4 Technical Specifications for the Low Profile AV Sensor	
Weight	2.1 lbs (.95 kg) including cable and connector
Sensor Dimensions	Length: 6.00 inches (15.2 cm) Width: 1.31 inches (3.3 cm) Height: 0.75 inches (1.9 cm)
Nose Angle	110° from horizontal
Wetted Sensor Material	Epoxy, chlorinated polyvinyl chloride (CPVC), Stainless-steel
Cable Material	Polyvinyl chloride (PVC), chlorinated polyvinyl chloride (CPVC)
Cable Length	25 ft (7.6 m)
Maximum Distance (between sensor and module)	75 ft (22.8 m) with optional extension cables. The distance can be extended up to 1000 ft (300 m) with the optional Quick Disconnect Box.
Operating Temperature	32° to 122°F (0° to 50°C)
Storage Temperature	-40° to 160°F (-40° to 71°)
Level Measurement Range	0.033 to 10.0 ft (0.01 to 3.05 m)
Maximum Allowable level	20 ft (6.1 m)
Level Measurement Accuracy	0.033 to 5.0 ft: ± 0.008 ft/ft (0.01 to 1.52 m: ± 0.008 m/m) >5.0 ft: ± 0.012 ft/ft (>1.52 m: ±0.012 m/m) Accuracy per foot of change from calibrated depth @77°F (25°C). Includes non-linearity and hysteresis.
Temperature Coefficient	±0.0023 ft/°F (±0.0013 m/°C) Maximum error within operating temperature range at zero pressure (per degree of change from calibration temperature).
Maximum Long-term Drift	0.033 ft (±0.010 m)
Velocity Measurement Method	Doppler Ultrasonic
Frequency	500 kHz
Transmission Angle	20° from horizontal
Typical minimum depth for velocity measurement	1 inch (25 mm)
Range	-5 to +20 ft/s (-1.5 to +6.1 m/s)
Velocity Accuracy	-5 to +5 ft/s (-1.5 to +1.5 m/s): ± 0.1 ft/s (±0.03 m/s) 5 to 20 ft/s (1.5 to 6.1 m/s): 2% of reading Velocity accuracy for a uniform velocity profile in water with a speed-of-sound of 4,850 ft/s.

Table 1-5 4250 Chart Longevity

NOTE: Report Generator is turned *off*.

Chart Speed, Inch/Hour	Time to Empty Roll
4	195 Hours (8 1/8 Days)
2	16 1/4 Days
1	32 1/2 Days
0.5	65 Days

Table 1-6 Battery Life Expectancy

Flow Meter Settings	Minimum	Default[2]	Maximum
Level Reading Interval	1 Minutes	5 Minutes	Continuous
Velocity Reading Interval	5 Minutes	30 Minutes	Continuous
Printer	Off	Off	4" per Hour
Report Generator	Off	Off	Every Hour
Average Current	14 mA	11 mA	70 mA
Nickel-Cadmium[3]	10.7 Days[5]	13.6 Days	2.1 Days
Lead-Acid[4]	17.4 Days	22.1 Days	3.4 Days

1. **These values are approximations based on calculations; actual times for your flow meter may vary substantially due to factors of battery age, charge condition, operating temperatures, and component differences.**
   "Minimum" settings are those providing the lowest average current draw. "Maximum" settings are those requiring the highest current draw. Your program should draw somewhere between the two. It is not possible to calculate the current draw for every possible program combination.
2. The default settings are the program entered at the factory. You can reset the flow meter to the default program at any time by pressing the **1** and **CLEAR ENTRY** keys at the same time.
3. The nickel-cadmium battery has a capacity of 4.0 ampere-hours at room temperature (20°C).
4. The lead-acid battery has a capacity of 6.5 ampere-hours at room temperature (20°C). Both batteries are assumed to be fully-charged with at least **95% of rated capacity** and in good condition. These calculations also assume a **5% safety factor** at the end of discharge. Lead-acid batteries should **never** be completely discharged.
5. All fractional times are rounded down.

1.9 How to Make Battery Calculations

To calculate battery life expectancy for an installation, you must know two things:

- The capacity of the battery you are using
- The average current draw of the flow meter or (other device) powered.

Battery capacity is expressed in ampere-hours. The battery manufacturer provides this information for each battery. This value is the product of a load current times an arbitrary time period: ten hours for nickel-cadmium batteries, and twenty hours for lead-acid types. The terminal voltage of the battery at the end of this time period is the discharged cell voltage, 10 volts for nickel-cadmium and 10.5 volts for lead-acid types. **Batteries are fully discharged well before the terminal voltage drops to zero volts.**

Isco batteries are rated at **4 ampere-hours** for the nickel-cadmium and **6.5 ampere-hours** for lead-acid types. Convert the battery current capacity into milliamperes and then divide this figure by the average current drawn by the unit. This will give you a number in hours. Divide that figure by 24, and you will have the number of days.

The published ampere-hour figures do not mean that you can expect to draw 4 amperes from the nickel-cadmium battery (or 6.5 amperes from the lead-acid battery) for one hour. At the one-hour rate, discharges are typically less than half the ten- or twenty-hour rate.

To convert ampere-hours to milliamperes, multiply by 1,000. *Examples:*

4 ampere-hours × 1,000 = 4,000 mAh

6.5 ampere-hours × 1,000 = 6,500 mAh

If you divide this figure by the average current of the flow meter, say 15 mA, you will have:

4,000 ÷ 15 = 266.67 hours

Divide this number by twenty-four to get days:

266.67 hours ÷ 24 = 11.1 days

For considerations of safety, we suggest you subtract 10% from this number (100% – 5% for 95% capacity and 5% for a reserve at the end of discharge).

11.1 – 1.1 = 10 days

This is the battery expectancy for a nickel-cadmium battery with a 15 mA continuous average drain, with a 10% derating factor. You can use the same method to calculate for lead-acid batteries, except the current will be 6,500 mA, and the period correspondingly longer, in this case a little over 16 days. You can run the full number of days calculated without derating if your batteries are new and at 100% capacity, but you will leave yourself no safety factor if you are in error on either of these assumptions. Remember, if the battery fails, there will be a period of time during which no measurements will be taken, (and no data stored, if you are also using FLOWLINK® software).

Batteries lose capacity as they age. Capacity also drops off as temperature falls. Low temperatures make less capacity available due to the slowing of the chemical reactions, while high temperatures accelerate the deterioration of battery plate separators, particularly if they are aged. Nickel-cadmium batteries show fairly rapid rates of self-discharge. A battery that is fully charged and then placed in storage will lose some capacity each day. In a week, this could easily be 5% or more.

When using lead-acid batteries, you must be careful to avoid complete discharge, as this may cause cell reversal, which will ruin the battery. Also, complete discharge in low temperature ambients may cause the battery to freeze, which can deform the plates or even crack the case. **Always operate these batteries with a reserve factor.**

1.9.1 Calculating Current Draw

Calculating current draw for a 4250 Flow Meter is somewhat more difficult than calculating the battery capacity. You cannot simply measure the idle current of the unit unless the printer and report generator are turned off in the program. These functions require power periodically, but not all the time. If the figures given in the previous table are not satisfactory for your application, you can use the following procedure (shown in Figure 1-7) to measure the actual current draw.

☑ Note

Do not attempt this procedure unless you have the proper equipment available and know how to make electrical measurements.

To measure current for a varying load requires a more-sophisticated type of multimeter, one that is capable of averaging high and low readings over a period of time. The *Fluke® 87 Multimeter* is one example of this type of meter. You should set the meter on MIN/MAX and let it run with your program for several hours or more. Other manufacturers' meters are also acceptable, but only if they are capable of averaging current draw. For a more representative test, the area-velocity sensor should be attached and submerged in water. You should run the test for at least eight hours, longer if necessary, or until the flow meter has exercised the entire program. The longer you run the test, the more accurate the average will be.

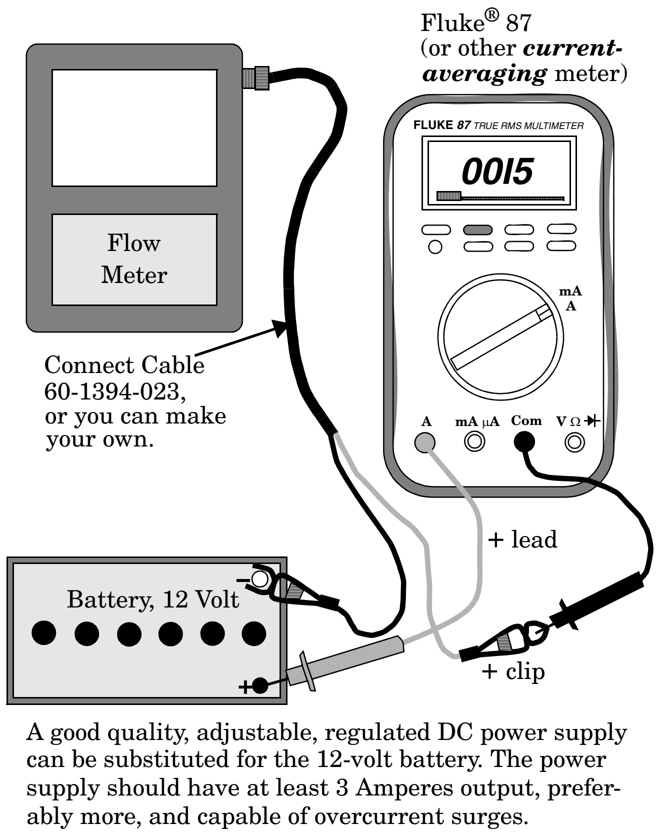


Figure 1-7 Measuring Flow Meter Current

More information about batteries used to power Isco equipment is available from the *Isco Power Products Guide*, which is shipped with this manual and any flow meter order.

4250 Flow Meter

Section 3 Installation

This section of the manual contains information on installing the 4250 Flow Meter. Included are sections on power sources, mounting methods, interconnection wiring, installation of the AV sensor and setup procedure for the unit.

3.1 Preparation for Use

The flow meter is shipped with a roll of paper installed and a standard program in the system memory, called the **default** program. This program exists to test the flow meter at the factory, and also because the computer must always have something programmed. You will usually program the flow meter differently for your installation.

You should familiarize yourself with the programming procedure and practice working through the program on the flow meter to become comfortable with programming. You can program the unit in the shop rather than at the job site, with the exception of the level adjustment, if you want. This will minimize the possibility of dirt and moisture getting inside the flow meter at the installation.

3.1.1 Installing the Desiccant Canister

If the unit is new, at this time you can install the desiccant canister. It is provided in the accessory package and looks like a small, flat can with little holes in it. Open the flow meter case lid. Note the small clamp that resembles a bottle cap opener located near the bottom right-hand corner of the case lid. Install the desiccant canister by pressing it under this bracket, with its viewing window lined up with the circular hole in the bracket.

Make sure the clamp is fully engaged over the canister. The particles inside the desiccant window should be blue. If the particles are pink, the desiccant is saturated and you need to regenerate it before using it. If the unit has been in use and has been returned for reprogramming, clean it and inspect it as outlined in Section 5 of this manual. You can also install the external desiccant cartridge, which provides pressure equalization for the AV sensor pressure transducer.

3.1.2 Installing the External Desiccant Cartridge

Snap the external desiccant cartridge into the clamps mounted on the top of the cabinet. Then attach the silicone tubing between the top of the desiccant cartridge and the black plastic elbow fitting mounted on the side of the case near the top.

This desiccator keeps moisture out of the AV sensor's reference port. This port connects to a tiny tube that goes through the case and the sensor cable all the way to the transducer. Like the case desiccant canister, the external desiccant cartridge should be colored blue. If it is violet or pinkish, you need to regenerate it.

You will need to remove the particles from the cartridge for regeneration; you cannot regenerate the cartridge like the case desiccant canister. The cartridge is plastic and will melt. See Section 5 for details on regenerating the desiccant cartridge.

⚠ CAUTION

Be sure to remove the red plastic cap from the desiccator cartridge when you install the flow meter. If you do not, the AV sensor will be unable to reference to atmospheric pressure, and inaccurate level measurements will result.

Many flow meters are installed in damp environments in atmospheres containing corrosive fumes. These fumes can form weak acids with moisture. Keeping the desiccators active and the door closed will prevent these fumes from damaging the flow meter. Keep the lid closed and latched except when you are installing the unit or changing the program.

Do **not** operate the flow meter with the door open or the desiccators saturated. If you leave the door open, moisture in the air will quickly saturate the desiccant. Dust may damage the printer mechanism. Water or dirt drawn into the reference port can block the tubing, preventing the pressure transducer from sensing atmospheric pressure.

Symptoms of a clogged reference port on the AV sensor are varied. Noticeable drift in measured level when you know the level is essentially constant, or an oscillation in the level corresponding to changes in barometric pressure are two indicators of clogging in the reference port tube.

If dirt and/or moisture block the reference tube between the desiccant cartridge and the AV sensor connector on the flow meter, you may be able to clear the blockage from the tube by applying compressed air. Likewise, if the blockage is inside an *extension cable* for the AV sensor, you can try to clear it with air. In these cases, both ends of the tube are accessible.

However, if the blockage is inside the AV sensor's cable, the sensor may be ruined. The cable is sealed where it enters the AV sensor and the sensor itself is a sealed unit. Consequently, you cannot push air through the tube. Applying pressure to the connector will only drive the water further into the line, and may destroy the transducer inside the probe. If you suspect blockage in the AV sensor's reference tube, return the probe to Teledyne Isco. The repair department may be able to vacuum the water or blockage from the line; however, water may cause permanent internal damage, and not all blockages are removable.

You can avoid this problem completely by preventing moisture from entering the reference tube in the first place. Maintain the desiccators. Inspect them frequently and regenerate them when necessary.

3.1.3 Opening the Case

To access the flow meter controls and plotter, you must open the case. Unlatch the two catches on the right side of the case and pull open the lid. You will need to open the case whenever you change the plotter chart, or change the programming with the keypad. You can read the display through the window, so you can take periodic readings without opening the case. Again, do not allow the flow meter to operate routinely with the door open.

3.2 Connection to a Power Source

The 4250 requires a 12-volt, direct current (12 VDC) power input. This power may come from various sources:

- Companion Isco sampler
- Isco Nickel-Cadmium Battery
- Isco Lead-Acid Battery
- Isco AC Power Supply
- External 12 VDC battery, such as a deep-cycle marine or RV type

Detailed information on power sources is provided in the *Power Products Guide* provided with this manual. The procedures for connecting various power sources to the flow meter are discussed in the following sections.

3.2.1 Low Power Indication

When power to the flow meter falls too low for the unit to operate properly, the message POWER LOST - LOW BATTERY will appear on the top line of the display. When power is lost or falls below operating limits, the flow meter will stop measuring level, the display will go blank, and the internal printer will not be able to print. However, the internal battery-backed RAM will retain your program selections and stored data in memory, if there is any. (Note that you must be using FLOWLINK software for any data to accumulate in memory.)

3.2.2 Isco Sampler

If you combine a 4250 Flow Meter with an Isco Wastewater Sampler in a flow-paced sampling system, you can power the flow meter from the sampler's power supply. Connect the flow meter to the sampler with the Isco flow meter-to-sampler cable. This cable attaches to the **Sampler** connector on the flow meter and the **Flow Meter** connector on the sampler.

The flow meter will then receive power from the sampler. Keep in mind that under certain conditions, such as a fast setting on the chart speed, the flow meter will draw a significant amount of power from the sampler's battery. In such cases it is better for the flow meter to have its own battery.

> ☑ **Note**
>
> Do **not** attempt to run a sampler from a power source installed on the flow meter. While a flow meter will operate satisfactorily with a power source installed on a sampler, *the reverse is not true***.** The sampler's pump draws heavy current, particularly on start-up. The flow meter-to-sampler connect cable cannot carry such currents. If you are using a single power source for a flow meter-sampler combination, **always** install the power supply on the sampler.

3.2.3 Isco Nickel-Cadmium Battery

Teledyne Isco offers a 4 ampere-hour 12-volt rechargeable nickel-cadmium battery pack to power the flow meter. Teledyne Isco packages this battery specifically for use with Isco flow meters and samplers. Refer to the *Power Products Guide* accompanying this manual for detailed information about this battery and the procedure for charging it.

Attaching the Nickel-Cadmium Battery – Install the battery on the top of the flow meter case, and attach its connector to the 12 VDC connector on the side of the flow meter. Place the battery with its cable pointing toward the right side of the cabinet. Secure the battery by stretching the two rubber draw catches on top of the flow meter until they slip over the two metal “U” brackets on the ends of the battery case. Then screw the battery connector into the top mating connector on the right side of the flow meter case.

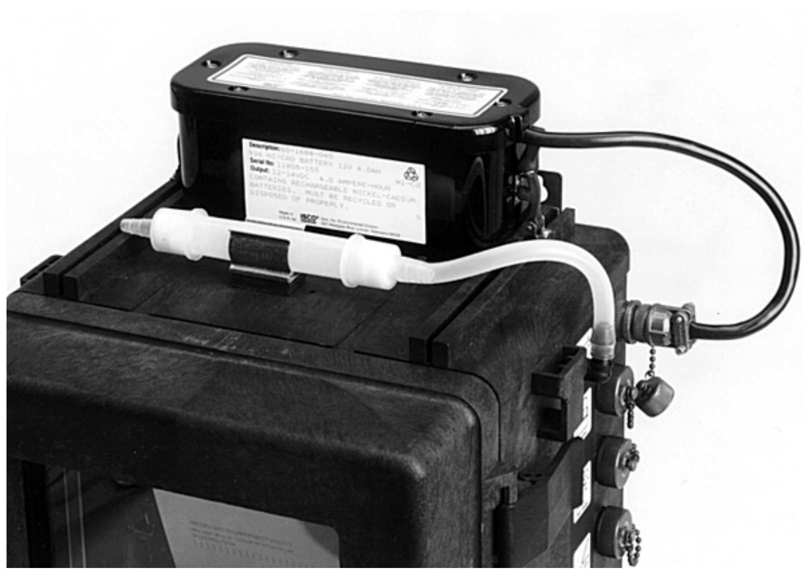


Figure 3-1 Battery Installed on Flow Meter

3.2.4 Isco Lead-Acid Battery

Teledyne Isco also offers a 6.5 ampere-hour 12-volt rechargeable lead-acid battery to power the flow meter. This battery is similar in size to the nickel-cadmium battery, except somewhat larger, reflecting its 50% greater capacity. Operation and maintenance of these batteries differs somewhat from that of the nickel-cadmium battery.

- Fewer charge-discharge cycles are possible, and a single deep discharge can ruin a battery, if it discharges all the way to cell-reversal.
- There is a linear voltage decrease as the battery discharges, while nickel-cadmium batteries show essentially the same voltage throughout discharge.
- Failure to recharge promptly and low temperature operation can also ruin the battery. Proper operation and maintenance are necessary for normal service life.

For detailed information on these batteries, refer to the *Power Products Guide.* Please read that manual if you intend to use lead- acid batteries on your flow meter.

Attaching the Isco Lead-Acid Battery – The lead-acid battery connects the same way as the nickel-cadmium battery. Place the battery on top of the case and secure it with the rubber draw catches. Attach the connector to the flow meter. If your flow meter is permanently installed, you may need to allow extra clearance above the flow meter for the slightly greater height of this battery.

⚠ CAUTION

Do **not** test either lead-acid or nickel-cadmium batteries for the condition of charge by “sparking” the output (shorting the terminals together with a wire, screwdriver, or other tool).

3.2.5 AC Power Supplies

Teledyne Isco also offers two different AC power supplies, the **High Capacity Power Pack** and the **Battery-Backed Power Pack**, to power the flow meter. These power supplies are designed for operation from 120 Volts AC, 50/60 Hz commercial power sources. Alternate versions, designed for operation from 240 Volts AC, 50/60 Hz are also available and are intended primarily for export. Both are supplied with a line cord for convenient attachment to the AC power source.

They are both capable of operating the flow meter. The Battery-Backed Power Pack provides 12 VDC at 5 Amperes, and is backed up by a 1.2 Ampere-hour nickel-cadmium battery. This is built in a package the same size as the standard power supply, and is intended for use where short-term power interruptions are frequent but unacceptable for flow meter operation.

☑ *Note*

The battery in the Battery-Backed Power Supply is of limited capacity. It is intended for short-term backup duty only. With one-fourth of the capacity of a standard battery, it can only power the flow meter for a limited period of time (approximately one day).

Attaching the Power Supply – Mount the power supply on top of the flow meter cabinet the same as described for the batteries. Secure the power supply with the two rubber draw catches pulled over the brackets on the ends of the power supply. Attach the short cable with the smaller connector to the top connector on the right side of the flow meter case. Connect the longer cord with the plug on it to an **unswitched** AC outlet. Refer to *Power Products Guide* for details about charging batteries with the power pack.

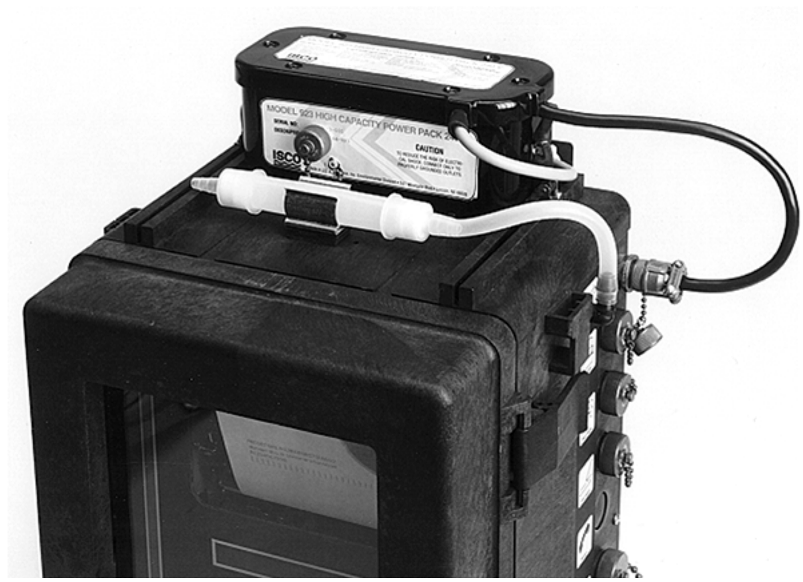


Figure 3-2 Power Pack Installed on Flow Meter

3.2.6 External 12 Volt Direct Current Source

You can also power the flow meter from an external 12 VDC source, such as an automotive, motorcycle, or marine battery. Many people have found that a deep-cycle marine/RV battery is particularly well-suited to this application. However, you will have to mount batteries of this type externally, as they are too large to fit on top of the flow meter. Teledyne Isco offers a special optional connect cable to power the flow meter from a separate battery. Mount the battery securely, *in an upright position*, so it will not inadvertently tip over, or be at risk of having its cable pulled off.

⚠ CAUTION

Be sure of proper polarity before attaching clips to the battery. **Never** attach the flow meter to a source of unknown polarity or voltage. If in doubt, check with a reliable DC voltmeter. **Never** attach the flow meter directly to an AC power source under any circumstances. Charge batteries only with compatible equipment, in accordance with manufacturer's instructions.

3.3 Flow Meter Mounting and Installation

The 4250 Flow Meter is a portable device; you may install it permanently or temporarily. You can suspend the flow meter in temporary installations, such as sewers, or mount it permanently in other installations, such as treatment plants, at your option.

⚠ CAUTION

Before any flow meter is installed, the proper safety precautions must be taken. The discussions of safety procedures provided in the back of this manual are only general guidelines. Each situation in which you install a flow meter varies. You must take into account the individual circumstances of your installation. Additional safety considerations, other than those discussed, may be required.

3.3.1 Carrying Handle

To help carry or suspend the flow meter, a handle is provided in the accessory package. To use the handle, clip the hooks at both ends onto the two metal brackets at the top of both side of the case.

3.3.2 Location of the Flow Meter

Because the flow meter uses an AV sensor for flow measurement, you do not have to install it directly above the measurement point, or even particularly close to the flow stream. You can install the flow meter in a convenient, protected location and route the AV sensor cable to the place where the level sensor is mounted. For example, you can install the flow meter above ground for protection and easy accessibility, and then you only need to enter the manhole for sensor installation and calibration (and occasionally thereafter for maintenance and inspection). You will need to mount the unit within 25 feet (7.6 m), (or 50 feet [15.3 m] with the 30 foot sensor) if you connect the sensor directly to the flow meter.

⚠ WARNING

The 4250 Flow Meter has not been approved for use in hazardous locations as defined by the National Electrical Code.

You can extend the distance to 50 feet (15.3 m) if you use the optional **25-Foot Extension Cable**. Connecting two extensions together lets you increase the distance to 75 feet (22.8 m). Do not exceed 75 feet with the extensions; this will slow the response of the sensor to level and atmospheric changes.

For distances from 75 to 1,000 feet, (304.8 m) use the optional **Quick-Disconnect Box**. Distances greater than 1,000 feet are not recommended. Details on the extension cable and Quick-Disconnect Box can be found in Section 4.

3.3.3 Mounting the 4250

The 4250 does not have any special requirements for mounting. You can locate it on any relatively flat surface either horizontally, supported by the two mounting pads and the stainless steel mounting bracket, or vertically, supported by the two plastic rails on the bottom of the case.

You can also panel-mount the flow meter, using the mounting bracket on the top rear of the case, or suspend it from a ladder rung using the optional suspension bracket. To use the bracket, the carrying handle should first be installed on the flow meter as described above. Then slip the handle through the suspension bracket.

Figure 3-3 4250 Suspended by Handle (handles may vary)

3.3.4 Vent Hose to Desiccant Cartridge

If you suspend the flow meter above the flow stream and there is any possibility of accidental submersion, attach several feet of vinyl tubing to the open vent on the end of the external desiccant cartridge. You should route this tubing to a place higher than the maximum possible level of the flow stream. This will prevent any water from entering the vent tube of the AV sensor in case of accidental submersion of the flow meter. Vinyl tubing can be purchased locally or from Teledyne Isco.

If you use the Quick-Disconnect Box to extend the distance between the flow meter and the sensor, attach the vinyl tubing to the desiccator cartridge vent on the Quick-Disconnect Box rather than the vent on the flow meter. (Presumably the flow meter is mounted safely away from the flow stream if you are using the Quick-Disconnect Box.) If you cannot mount the Quick-Disconnect Box far enough above the flow stream to ensure against accidental submersion when the flow stream is high, you should protect the desiccator and the reference port by venting them with vinyl tubing to a point the water cannot possibly reach.

Remember that water or other blockage inside the sensor's vent tube can ruin the sensor. It is even more important to protect the Quick-Disconnect Box than the flow meter, because the AV sensor will be directly attached to the Quick-Disconnect Box. When connecting the sensor to the flow meter, you may use an extension cable, which would offer some protection to the sensor.

3.4 Quick-Disconnect Box

You can install the flow meter as far as 1,000 feet from the AV sensor if you use the Quick- Disconnect Box. Otherwise, you must locate the flow meter within 75 feet of the 10 foot AV sensor, (100 feet for the 30 foot AV sensor), as this is the maximum length of cable available to connect the AV sensor to the flow meter (25 or 50 feet supplied with either AV sensor plus 50 feet maximum with two of the AV sensor extension cables.) Do not try to add more extension cords. If you need greater lengths, use the Quick-Disconnect Box.

Figure 3-4 Quick-Disconnect Box for the Area Velocity Sensor

To use the Quick-Disconnect box, you will need a cable of the correct length with an M/S connector to plug into the flow meter. Teledyne Isco will build the cable with the proper connector on one end and stripped wires on the other end as a special order. You should power the flow meter from AC if you must use the Quick-Disconnect Box, especially if you need to run the full 1,000 feet.

You can install the cable in conduit and connect the conduit to the Quick-Disconnect Box or you can run the cable in the open to the Quick-Disconnect Box and attach it with a waterproof compression bushing (available from Teledyne Isco). If you use conduit, use a liquid-tight fitting and a washer at the Quick-Disconnect Box.

Wire Color	Terminal Number
Red	1
Green	2
White	3
Black	4
Orange-White	5
Orange	6
Blue	7
Blue-White	8

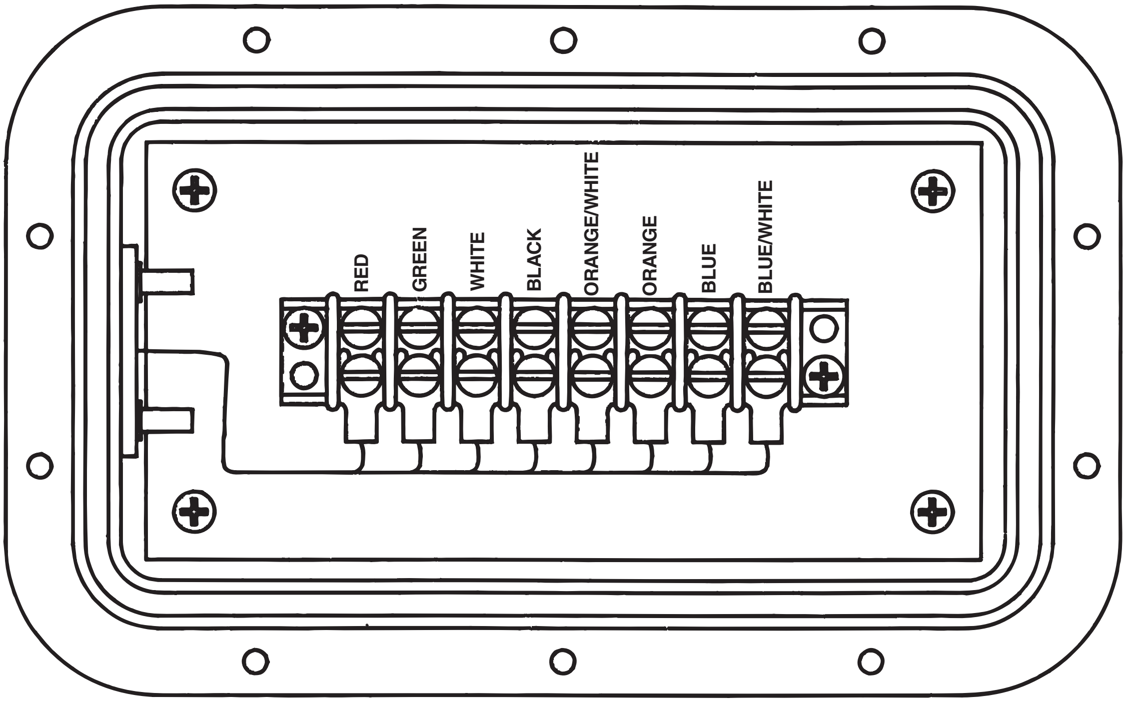


Figure 3-5 Cable Connections in the Quick-Disconnect Box

The wire colors shown are for the Teledyne Isco-supplied custom cable. You must use the Isco cable because the connector at the flow meter end of the cable is special and not available elsewhere. When you wire the cable inside the Quick-Disconnect Box, attach each wire to the terminal that has the **same color** wire soldered to it. Mount the Quick-Disconnect Box with screws through the holes in the stainless steel backplate. The connector on the AV sensor cable connects to the mating connector on the side of the Quick-Disconnect Box.

If you use the cable without conduit, you must install a compression bushing on the cable to make a water-tight connection. A picture of the compression bushing is on the next page. If you run the wiring inside conduit, liquid-tight fittings are needed. To minimize the effects of corrosion, we suggest the use of non-metallic conduit, if permissible.

The desiccant cartridge on the bottom of the Quick-Disconnect Box provides the atmospheric reference to the sensor's pressure transducer. If there is any chance of submersion of the Quick-Disconnect Box, attach vinyl tubing to the desiccant cartridge and route it to a place well above the maximum expected liquid level. When you have completed the wiring inside the box, replace the cover and tighten the screws that hold the cover securely to prevent the possibility of any moisture entering the case.

3.5 Extension Cables

The 10-foot range and low profile AV sensors are provided with 25 feet of cable. The 30-foot range AV sensor is provided with 50 feet of cable. If these lengths are insufficient, it is possible to connect an extension cable between the flow meter and the AV sensor. Teledyne Isco provides a 25-foot extension cable for either sensor.

⚠ CAUTION

The AV sensor extension cables and the AV sensor cable **cannot** be cut for any reason, or they will be ruined. The connectors are factory-sealed and neither the cable nor the vent tube inside can be satisfactorily spliced in the field.

Teledyne Isco does not recommend connecting more than two extension cables together to exceed the 75-foot limit (100 ft. for the 30 ft. sensor). Increasing the length of the vent tube beyond 75 feet slows the response of the pressure transducer, and this may cause measurement errors. For greater distances use the Quick-Disconnect Box and a custom-built cable.

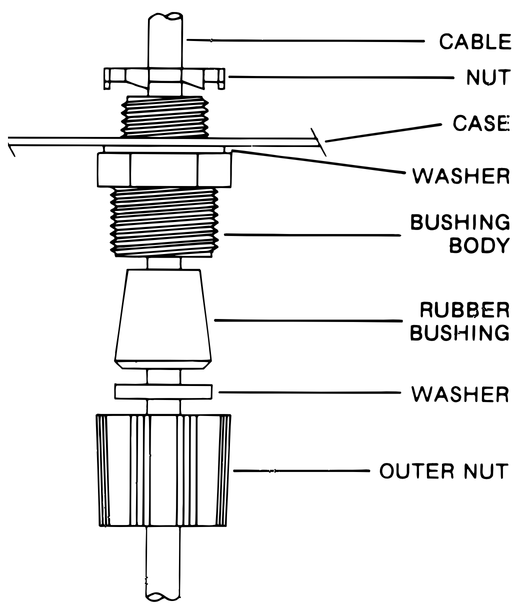


Figure 3-6 Assembling a Compression Bushing

The AV sensor uses a differential pressure transducer and two ultrasonic transducers. The cable connecting the AV sensor to the flow meter contains a small tube that references the pressure transducer to atmospheric pressure. This allows a true differential pressure measurement unaffected by changes in barometric pressure. This tube is vented through the connector into the cabinet of the 4250. From there, it is vented to the atmosphere through a desiccant cartridge mounted on the side of either the flow meter or the Quick-Disconnect Box.

3.6 Area Velocity Sensor Installation

Before installing the AV sensor, please consider the following:

- Exact dimensions for the channel and the correct level of the flow stream are essential for accurate results.
  The importance of accurate measurements for both area and level cannot be overstated. **The 4250 makes all subsequent calculations based on these measurements.**
- Errors in level measurement are more significant at low flows, while dimensional errors become significant at higher flows.
  Even minor errors in measurement will have a significant and cumulative effect. For example, in a nominal 10" diameter pipe with a 3" liquid level, a measurement error of only 1/4" in the diameter of the pipe and 1/4" in the level will result in a cumulative flow error of more than **14%!**
- Damage to the pressure transducer, ultrasonic transducers, electronics, or cable *will ruin* the sensor.
  Handle the sensor with reasonable care when installing. Do not drop or hit it. The pressure transducer is sensitive to shock. The sensor is encapsulated in a plastic potting compound and if damaged, cannot be opened for repair.
- The standard AV sensor accurately detects levels above approximately 0.1 foot (30 mm) and velocities for streams with a minimum depth of 2 – 4 inches (50-100 mm).
  This value is selected in programming. See Measuring Minimum Depth on page 2-14. Below the minimum depth, velocities are approximated, based on previous measurements. Although the standard sensor can measure levels less than 0.1 foot, (about one inch, or 25 mm) accuracy in this range is not guaranteed.
  Shallower streams should be measured using the low-profile AV sensor. Streams that run consistently below one inch are not a good application for the 4250.
- Velocity measurements depend on the presence of some particles in the water, either air bubbles or suspended solids.
  If the flow stream is so clear that there are neither air bubbles nor suspended solids, the velocity sensor cannot function properly and will not be able to read velocity. In such cases, it may be necessary to aerate the water upstream from the sensor with a small pump or other apparatus to ensure there is something to reflect the ultrasonic waves.
- When installing the AV sensor in a pipe or invert, mount the sensor upstream from the outfall. For the most reliable readings, place the sensor at the bottom center of the flow stream.

Although the sensor is easiest to calibrate when located at the bottom of the stream, you can locate it off-center in a larger pipe, if there are good reasons to do so. Streams that have large amounts of silt would be suitable for this. You can still calibrate the level accurately by using the offset distance to set the zero level in the program (see Page 2-14).

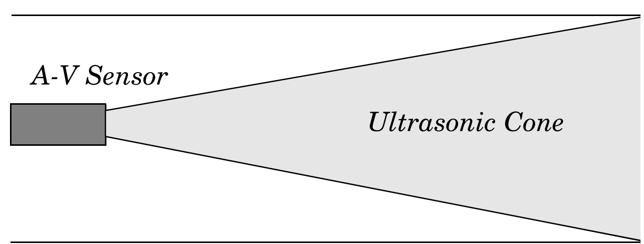
☑ **Note**

For installations where the sensor is mounted off-center, you must always have enough flow above the sensor to meet the minimum measurement depth. The AV sensor **cannot measure** either level or velocity if the flow stream falls below the sensor.

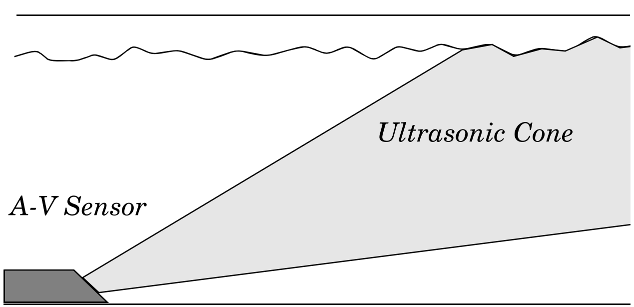
3.6.1 Level Measurement in Open Channels (No Primary Device)

When measuring level to calibrate an area-velocity installation, keep in mind the following:

- Make the measurement as accurately as possible.
- Measure the level at a point inside the ultrasonic “cone” extending upstream from the AV sensor.
- Measure level in an area of stable flow. (This may affect sensor location.)

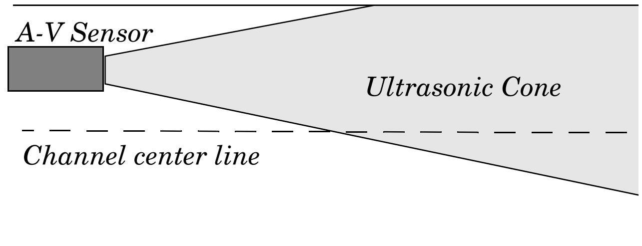


Top view of channel



Side view of channel

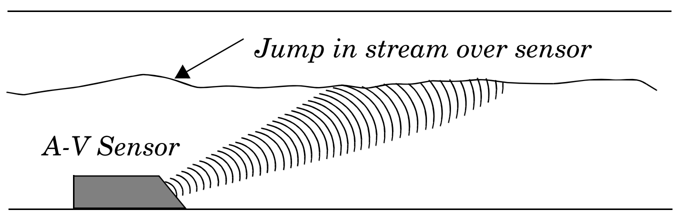
The sensor may be installed at a point offset from the bottom center line of the channel in cases where silting is a problem. However, typical installations are at the bottom center. Note how offset mounting of the sensor will change the dispersal of the ultrasonic “cone.”



Effect of offset mounting of sensor (Top view of channel)

In such cases, make sure you measure depth at a point **inside** the cone. In large channels, you may have to measure several feet upstream from the sensor.

Measure the diameter of the pipe. Then measure from the top center of the pipe to the liquid surface and subtract this distance from the pipe diameter to get the level. If the stream is not calm, average the measurements from the crest and the trough of the waves. Measure some distance **upstream** from the installed AV sensor. We suggest using a distance equal to the depth of the flow stream. For example, if the flow stream is one foot deep, you would measure level at a point one foot upstream from the sensor. Do not measure right at the sensor, as the profile of the sensor and the mounting strap may cause a "jump" or localized rise in the level. If you cannot measure upstream after installation of the sensor and strap, measure the level before installing the sensor. Do **not** measure downstream from the sensor.

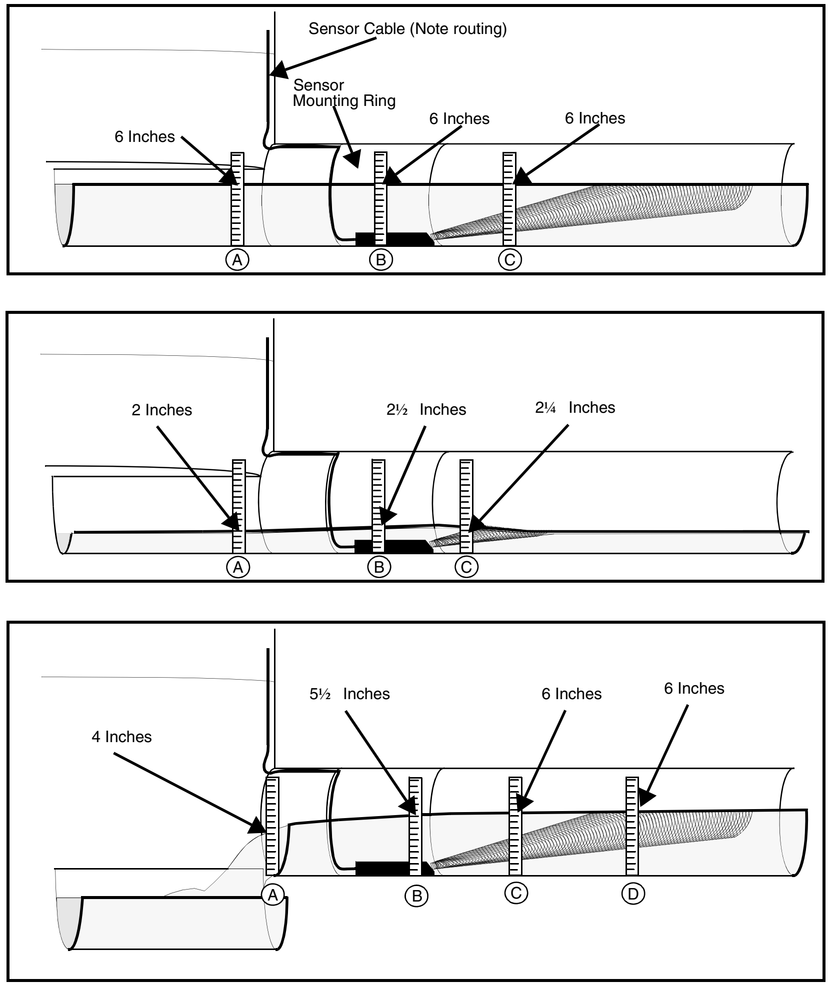


Side view of channel

If the level is low enough that you can see a visible jump or disturbance in the liquid surface where it flows over the sensor and mounting ring, you should measure the level with the sensor and ring out of the stream.

Changes in channel shape that affect the stability of the flow such as elbows, outfalls, inverts, etc. should be considered when locating the sensor. Avoid installation in areas where such changes in channel shape nearby make the flow turbulent. Instead, install where the flow has stabilized.

- You do not have to install the sensor with a primary measuring device.



*The flow in this 10" round pipe is **uniform**. The ideal level measurement point is always within the ultrasonic cone – point **C**, but it is not easily accessible. In this example, level measurement at point A is acceptable due to the **uniform** flow.*
Note: Not drawn to scale. Depths in all three examples are to show flow characteristics of each channel.

*The flow in this 10" round pipe is **not** uniform, due to the low liquid level and the disturbance caused by the sensor. At point **B**, the level rises as the liquid passes over the sensor and mounting ring. Measure level at **C.** If the flow becomes uniform when the sensor and ring are removed, take a level measurement close to the sensor location.*

*The flow at the a-v sensor is **not** uniform. The level drops sharply into the lower outfall. Similar effects would be noted in the case of an elbow or bend in the channel. In this example, the sensor should be moved forward to the uniform flow (between points **C** and **D**). Take the level measurement within the uniform flow. It might also be necessary to average several level measurements.*

Figure 3-7 Methods of Level Measurement

However, if you do install the sensor in a channel that has a primary measuring device (weir or flume) install it upstream or downstream from the device, not inside the device.

Primary devices with narrowed passages (most flumes) change the velocity of the liquid as it passes through the device. To minimize this effect, install the AV sensor at a point where the stream velocity has returned to normal.

Install the AV sensor at the prescribed measuring point of a primary measuring device if you only want to measure level. In such instances, program the flow meter using level-to-flow rate conversion with a secondary indication of velocity, rather than area-velocity conversion (see Section 2). Information on where to install the sensor is available for most primary measuring devices from the *Isco Open Channel Flow Measurement Handbook* or from the manufacturer of the device.

3.7 Rectangular and Trapezoidal Channels

A flat, anchored mounting plate is a common mounting choice for installing sensors in rectangular or trapezoidal channels. See the *Isco Mounting Rings Installation and Operation Guide* for more information.

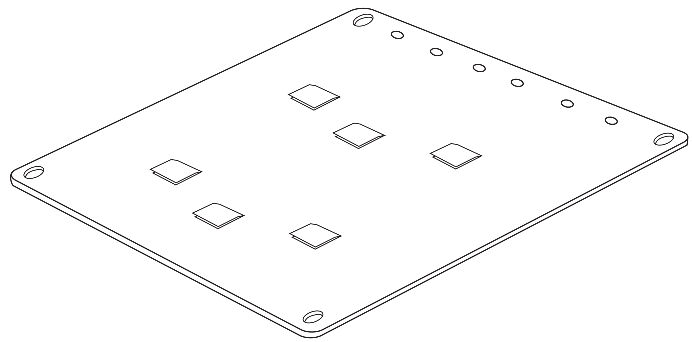


Figure 3-8 Isco Rectangular Mounting Plate

3.8 Mounting Rings for Circular Channels

Consult your Isco Mounting Rings Installation and Operation Guide for detailed hardware information.

The following sections describe sensor installation using the two options available for mounting the Sensor in pipes or round-bottomed flow streams. For pipes up to 15" (38.1 cm) in diameter, **stainless steel self-expanding mounting rings** (**Spring Rings**) are available. For pipes larger than 15" in diameter, Teledyne Isco offers the **Scissor Rings (Universal Mounting Rings)**. Area velocity sensors can also be installed using primary measuring devices.

3.8.1 Spring Rings

To install a spring ring, you compress the ring, slip it inside the pipe, and then allow it to spring out to contact the inside diameter of the pipe. The inherent outward spring force of the ring firmly secures it in place. A typical self-expanding mounting ring (with a probe mounted on it) is shown in Figure 3-9.

These mounting rings are available for use in pipes with inside diameters of 6" (15.2 cm), 8" (20.3 cm), 10" (25.4 cm), 12" (30.5 cm), and 15" (38.1 cm). The Teledyne Isco part numbers for the various size mounting rings available are listed in Appendix B. These part numbers include not only the ring, but also the miscellaneous hardware necessary to mount the sensor on the ring.

⚠ CAUTION

Always wear leather gloves when handling the rings (either type). The metal is finished, but there is still a possibility of cutting your hands on the edges.

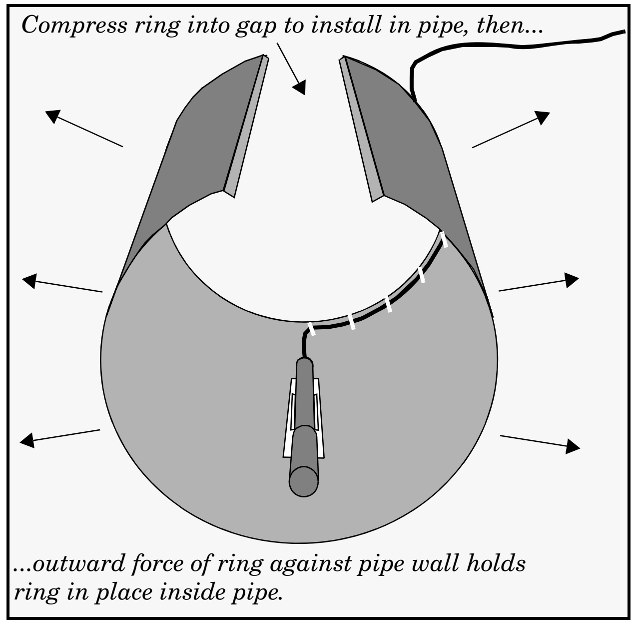


Figure 3-9 Sensor Installed on a Spring Ring

⚠ CAUTION

Make sure the slots on the sensor are completely pressed onto the tabs on the ring. This is particularly important where there is any possibility of reverse flows, or where flows are of high velocity. If the sensor is not fully pressed onto the mounting ring tabs, it might come loose in the stream, and could possibly be damaged or lost.

Completing the assembly

To complete the sensor-spring ring assembly procedure, attach the sensor cable to the downstream edge of the ring. Follow the cable routing shown in Figure 3-9. Other routing directions may affect measurement accuracy. The cable can actually create a stilling well downstream from the sensor, causing the level to read low. Use the self-locking plastic ties supplied with the ring. Install the ring in the pipe by compressing it. Press inward on both sides and slide the ring into the pipe.

Route the sensor cable out of the stream and secure it in position by placing the ties through the holes in the mounting ring and then locking them around the cable, as shown. To prevent debris from catching on the cable, it is important to attach the cable to the mounting ring so it offers as little resistance to the flow as possible.

⚠ CAUTION

Make sure the sensor cable is securely fastened along the back (downstream) edge of the ring. Otherwise, the sensor may provide **inaccurate level readings** under conditions of high velocity.
Do not overtighten the plastic cable ties; they should be tightened just enough to secure the cable in place, without greatly indenting the cable. Overtightening the plastic ties may collapse the reference tube in the cable, blocking it.

The spring ring may need anchoring. Under conditions of high velocity (greater than 5 feet per second or 1.5 meters per second), the ring may not have sufficient outward spring force to maintain a tight fit inside the pipe. The ring may start to lift off the bottom of the pipe in a waving fashion, or may even be carried downstream.

This problem is more prevalent in the larger diameter pipes (10", 12", and 15", and in pipes with smooth inside surfaces, such as plastic pipes). If any of these conditions are present, or if movement of the mounting ring is detected or suspected, you must anchor the ring in place. You can do this by setting screws through the ring into the pipe, or by other appropriate means. If there is a problem with the smaller diameter rings, it may be sufficient to simply increase the outward spring force of the ring by bending it into a less round configuration.

3.8.2 Scissors Rings

For pipes larger than 15" in diameter, Teledyne Isco offers the adjustable Scissors Ring (also known as the Universal Mounting Ring). This device consists of two or more metal strips that lock together with tabs to form a single assembly. There is a base section where the sensors are mounted, one or more extension sections (usually), and a scissors section at the top that expands the entire assembly and tightens it inside the pipe. The scissors mechanism includes a long screw that increases the width as it is tightened.

The assembled rings fit pipe diameters from 16" to 80". Secure the unit in place by tightening the scissors mechanism with a 5/8" socket wrench or other suitable tool. Ring sections are .040" thick half-hard 301 stainless steel sheet. All other parts are also stainless steel, except for the plastic cable ties in the hardware kit.

Each extension, 1, 2, 3, and 4, adds 9.0", 21.5", 31.5", or 41.5", respectively, to the circumference of the ring. Used alone, the base section fits pipe that is approximately 16" to 18" in diameter. The 9.0" (the smallest) extension exists so that in larger pipe sizes, where large variations in circumference can occur, you can use one or two of these extensions to take up or remove slack, to bring the scissors mechanism into a position where it can be effectively tightened.

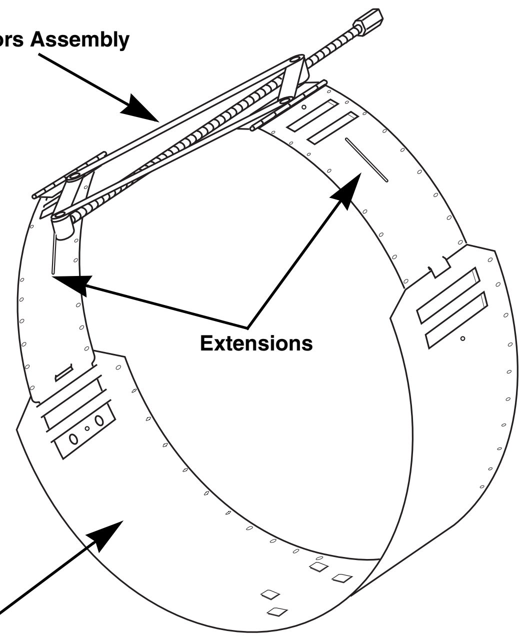


Figure 3-10 Scissors Ring Adjustment

Mounting ring kits are available for different pipe sizes. A kit is also available for partial pipe applications (consult your *Isco Mounting Rings Installation and Operation Guide*). For a listing of part numbers and ordering information, see Appendix A.

3.8.3 Completing the AV Sensor Installation

The AV sensor installation is finished by coiling any excess sensor cable and securing it using cable clamps or other means. The reference tube inside the cable can be restricted or blocked if the cable is kinked, sharply bent, or otherwise pinched. The sensor cable should be handled and mounted with care. Also, if there is any appreciable distance between the point where the sensor cable leaves the mounting apparatus and the location of the flow meter, *be sure* to attach the cable to the flow stream wall to prevent it from vibrating, moving around, tangling, or possibly collecting debris.

⚠ CAUTION

Under no circumstances should you leave any extra length of sensor cable dangling freely in the flow stream where it could trap debris or become tangled.

Use gloves and eye protection when assembling and installing the rings in a pipe. Though deburred, the edges of the stainless steel can cut if improperly handled. *Please read the information on how best to install this device.*

Observe general safety procedures when entering any manhole. See “General Safety Procedures” in the back of the manual for more information on general hazards and necessary precautions.

3.9 Sampler Interface

One of the uses of the 4250 Flow Meter is to control a sampler in a flow-paced sampling mode. Flow-paced sampling means that the flow meter is programmed to signal the sampler to take a sample after a specific volume of flow has passed through the flow stream, rather than after a particular period of time. In this mode, the sampler and flow meter will be able to compensate for varying flow rates. The 4250 Flow Meter may be used with any of the Isco Wastewater Samplers listed in Section 1.

An optional 25 foot (7.6 m) long connect cable is available to connect the flow meter to the sampler. Attach the six-pin female connector on the cable to the Sampler connector on the side of the flow meter. (This is the second connector from the top.) Attach the connector on the other end of the cable to the Flow Meter socket on the sampler. The flow meter will then be connected to the sampler's power supply, and the sampler will be able to receive flow-proportional signals from the flow meter. Refer to the sampler manual for further details.

4250 Flow Meter

Section 4 Options and Accessories

This section describes accessories available for use with 4200 Series Flow Meters. There are two groups of accessories. One group of options you can use with any of the 4200 Series. The other group are accessories for a specific type of level sensing and can only be used with one flow meter of the series. This section covers the accessories that are usable with any 4200 Series Flow Meter. Application-specific options are covered in the Installation sections of each type of flow meter.

Teledyne Isco offers the following options for use with all 4200 series flow meters:

- 4200T Modems
- 4-20 mA Outputs (Internal and External)
- Model 674 Tipping Bucket Rain Gauge
- Flowlink® Software (used with the modem or a laptop computer)
- Parameter Probes - Temperature, pH (acidity/alkalinity) and D.O. (dissolved oxygen)
- Mechanical Totalizer
- High-Low Alarm Relay Box
- YSI 600 Multi-Parameter Sonde

The 4-20 mA Output Interface, alarm box, rain gauge, and parameter probes are options you can field-install any time. The modems require factory modification to the flow meter, and you should specify these options when you order. If you want to add any of these later, you will need to return the flow meter to the factory.

4.1 4200T Modem

The 4200T Modem is a circuit board installed inside the flow meter that transmits flow meter data over standard telephone lines. The modem also makes it possible for the flow meter to receive data from compatible equipment at the other end of the phone line. Modems allow digital equipment to talk and listen to other remotely-located digital equipment over telephone lines.

4.1.1 How it Works

The analog phone system cannot transmit digital signals through repeaters; digital machines cannot communicate directly over phone lines. Modems convert the data into tones and transmit them over phone lines. The equipment on the other end of the line answers with tones through its modem. The first modem converts these tones back to digital data and interprets it. The 4200T Modem is full duplex and works in the auto-answer mode. It operates at 300/1200/2400 baud. This modem has speech and tone capabilities and comes with a connect cable to attach to the telephone line.

☑ **Note**

The modem is disabled when an interrogator cable is connected to the flow meter's interrogator port. It cannot receive incoming calls, and the alarm dialout will be rendered inoperable, while this cable is connected. **Disconnect the interrogator cable in order to use the 4200T Modem.**

4.1.2 Modems and Flowlink Software

The 4200T Modem communicates with Teledyne Isco's Flowlink data storage and acquisition software, setting up the flow meter to collect blocks of data. Flowlink allows storage and interpretation of flow meter data. Other Flowlink software packages can write reports with this collected data.

4.1.3 Connection to a Telephone Line

The FCC (Federal Communications Commission) governs communications over telephone lines. Your local telephone company will provide you with the line between the flow meter and the computer. Call them for connection information. The FCC requires the following information be published for connecting the modem to the phone line.

"This equipment complies with part 68 of the FCC rules. On the case of this equipment is a label that contains, among other information, the FCC registration number and ringer equivalence number for this equipment. If requested, this information must be provided to the telephone company."

"This equipment uses the following USOC jacks: USOC RJ11C.

"The REN is used to determine the quantity of devices that may be connected to the telephone line. Excessive REN's on the telephone line may result in the devices not ringing in response to an incoming call. In most, but not all areas, the sum of REN's should not exceed five (5.0). To be certain of the number of devices that may be connected to the line, as determined by the total REN's, contact the telephone company to determine the maximum REN for the calling area.

"If this equipment causes harm to the telephone network, the telephone company will notify you in advance that temporary discontinuance of service may be required. If advance notice isn't practical, the telephone company will notify the customer as soon as possible. Also, you will be advised of your right to file a complaint with the FCC if you believe it is necessary.

"The telephone company may make changes in its facilities, equipment, operations, or procedures that could affect the operation of the equipment. If this happens, the

telephone company will provide advance notice in order for you to make the necessary modifications in order to maintain uninterrupted service.

"If trouble is experienced with this equipment, please contact the Teledyne Isco Customer Service Department, (800) 228-4373 or, outside the U.S.A., call (402) 464-0231, for repair and (or) warranty information. If the trouble is causing harm to the telephone network, the telephone company may request you remove the equipment from the network until the problem is resolved.

"The following repairs can be done by the customer: None.

"This equipment cannot be used on telephone company-provided coin service. Connection to Party Line Service is subject to state tariffs.

"When programming and/or making test calls to emergency numbers:

"Remain on the line and briefly explain to the dispatcher the reason for making the call."

"Perform such activities in the off-peak hours, such as the early morning or late evenings."

4.1.4 Types of Service

The 4200T Modem is compatible with standard telephone lines and comes with a 12 foot cable. The cable connects the flow meter's **Modem** connector to a standard telephone jack, type USOC RJ11C, supplied by the phone company. You must mount the flow meter within 12 feet of this jack.

We are required by the FCC to provide the following notice:

"This equipment generates and uses radio frequency energy and if not installed and used properly, in strict accordance with the manufacturer's directions, may cause interference with radio and television reception. There is no guarantee that interference will not occur in a particular installation. If this equipment does cause interference to radio or television reception, which can be determined by turning equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- **Reorient the receiving antenna on the television.**
- **Relocate the unit with respect to the receiver.**
- **Plug the unit into a different outlet so the unit and receiver are on different branch circuits.**
- **If necessary, consult the manufacturer or an experienced radio-television technician for additional suggestions."**

You may find the following booklet, prepared by the FCC, helpful: *How to Identify and Resolve Radio-TV Interference Problems*. This book is available from the U.S. Government Printing Office, Washington, D.C. 20402, Stock No. 004-00-00345-4.

4.2 Connection to External Serial Device

Teledyne Isco offers two serial outputs from 4200 series flow meters. There is a software-enabled output that is transmitted on the RAIN GAUGE connector. This signal also appears on the INTERROGATOR connector. This feature lets the flow meter transmit the most recent values for all currently enabled ports as ASCII text. You can select the baud rate and the frequency of transmission. You can then write a simple program to retrieve this data periodically, or you can do it interactively using a terminal program. This option (SERIAL OUTPUT) is discussed in detail in Section 2.

Teledyne Isco offers a 300 baud output on the RAIN GAUGE connector. This port provides ASCII level and flow rate data for remote transmission to any ASCII-compatible equipment. Every 15 seconds the flow meter transmits a line of data which includes level, units of level measurement, percentage of maximum flow rate, maximum flow rate, a total flow value, units of flow, sample number, bottle number, text, time, and date.

If you are using the flow meter with an Isco sampler, the data line also includes an indication of a sampling event.

You can transmit this data line to a computer, or to a locally-connected (within 250 feet) device capable of interpreting serial data, such as a video display terminal or a printer. The specifications for this serial data output are as follows: 300 baud, 7 data bits, 2 stop bits, even parity. The printed (or displayed) line contains 110 characters and will appear similar to the following:

```
+01.409F 100.00% 2.500+0 CFS     0001533+0 CF     00 00
90 DEGREE V-NOTCH WEIR
000 0 90 04 04 02 31 48
```

The last two characters (not displayed) are a 'CR' (carriage return) and a 'LF' (line feed). The large gaps between some of the words indicate extra character spaces which are not used in this particular text, but which are available for use if needed.

> ☑ **Note**
>
> You cannot use both serial outputs at the same time. You must select one or the other.
> The serial output is paralleled with the Interrogator Port and the Internal Modem. Use of either the Interrogator Port or the Internal Modem will cause non-standard data to be transmitted.

4.3 4-20 mA Analog Outputs: External and Internal

These outputs provide connection between a 4250 Flow Meter and non-Isco process-control equipment, such as chlorinators, or any other type of equipment that you can control with a 4-20 milliampere current loop. Analog outputs convert digital information from the flow meter to a variable analog output current ranging from 4 to 20 milliamperes. When a condition measured by the flow meter is converted into an analog output, 4 mA becomes the 0% or baseline for the condition, while 20 mA becomes the 100% or full-scale of the condition. Teledyne Isco offers two different arrangements for providing the 4-20 mA outputs. One is an external box that converts the signals from the flow meter to a 4-20 mA current loop. The other is an internal circuit board containing three separate analog output circuits on the same board.

The 4 to 20 mA current is an industrial standard current loop for process control equipment that must respond to changing conditions by varying output rates.

4.3.1 External 4-20 mA Output Interface

The External 4-20 mA Output Interface has its own case and AC power supply. Commercial power (120 VAC) must be available for this device. Battery operation (12 VDC) is not feasible due to voltage and current demands. It comes with a line cord, connectors, and two interconnect cables. One cable has 6-pin M/S connectors on both ends. This cable connects the input of the 4-20 mA Output Interface to the flow meter **Interrogator** connector. The other cable has a three-pin plug on it that connects to the output connector of the 4-20 mA Output Interface. This cable ends in three pigtailed wires you connect to the equipment you want to control with the 4-20 mA Output Interface.

Table 4-1 4-20 mA Output Interface Specifications

Power	120 VAC 1/8 Amp.
Output Connector	3-pin male plug Pin A: + current out Pin B: – current out Pin C: not used
Output Accuracy: At 72• F (22•C) Full Oper. Range	 ±0.25% of full-scale ±0.5% of full scale
Operating Temperature Range	0• to 140•F (–18• to 60•C)
Resolution	0.1% of full-scale
Input Connector	6-pin male M/S Pin B: – pulse input Pin F: + pulse input Pins A, C, D, E: NC
Isolation	Output current optically isolated from flow meter.
Fusing	1/4 Amp. internal on AC line.
Adjustments / Calibration	Factory-calibrated; when used within range, no adjustment needed,
Maximum Distance	1,500 ft. (457.3 m) using 18 AWG wire.

4.3.2 Internal Multiple Analog Output Board

For those needing more than one analog output, Teledyne Isco offers the Multiple Analog Output Board, which is installed inside the flow meter. This board provides three isolated analog outputs. The board is compatible with the existing external 4-20 mA output box (60-1784-039). A flow meter can use either the internal board, the external box, or both, for a maximum number of four analog outputs.

☑ Note

If your flow meter has both the multiple analog output board and the external analog converter, the internal ports will be designated Analog Outputs 1, 2, and 3. The external converter will be designated either "External" or "Analog Output 0."

The Multiple Analog Output Board consumes a minimum of 16 mA per output; consequently, the flow meter should be AC-powered. If you must use battery power, you should consider the following to extend battery life:

- Use a Solar Panel Battery Charger
- Use a larger battery: either a commercial deep-cycle/marine type, or an Isco 35 Ampere-hour lead-acid battery.
- Order only one analog output.
- Flow meter program choices also affect power consumption. Use "minimum" settings, if possible. (See Section 1, Table 1-6 and Section 5.)

The outputs from the analog output board are electrically isolated from the flow meter and from each other by internal DC-DC converters. The board uses the opening for the modem connector for its outputs. Normally, a flow meter will not need both the analog and modem boards. If your installation does, however, you should contact the factory.

The analog board terminates in a 6-pin male M/S connector on the flow meter case. Flow meters built with the analog board option are also supplied with an output cable. This cable connects to the wiring that runs to the equipment controlled by the 4-20 mA current loop and to the 6-pin M/S connector on the flow meter. The cable has a 6-pin female M/S connector and is provided with stripped pigtail ends for convenient wiring.

Table 4-2 Multiple Analog Output Board Specifications	
Operating Temperature	0 to 140• F (–18 to 60• C)
Output Accuracy	±0.5% of full-scale
Resolution	0.1% of full-scale (0-20 mA)
Electrical Isolation	Isolated from each other and from the flow meter.
Calibration	Factory-calibrated; no further adjustments necessary.
Maximum output distance	1500 feet (457.3 m) using 18 AWG wire.
Current Range (per loop)	0 to 20 mA
Maximum Load (per loop)	750 ohms
Analog Output 1 Terminations	Pin A (Red wire –) Pin C (White wire +)
Analog Output 2 Terminations	Pin D (Brown wire –) Pin F (Blue wire +)
Analog Output 3 Terminations	Pin E (Black wire –) Pin B (Green wire +)
Note: If you must strip the cable further back to facilitate wiring, you will expose an orange, yellow, and purple wire. You may disregard these wires, as they are not connected in this application.	

4.4 Pacing Non-Isco Equipment

For applications requiring the conversion of the flow meter's flow proportional output signal to a fixed duration contact closure, Teledyne Isco offers the Type 'E' Interface.

Figure 4-1 Type 'E' Interface for pacing non-Isco equipment

To allow connection to a second device simultaneously, you must connect using the special Isco Y cable, part #60-5314-278. A connected sampler must have its own external power. NEVER connect the sampler and flow meter to the same power source.

⚠ CAUTION

Do not use the standard Isco Y cable (60-3704-081) with the Type 'E' Interface. This cable is designed for Isco sampler connection only.

Use of this device requires a factory modification to the flow meter. If you are connecting the Type 'E' Interface to a previously purchased flow meter, prepare the unit by performing the steps described in this section, or contact the factory to return the unit for modification by Technical Service.

⚠ DANGER

Risk of electrocution. Disconnect the flow meter from power before performing any modification or repair.

⚠ CAUTION

Always protect your equipment by observing anti-static precautions when exposing internal components. Turn to Section 5.7.1 for recommended precautions.

1. Remove the four Phillips screws on the front panel. Carefully pull the panel away from the case to access the interior.
2. Remove the lower metal shield by sliding it downward, freeing the tabs from their slots.
   This exposes the power supply PCB.

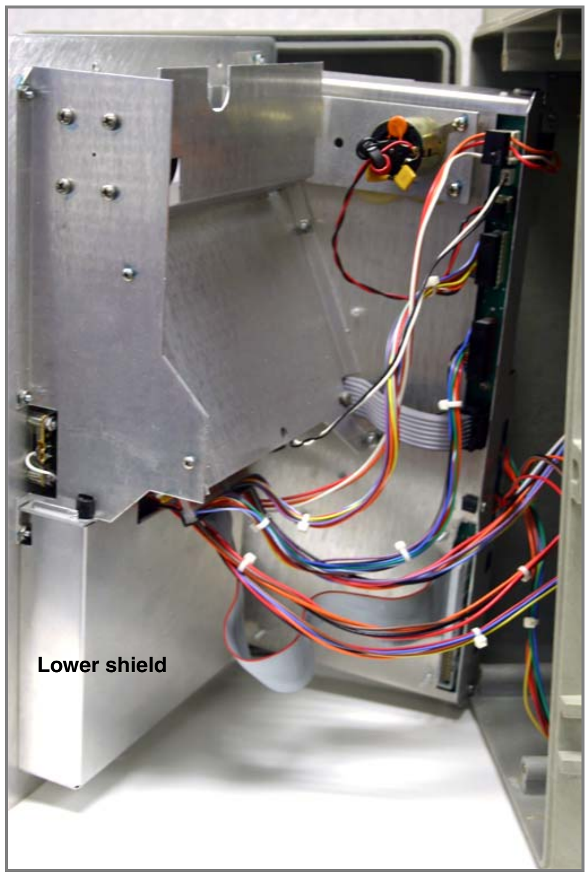


Figure 4-2 Flow meter with front panel removed

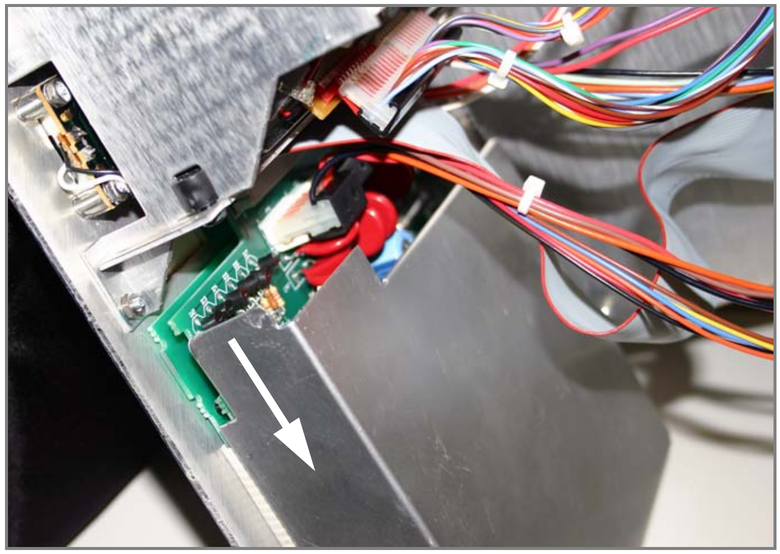
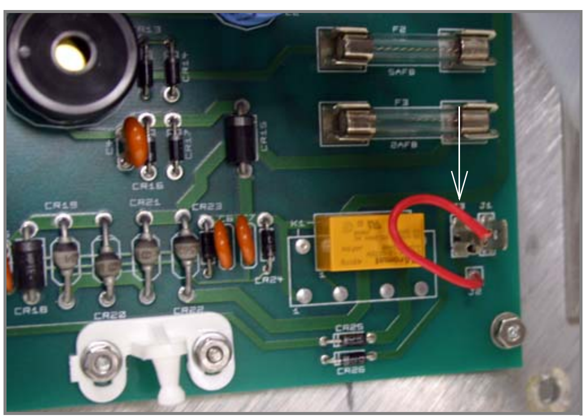
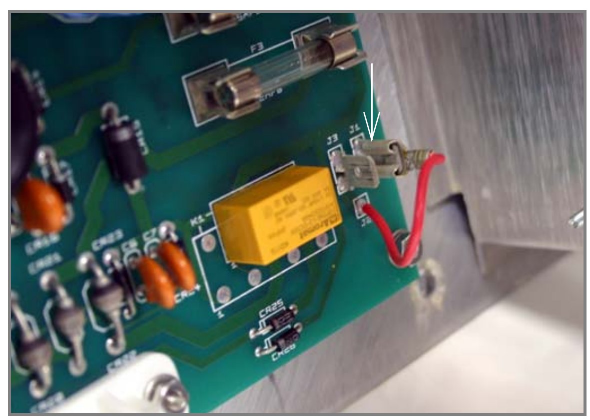


Figure 4-3   Removing the lower shield

3. In the lower right hand corner of the power supply PCB, disconnect the red wire's spade connector from J3 and connect it to J1.



Disconnect from J3.



Connect to J1.

Figure 4-4   Type 'E' modification

4. Replace the metal shield and carefully reattach the front panel to the flow meter case.

4.5 Tipping Bucket Rain Gauge

A Tipping Bucket Rain Gauge is available from Teledyne Isco for use with 4200 Series Flow Meters. The gauge connects to the flow meter by a cable terminated in an M/S connector. This connector plugs into the Remote Printer/Rain Gauge connector on the case. A Y-connect cable is available that allows use of both the rain gauge and a YSI 600 Multi-Parameter Sonde at the same time. You can connect extra cable (user-supplied) between the rain gauge and the factory-supplied cable as long as you do not exceed a maximum total length of 1,000 feet. Use 18 AWG wire or larger. **Do not cut the M/S connector from the cable**. The rain gauge is factory-calibrated to provide a contact closure to the flow meter for every hundredth of an inch (0.01") [or 0.1 mm] of rainfall. Software in the flow meter stores this information in memory and prints the accumulated data as a text line on the printer chart. It also allows the printout to be expressed in metric. You may, if you wish, provide a rain gauge of your own choice, but to ensure compatibility with the flow meter's operating environment, it must conform to the following specification:

- It must provide an isolated, dry contact closure.
- It must be a normally open contact configuration.
- It must close for 100 ms (–25 ms +150 ms) with less than 2 ms contact bounce.
- It must provide a contact closure for every 0.01" (or 0.1 mm) of rainfall

A cable assembly is available to connect a user-supplied rain gauge to the flow meter. More information about the rain gauge is available from the factory or the Rain Gauge Manual.

Figure 4-5 674 Tipping Bucket Rain Gauge

4.6 Isco Flowlink Software

Teledyne Isco offers a proprietary software system for data acquisition, storage, retrieval, and analysis. This software system, Flowlink, contains programs that allow 4200 series flow meters to store blocks of level and other data readings in the flow meter's memory. You retrieve this stored data with either a laptop computer or central computer connected to the flow meter by modem. You can use other programs in the package to process the retrieved data for further analysis. In addition to storing data, this software makes it possible to divide part of the flow meter's memory into partitions. These partitions may be formatted in "rollover" or "slate" mode of data storage. You can also set up the flow meter to store data as a result of some sort of "triggering" event, such as level rising to a predetermined point, the passage of a predetermined time interval, or the occurrence of a storm event, such as rainfall.

Consult the Factory - A detailed explanation of the Flowlink software is beyond the scope of this manual. Information on Flowlink Software is available from its manual or from the factory.

4.7 High-Low Alarm Relay Box

Teledyne Isco offers a control box that monitors flow rate data available from any 4200 Series Flow Meter. Alarm relays trip when the flow rate exceeds or falls below pre-selected limits. High and low set points are user-set and range from 0% to 99% in 1% increments. Output from the unit is the switching of form C (SPDT) relay contacts. The unit has 2 relays; one for high alarm and the other for low. The availability of form C contacts (both NO [normally open] and NC [normally closed] contacts) means you can switch loads either on or off. Relay contacts are rated 3 Amperes at 24 volts AC or DC. The alarm box operates on 12 VDC supplied from the flow meter. Current consumption in standby condition is approximately 10 mA. In alarm, current increases to 190 mA. You can connect as many as four alarm boxes to a flow meter, if the flow meter is powered from the AC line.

☑ **Note**

Do not use the alarm box if your flow meter has a modem or uses Flowlink software (through either a modem or laptop computer).

Use the alarm box with caution in battery-powered installations, as it will significantly increase power consumption.

In standby condition, an alarm box consumes about one ampere-hour of battery capacity in four days (or reduces capacity approximately 25%). In alarm condition, one alarm box will completely discharge a fresh (4 Ah) battery in 21 hours. Teledyne Isco recommends using only one alarm box in a battery - powered installation, and you can expect to change the battery more often.

4.7.1 Installation

The High-Low Alarm Relay Box is enclosed in a high-strength plastic box and is easily installed. Mount the unit with corrosion-resistant hardware through the 2 holes in the stainless steel mounting plate attached to the case. Two threaded holes in the case allow the use of either 1/2" conduit fittings or compression bushings. While the alarm box is suitable for use in damp locations, do not install it where there is any possibility of submersion. Where temperatures are expected to fall below freezing, Teledyne Isco recommends installation of the alarm box indoors or in a heated location, as the manufacturer of the microprocessor does not specify its operation below 32• F (0• C).

⚠ DANGER

Hazard of electric shock! Use the relay contacts for low voltage (24 V) pilot duty only. Do not wire 120 VAC or higher voltages to the relay contacts.

4.7.2 Wiring to a 4200 Series Flow Meter

Connecting the High-Low Alarm Relay Box to a 4200 Series Flow Meter requires a cable and an M/S connector. A special cable, 25 feet long, is available from Teledyne Isco. On one end of the cable is a 4-pin, male M/S connector. Plug this connector into the Remote Printer/Rain Gauge connector on the flow meter. The other end of the cable has 3 stripped wires. Attach them to the alarm box according to the instructions in the alarm box instruction manual.

BLACK	+12 VDC
GREEN	–12 VDC
WHITE	DATA

4.8 Parameter Sensing with Isco 4200 Series Flow Meters

Isco 4200 Series Flow Meters have the capability of displaying, recording, and (if Flowlink software is used) storing data provided from parameter sensors. The parameter sensors available for the Isco flow meters are for **temperature, dissolved oxygen (DO), pH,** (concerned with the acidity or alkalinity of a solution), and the **YSI 600 Multi-Parameter Sonde.** See **Section 2** for information on the YSI 600 Sonde. This section covers the Isco pH, D.O., and temperature sensors.

4.8.1 Installation of Parameter Probes

The parameter probes, as well as other Isco probes such as the submerged probe and area-velocity probe, require complete, continuous submersion in the flow stream for proper operation. Dry operation can damage the pH and D.O. probes. The YSI Sonde (only) may be suspended vertically in the stream. Teledyne Isco offers a series of rings that provide mounting for the probes in round pipes.

- Each probe snap-mounts to a specialized sensor carrier.
- The sensor carrier then attaches to the rings or mounting straps.

- The probe cable is carefully routed out of the stream.
- Only the temperature probe can connect directly to the flow meter's parameter probe connector.
- The pH and D.O. probes both connect to parameter modules (amplifiers). The pH probe connects to the 201 pH Module and the D.O. probe connects to the 270 D.O. Module. The modules are not interchangeable.

Note

The 270 D.O. module has been discontinued. Probes, service kits, and accessories are still available to maintain existing field units.

Isco flow meters are built with one parameter sensing port, and can only sense temperature plus one parameter at a time, (unless you use the YSI Sonde.) You must select temperature, D.O. with temperature, or pH with temperature. If you want to change probes later, you can, but you will need to reprogram the flow meter. Note that selection of either pH or D.O. in step 1 (where **units of measure** are defined) will lock out any mention of the other in the menus for the rest of the program.

The Parameter Modules themselves plug into the Parameter Probe connector on the flow meter.

CAUTION

The pH and D.O. probes require continuous submersion after installation, or they will lose sensitivity. **Prolonged dehydration of the sensor bulb may damage or even ruin the pH probe.**

4.9 Temperature Probe

The temperature probe is the simplest of the three, consisting of a thermistor inside a metal housing. The thermistor changes resistance with an increase or decrease in temperature. The flow meter converts this resistance change to a temperature reading and displays it, in degrees Celsius or Fahrenheit, as chosen by menu selection.

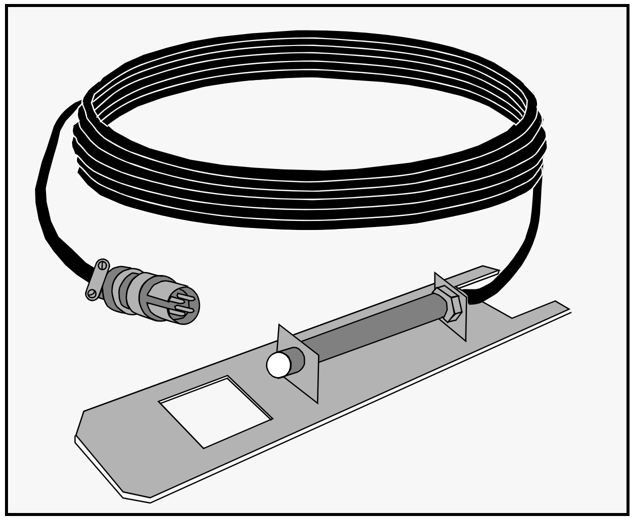


Figure 4-6 Temperature Probe

4.10 pH Probe

The pH probe measures the acidity or alkalinity of an aqueous solution by determining the relative quantity of dissociated hydrogen ions, H^+ (actually H_3O^+) in the solution. A larger quantity of H^+ ions indicates acidity, while a smaller quantity of H^+ ions indicates alkalinity. The *H* in pH stands for Hydrogen and the *p* stands for power.

The normal scale for pH runs from 0 to 14, with 0 being most acidic and 14 being most alkaline. Distilled water at 25° C is neutral at 7, based on the fact that the dissociation constant (number of H^+ and OH^- [hydroxyl] ions present) for pure water at that temperature is 10^{-7}.

The **dissociation constant** is a number indicating the degree of ionic dissociation for a substance after it is dissolved in water. Dissociation constants vary widely for substances depending on the nature of the substance's chemical bonds. Ionic salts tend to have higher constants.

Each number on the pH scale between 7 and 0 equals a tenfold increase in H^+ ion. Each number between 7 and 14 equals a tenfold decrease of H^+ ion. pH measurements of wastewater are commonly made to monitor the effect of treatment chemicals added to raise or lower the pH.

Water that has been used for various industrial processes may deviate substantially from 7. Chemicals are often added to the water to bring the pH close to that of neutral water, which is 7. For example, if the effluent has a concentration of heavy metal ions, they must be removed before discharge. Raising the pH of solutions containing transition-metal ions will cause them to precipitate, where they can easily be removed as sludge. The resultant solution will be high in pH and will require acid to neutralize it.

Figure 4-7 pH Probe (with protective cap)

The pH probe is a combination of two electrochemical half-cells. Together they provide a low-voltage signal that corresponds to the hydrogen-ion concentration of a solution. If you look at the pH probe, you will see a glass bulb on one end. This is called the glass mono electrode.

The glass is of special composition, sensitive only to hydrogen ions, and is exposed to the solution to be measured. The specific sensitivity to hydrogen ions prevents interference from other ions that may be present in the solution. It is essential to prevent grease fouling of this membrane. The glass membrane produces an electrical potential proportional to hydrogen ion activity. The other electrode, called the reference electrode, completes the circuit between the glass electrode and the solution.

The Isco pH probe combines both electrodes in a single housing and also contains an amplifier to reduce the extremely high impedance of the circuit. This improves the reaction of the probe to stray capacitance and reduces interference caused by electrical noise in the vicinity.

pH measurement is affected significantly by temperature, like any other chemical reaction. Consequently, temperature compensation is provided. in the flow meter. The Isco pH probe has a built-in temperature sensor that is exposed for faster response.

The pH probe connects to a Parameter Module that plugs into the Parameter Port on the flow meter. The probe has a 25 ft. (7.6 m) cable. For greater distances, contact the factory. The maximum distance between the module and the flow meter is 1,000 ft. (304.8 m).

When the ion-selective electrode and the reference electrode are connected to a high-impedance voltmeter and submerged in a solution, ions move to the surface of the membrane. The electrical charge on the ions creates a potential difference across the barrier between the solution and the membrane. This potential, or voltage difference, is proportional to the activity of the ions in the solution.

The potential, when read by a sensitive voltmeter, translates into a reading of pH. With an Isco flow meter, the voltage is sent first to a preamplifier inside the probe to reduce the impedance of the circuit and improve the signal-to-noise ratio, and then on to the parameter module to allow greater operating distance from the flow meter. The flow meter determines the pH value and displays it.

4.10.1 pH Probe Calibration

The 4250 provides a two- or three-point calibration for the pH probes with commercially-prepared calibrated buffer solutions. Calibrations of 4 and 7, 7 and 10, and 4, 7, and 10 are all possible. For accurate readings you must clean and re-calibrate the probe on a regular basis. How often you need to do this depends on the condition of your flow stream. Flow streams with a high grease content will coat the sensing surfaces of the probe quickly, clogging them and slowing the response time or stopping it altogether. **Installation in very greasy flow streams is not recommended.**

> ☑ **Note**
>
> For pH probe calibration, Teledyne Isco recommends that you use a glass container for the buffer solutions to ensure that the following conditions are met:
> The probe must be properly submerged in solution, and there must be no air trapped under the probe membrane, or the reading may become incorrect and/or erratic.
> Do not touch the probe until after you have performed step 6.

To calibrate the pH probe with the flow meter:

1. Go to program Step 1: PROGRAM, SETUP and select PROGRAM.
2. Step through the units of measure with the **Enter** key until you reach the menu that says pH UNITS - NOT MEASURED, pH. Select pH. You must do this in step 1 or the pH menu will not appear later.
3. Now go to step 3. PARAMETER TO ADJUST - NONE, LEVEL, pH (other selections may appear.) and select pH. If the pH menu does not appear in step 3, go back to step 1 to make sure you have turned it on. Then the pH selection of calibrations will appear.
4. Place the pH probe in the appropriate buffer solution until the stainless steel body is one inch beneath the surface.
5. If you select 4 & 7, the following screen will appear. Calibration with the other menu options (7 & 10 or 4, 7, & 10) is essentially the same as shown below. For the other menus, see Section 2.

```
RINSE PROBE AND PLACE IN 4.0 pH SOLUTION
PRESS ENTER WHEN STABLE: X.XX pH
```

6. Wait for the reading to stabilize (this may take from 30 seconds up to 5 minutes). When the probe has stabilized, press **Enter** and the following display will appear:

RINSE PROBE AND PLACE IN 7.0 pH SOLUTION PRESS ENTER WHEN STABLE: *X.XX* pH

When you have entered this second value, the pH probe calibration is complete. You can then install the probe in the flow stream.

☑ **Note**

An asterisk (*) may occasionally appear next to the pH reading for approximately 30 seconds, during which time the most recent reading will be displayed. This may be normal flow meter operation due to other internal functions, or could inicate pH fluctuation in the stream.

4.10.2 pH Probe Installation Guidelines

Installation of the pH probe is similar to the submerged level sensor and other parameter probes.

- Install the probe only in streams that have continuous flow. The sensing end of the probe must always remain wet.
- For proper operation, there must also be enough flow to submerge the sensing end of the probe completely.

If flow in the stream is intermittent (dry for periods of time), the pH sensing bulb will dry out and its response time will slow. This is a problem in situations where pH changes rapidly. If the probe is dry long enough, it will first lose sensitivity, then be slow to respond, and finally stop working. Never let the sensing end of the probe dry out completely.

- Installation in streams with high grease content will result in poor performance and require frequent cleaning and recalibration.

Greasy substances, being nonconductors of electricity, weaken the electrical potentials formed between the glass mono-electrode and the solution, slowing or halting the response altogether.

The pH Sensor operates satisfactorily mounted either horizontally or vertically in the stream. However, horizontal mounting is more secure, and presents less of a debris trap.

- Simple suspension of the probe is not recommended, particularly in streams of high velocity, or those that carry debris.

If you mount the pH probe vertically, mount it securely. Do not just hang it from the top of the pipe by its cable. Suspending the probe in the stream is not stable.

For horizontal mounting, the probe fastens to a sensor carrier that snap-fits to an Isco mounting ring. The mounting rings fit various diameters of round pipes 15" diameter and smaller. For larger pipes, use the **Isco Universal Mounting Ring**. For installation details, refer to the instruction sheet supplied with the mounting ring.

The mounting rings are held in place by the outward force of spring pressure in the smaller sizes and by a screw arrangement in the larger sizes. After mounting the probe in the ring or strap, route the cable out of the stream so it will not trap debris that could clog the sewer.

Mount the **pH Module** within 25 feet of the probe, but in a location higher than the highest anticipated level for the flow stream. The amplifier box is sealed and will withstand temporary submersion, but this should be avoided.

> **Note**
> Do not connect an Isco pH probe and temperature probe to the 201 module at the same time. The “Temperature Probe” input on the 201 module is for use ONLY with non-Isco pH probes that do not have built-in temperature sensing. The Isco pH probe contains its own integral temperature sensor, which, if connected in parallel with a separate temperature probe, will cause erroneous readings.

Figure 4-8 pH Parameter Module

> **Note**
> When installing the pH probe and its sensor carrier, make sure the mounting slots on the carrier are completely pressed into the mating tabs on the ring. The probe relies on a full engagement between tabs and slots for secure mounting. If the slots are loose against the tabs, the probe may be swept away by the force of the stream.

Always mount the probe in an easily-accessible location, because you will need to clean it from time to time. Also, all pH probes are consumable items, meaning that they will eventually fail and have to be replaced. The probe is due for replacement when you can no longer calibrate it (after cleaning) to ±0.2 pH with the standard buffers of 4, 7, and/or 10. Another indication of end-of-life is when the probe calibrates satisfactorily, but takes too long to stabilize (more than 10 minutes). Such a probe could not possibly respond to rapidly-changing pH. If your situation requires fast response, you should consider replacement when stabilization time reaches 5 minutes.

You can mount the probe facing either upstream or downstream, but Teledyne Isco recommends facing upstream, as there is a stop on the sensor carrier that is not effective when the probe is facing downstream. Remember to unscrew the rubber guard cap from the sensing end of the probe when you install it, or the probe will be unable to sense the flow stream.

The guard cap is to protect the probe during shipment and storage and to keep the glass membrane and liquid junction from drying out. If you remove the probe for any reason, clean it and replace the cap after filling with 4.0 buffer solution. **Never store the probe dry or without the cap in place.**

The Isco amplifier box extends the allowable distance between the probe and the flow meter. The probe has a 25-foot cable, so you must mount the amplifier within this distance. The maximum distance between the amplifier box and the flow meter is 1,000 feet.

Table 4-3 pH Probe Specifications

Description	Submersible, horizontal-mounting probe with combination-type electrodes. Porous Teflon® liquid junction to resist fouling and coating. Steam-sterilized glass hemi-bulb for long- term stability.
Size	6" long × 3/4 NPT.
Body Material	Stainless Steel.
pH Range	0 to 14 pH units.
Temperature	32• to 176• F (0• to 80•C).
pH Accuracy	±0.1 pH units over the full range.
pH Electrode Junctions	Double porous junction
Temperature Compensation	Performed by software inside the flow meter. The standard pH Probe contains an integral temperature sensor.

4.10.3 Storage and Maintenance of pH Probes

If you remove the pH probe from operation, be careful to keep the glass sensor bulb wet. Always store the probe with the rubber cover screwed completely over the threaded end of the sensor. Exposure to air causes the glass membrane on the sensor bulb to dry out. This makes it very slow to respond in solution. **Prolonged or repeated dehydration of the bulb will ruin the probe.**

The pH sensitive glass can also become “conditioned” to its environment, especially when it is continuously exposed to high pH (10 and above) solutions. The glass does have a memory and will respond slowly when exposed to a lower pH solution after having been in a high pH solution for any significant period of time.

Storage of a pH probe in a 4.0 buffer solution is recommended as this has a regenerative effect on the glass and does not put a memory on it. Tap water will work if 4.0 buffer solution is not available. Deionized water is good for quick rinses to clean the element, but not for prolonged storage of an electrode. Continuous exposure of the ion-sensitive membrane to a wetted, but non-ionic solution will improperly condition the membrane.

The reference electrode is also adversely affected when allowed to dry out. Salt crystals from the electrolyte or precipitates of the solution measured will form salt bridges, either within or on the surfaces of the liquid junction, causing the reference to be less conductive and resulting in a higher reference impedance.

This condition will typically worsen until the unit no longer functions. Soaking the reference electrode in a 4.0 pH solution, or tap water if the buffer is not readily available, may bring the reference back to life. Boiling the electrode in 4.0 buffer solution or tap water could revive the electrode in more severe situations. If none of these solutions work, it may be necessary to replace the probe.

4.11 Dissolved Oxygen (D.O.) Probe

This probe measures the amount of oxygen dissolved in a stream or waterway. Oxygen dissolved in water is necessary for many forms of life that dwell in lakes and streams. Inadequate supplies of dissolved oxygen will cause fish and other aquatic life that depend on them as a food source to die off or be sharply diminished in numbers. The measurement of dissolved oxygen content is of interest to those monitoring the condition of lakes and streams. Fish must have a certain minimum concentration of dissolved oxygen to thrive, typically 4 to 6 mg/l.

Various types of pollution can cause the amount of oxygen dissolved in water to drop sharply, placing the aquatic life forms at serious risk. The D.O. probe measures the amount of oxygen dissolved in water in a range from 0 to 20 mg/l. Note that the flow meter can display D.O. in either mg/l (milligrams per liter) or ppm (parts per million) depending on your choice in programming.

☑ **Note**

The D.O. module has been discontinued. Probes, service kits, and accessories are still available to maintain existing field units.

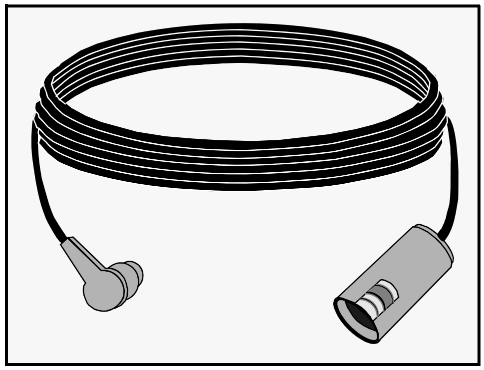


Figure 4-9 The D.O. Probe

For effective use of the D.O. Probe, please read and consider the following before making the installation:

- The D.O. Probe requires constantly moving water.
  The probe consumes oxygen during operation; this will deplete the oxygen available from stagnant or stratified waters, resulting in an inaccurate reading. Do not install it in a stilling well or in any location where water movement is intermittent or very low. As a guideline, a minimum velocity of one foot per second is suggested.
- Frequent maintenance is necessary when the probe is installed in flows with grease or solids content.
  Tests conducted by Teledyne Isco with probes installed in various waste streams have indicated that greases and solids quickly coat the probe's membrane, making it impossible for oxygen to enter the reaction chamber. This will result in an abnormally low reading, or no reading at all.
- Cleaning the membrane is generally not effective, as it tends to drive the solids further into the membrane pores. You must usually replace both the electrolyte and the membrane to get an accurate reading. In severe cases of fouling it may be necessary to change the membrane very frequently, even as often as every other day.

4.11.1 How the D.O. Probe Works

A thin, permeable membrane stretched over the sensor isolates the electrodes from the environment, but allows gases to enter. When a polarizing voltage is applied across the sensor, oxygen that has passed through the membrane reacts at the cathode, causing a current to flow. The membrane passes oxygen at a rate proportional to the pressure difference across it. Since oxygen is rapidly consumed at the cathode, it can be assumed that the oxygen pressure inside the membrane is zero. Hence, the force causing the oxygen to diffuse through the membrane is proportional to the absolute pressure of oxygen outside the membrane. As the oxygen partial pressure varies, both the oxygen diffusion through the membrane and the probe current change proportionally.

4.11.2 Probe Preparation

The following describes how to prepare a new probe for use, or how to change membranes on an existing probe. First, unscrew the sensor guard; remove the O-ring and membrane, then thoroughly rinse the sensor with distilled water. Prepare the KCl electrolyte according to the directions on the bottle. Use distilled water only. You install the membranes by hand. The probe is shipped with a small folder containing several replacement membranes.

Steps for installing a new membrane:

1. Secure the probe body so it is in an upright position. You can use a vise, adjustable wrench, or locking pliers, etc., whatever is satisfactory. Do not apply too much force to the probe body, or you will crack it.
2. Fill the cavity around the silver anode with electrolyte to the point where any more electrolyte would spill over. The liquid should be free of bubbles and should completely cover the tip of the sensor.
3. Lightly lay the membrane across the top of the probe. If you do this carefully, there will be no bubbles under the membrane.

☑ Note

Handle the membrane material with care, touching it at the ends only.

4. Place the O-ring on top of the membrane, generally conforming to the circumference edge of the probe.
5. Place the thumb and index finger from both hands opposite each other on the O-ring at equal distances.
6. Roll the O-ring down over the end of the probe, being careful not to touch the membrane where it covers the probe.
7. Trim off excess membrane with scissors or a sharp knife. Check to see that the stainless steel rod (thermistor) protruding below the liquid cup is not covered by extra membrane.

☑ Note

There must be no bubbles under the membrane and no creases in it for the probe to function correctly.

8. Shake any excess KCl solution from the probe. Reinstall the sensor guard. Keep the sensor in a humid environment when not in use and between measurements. The plastic bottle that was placed over the end of the sensor when it was shipped is ideal for this purpose. Place a piece of moist tissue inside the bottle, and slide the bottle over the probe.

4.11.3 Membrane Thicknesses

Teledyne Isco supplies a 2 mil (.002") thick membrane for use with the D.O. probe. This membrane is recommended for long-term monitoring situations only, typical of our users' applications. Use only this thickness membrane with D.O. probes connected to Isco flow meters. Do not use other thickness of membranes as the Parameter Module used with the probe is calibrated only for the 2-mil membrane, and cannot be recalibrated in the field. Do not use other membrane thicknesses or inaccuracy will result. Besides, the thinner membranes are very fragile and difficult to install.

4.11.4 Probe Installation

The D.O. probe attaches to a sensor carrier bracket that snaps into an Isco mounting ring. Use the specific size mounting ring for pipes less than 15" in diameter, and the universal mounting ring for pipe sizes greater than 15" diameter. Refer to the instruction sheet supplied with the mounting ring.

☑ Note

When installing the D.O. probe and its sensor carrier bracket, make sure the mounting slots on the sensor carrier are completely pressed into the mating tabs on the ring. The probe relies on a full engagement between tabs and slots for secure mounting. If the slots are loose against the tabs, the probe may be swept away by the force of the stream.

4.11.5 Probe Operation and Precautions

The following factors determine the life of the D.O. probe and the frequency of service.

- Membrane life depends on use. Membranes will last longer if installed properly and treated with care during use. Contents of the flow stream are also important, as some substances will foul the membrane very quickly. Erratic readings will result from loose, wrinkled or fouled membranes, or from large bubbles in the electrolyte reservoir. If erratic readings or evidence of membrane damage occur, you should replace the membrane and the KCl electrolyte.
- In environments where the membrane becomes rapidly coated with oxygen-consuming or oxygen-evolving organisms, erroneous readings may occur. Chlorine, sulfur dioxide, nitric oxide, and nitrous oxide can affect readings by reacting like oxygen at the probe. If your readings seem unreasonable, you may need to perform analysis to determine whether these gases are the cause. Long-term use, as for monitoring, can magnify the effect of these factors in some applications.
- Avoid any environment containing substances that may attack any of the probe's materials. Some of these substances are concentrated acids, caustics, and strong solvents. The probe materials that come into contact with the sample include FEP Teflon, acrylic plastic, ABS plastic, EPR rubber, stainless steel, epoxy, polyetherimide, and the polyurethane cable covering.
- For correct probe operation, the gold cathode must always be bright. If it is tarnished (which can result from contact with certain gases) or plated with silver

(which can result from extended use with a loose or wrinkled membrane), you need to restore its surface. You can return it to Teledyne Isco or clean it yourself with a probe reconditioning kit. (This kit is available from Teledyne Isco.) Never use chemicals or any abrasive not supplied with this kit. It is also possible for the silver anode to become contaminated, which will prevent successful calibration. Try soaking the probe overnight in a 3% ammonia solution; then rinse with deionized water, recharge with electrolyte, and install a new membrane. If you are still unable to recalibrate the probe after several hours, return the probe to Teledyne Isco for service.

- If the sensor O-ring is worn or loose, you should replace it. The probe comes with a kit of O-rings and replacement membranes. Additional replacement O-rings are available from Teledyne Isco in an O-ring replacement pack.
- If the probe is not going to be in constant use, you should store it in the plastic bottle provided in shipping. To keep the electrolyte from drying out, place a small piece of moist towel or sponge in the bottle and insert the probe into the open end. If you need service for your D.O. probe, Teledyne Isco recommends returning the unit for evaluation. In addition to servicing the probe, we can also provide advice on product applications, and you can also purchase other accessories for use with the D.O. probe. Use only 2-mil membranes with D.O. probes connected to Isco flow meters.

Table 4-4 D.O. Probe Specifications

Cathode	Gold
Anode	Silver
Membrane	FEP Teflon; 2 mil standard
Electrolyte	Half-saturated KCl (Potassium Chloride)
Temp. Range	0° to +45• C
Polarizing Voltage	0.8 Volts (Nominal)
Probe Current in Air at 30• C	19 microamps (nominal)
Probe Current in Nitrogen at 30• C	0.15 microamps or less
Connection	12 ft. (3.2 m) cable with 5-pin male M/S connector
Response Time	Typical response for dissolved oxygen, using supplied membranes, is 90% in 20 seconds. Response at low dissolved oxygen levels is typically 90% in 60 seconds.

Figure 4-10 D.O. Parameter Module

You must use the Isco 270 D.O. Module box between the probe and flow meter; this extends the distance between the probe and the flow meter to 1,000 feet.

4.11.6 Calibrating the D.O. Probe with a Flow Meter

Prepare the probe as described above if this has not already been done (fill the probe cavity with electrolyte and seat the membrane).

Note

You must use the Isco Temperature Probe with the D.O. Probe to provide temperature compensation.

Wrap both the D.O. Probe and Temperature Probe in a damp cloth. Wait ten minutes for it to stabilize, then proceed.

Go to **step 1** on the flow meter. Select PROGRAM, then step through the units of measure with **Enter** until you reach the menu for pH measurement. Select NOT MEASURED. Press **Enter**. Then D.O. UNITS will appear. Select either MG/L or PPM. Press **Enter**. Exit the program and re-enter going to **step 3**.

You must select measurement of D.O. in **step 1** or the D.O. menu will not appear in **step 3**. If you cannot get the D.O. menu to appear in **step 3**, recheck your selections in **step 1**. Remember that you must select NOT MEASURED for pH in **step 1** or D.O. will not appear on the menu for the rest of the program.

```
SELECT PARAMETER TO ADJUST
NONE LEVEL D.O.
```

Select D.O. Press **Enter**. This display will appear:

```
D.O. CALIBRATION
D.O STANDARD, ABS BAROMETRIC PRESSURE,
```

Altitude is just off the screen. You can select D.O. STANDARD if this calibration medium is available to you. Do not select ABS (absolute) BAROMETRIC PRESSURE unless you are at sea level or know how to correct for this value. The barometric pressure provided from the Weather Bureau is corrected for altitude. Select ALTITUDE.

ALTITUDE UNITS OF MEASURE FT, M

Then:

ENTER ALTITUDE ALTITUDE = *XXXXX* FEET *(or meters)*

Enter the altitude for your location. This is critical to the probe's accuracy. The following display will then appear:

WRAP D.O. PROBE IN MOIST CLOTH PRESS ENTER WHEN STABLE: *X.XXX* MG/L

The reading is in milligrams of oxygen per liter. If you chose PPM in program step 1 for D.O. units, the reading would be in parts per million.

4.12 Installation of Parameter Probes in Mounting Rings

The parameter probes and their carriers snap onto Isco Spring Rings and the base section of Isco Scissors Mounting Rings. You can also install them in other ways with custom hardware as is appropriate for your situation. For information on the Spring Rings and the Scissors Mounting Ring, refer to Section 3.8.

4.13 The YSI 600 Multiple Parameter Sonde

The YSI 600 Sonde is a multi-purpose water quality measurement and data collection system. It is intended for use in research, assessment, and regulatory compliance. The YSI 600 Sonde can measure the following water qualities:

- Dissolved Oxygen
- Conductivity
- pH
- Salinity
- Total Dissolved Solids
- Temperature

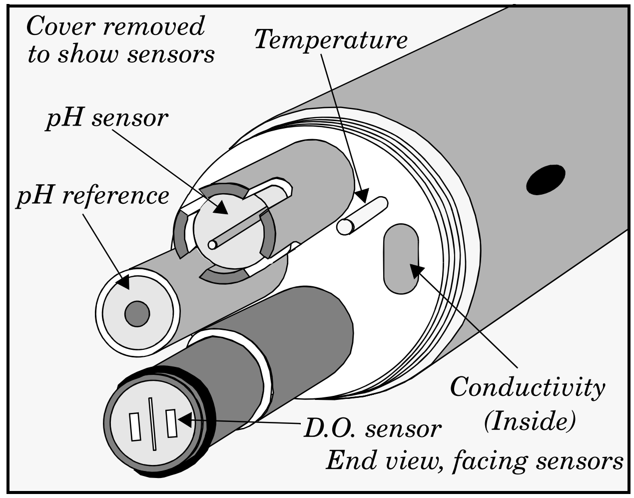


Figure 4-11 The YSI 600 Multiple Sensor Sonde

The YSI 600 is ideal for profiling and monitoring water conditions in industrial and wastewater effluents, lakes, rivers, wetlands, estuaries, coastal waters, and monitoring wells. It can be left unattended for weeks at a time with measurement parameters sampled at your selected interval and data transmitted to the flow meter. You can use the YSI 600 as deep as 200 feet below the surface, or in as little as a few inches of water. The fast sensor response of the YSI 600 makes it ideal for vertical profiling. Its small size means it can fit inside two-inch diameter monitoring wells.

A **Rapid Pulse Dissolved Oxygen Sensor** eliminates the need for stirring, providing accurate results without an expensive and bulky stirrer. Because no stirring is required, no supplemental power supply or battery is needed, and sensor drift caused by passive fouling is minimized.

The YSI 600 communicates with any 4200 Series flow meter equipped with suitable hardware and software. Earlier model 4200 flow meters can be factory-modified to work with the YSI Sonde. Data can be exported through Flowlink for further processing.

The YSI 600 is available with a 25 foot cable to connect to the flow meter. The cables are waterproof at the sonde and can be used in lab or field.

Information about programming the flow meter to use the YSI 600 is found in Section 2 of this manual. Information about the YSI 600 Sonde is found in the YSI manual.

Table 4-5 YSI 600 Probe Specifications

Complete Unit	
Medium	Fresh, Sea, or Polluted Water
Temperature	–5° to +45° C
Storage Temp	–40° to +60°C
Depth	0 to 200 Feet (0 to 61 meters)
Diameter	1.6 Inches (4.06 cm)
Length	14 Inches (35.6 cm)
Weight	4.9 Pounds (2.22 kg)
Materials	PVC, Stainless Steel
Computer Interface	RS-232C, SDI-12
Power	12VDC, Externally supplied
System Requirements	Connects to ***modified*** 9-pin Rain Gauge Terminal on any 4200 Series Flow Meter. Operation of Rain Gauge with YSI 600 is still possible with a special Y-connect cable. Modification of older 4200 Series Flow Meters is possible with changes in connectors and boards. Consult factory.
Sensor	
Temperature	
Sensor Type	Thermistor
Range	–5° to +45° C
Accuracy	± 0.4° C
Resolution	0.1° C
Dissolved Oxygen % Saturation	
Sensor Type	Rapid Pulse - Polarographic
Range	0 to 200 % Air Saturation
Accuracy	± 2% Air Saturation
Resolution	0.1% Air Saturation
Dissolved Oxygen mg/L	
Sensor Type	Calculated from % air saturation, temperature, and salinity
Range	0 to 20 mg./L
Accuracy	± 0.2 mg./L
Resolution	0.01 mg./L
pH	
Sensor Type	Glass Combination Electrode
Range	2 to 14 pH Units
Accuracy	± 0.2 Units
Resolution	0.01 Units
Conductivity*	
Sensor Type	Four-Electrode Cell

Table 4-5 YSI 600 Probe Specifications (Continued)	
Range	0 to 100 mS/cm
Accuracy	± (1% of reading + 0.001 mS/cm)
Resolution	0.01 mS/cm or 1 µS/cm
*Specific conductance (conductivity corrected to 25° C), resistivity, and total dissolved solids measurements are also provided. These values are automatically calculated from conductivity according to algorithms found in *Standard Methods for the Examination of Water and Wastewater* (ed. 1989).	
Salinity	
Sensor Type	Calculated from conductivity and temperature
Range	0 to 70 ppt
Accuracy	± 0.2 ppt
Resolution	0.1 ppt

4.14 Mechanical Totalizer

A mechanical totalizer is available for the 4250 that consists of a seven-digit, non-resettable mechanical counter mounted in the front panel. It must be ordered with the flow meter. The totalizer advances according to program selections for units of measure and the maximum flow of the primary device used. The totalizer is internally set to advance at $^1/_{100}$ of the rate of the display totalizer. Consequently, you must multiply the number shown on the mechanical totalizer by 100 to determine the actual value for total flow.

4250 Flow Meter

Section 5 Maintenance and Service

5.1 Routine Maintenance and Minor Service

The following sections provide routine maintenance and servicing instructions. Included are sections on cleaning the flow meter, reactivating the desiccators, maintaining the bubble line, servicing the internal printer, elementary troubleshooting and servicing CMOS circuitry.

Teledyne Isco recommends that you become familiar with the maintenance procedures presented here. While the 4250 is ruggedly built to withstand severe field conditions, it will function best and remain most reliable if you follow these simple procedures.

5.1.1 Care of the Flow Meter Case

If you close and latch the lid, and cap all the M/S connectors on the side of the case tightly, you can clean the case by spraying it with a hose or washing it with soapy water. Do not use a hose with a nozzle or a high pressure hose-and-wand. Do not immerse the flow meter in a tank of water to wash it. The flow meter can usually withstand accidental submersion in water, if that should occur, but it is not intended for routine submersion.

5.1.2 Care of the Case Seal

From time to time you should inspect the case seal and clean it, if necessary. The ridge around the edge of the case and the groove on the cabinet door form a seal when the door is closed. Keep this seal free of dirt, sand, etc. If it isn't, clean it carefully with a damp cloth. Also keep the rubber gasket in the lid clean. You can clean it with a small brush and a damp cloth. If you do any cleaning while the case is open, be careful not to let any dirt or debris fall inside the flow meter assembly. It is best to work on the flow meter with the case standing upright. If you don't maintain the seals properly, they may leak, causing damage and eventual failure of the components inside.

5.1.3 Preventing Moisture Damage

To prevent moisture damage to the internal components, keep the lid tightly latched at all times, except when it is necessary to change the program or change the chart. Do not operate the flow meter routinely with the case open. This will expose the internal components to dirt and moisture; it will also saturate the desiccant canister inside the case very quickly. Inspect this canister periodically and recharge it as necessary as described subsequently. It is also important to keep the external connectors clean by keeping the mating connectors or the protective caps tightly screwed down. Under severe operating conditions you can spray the threads of the connectors with a cleaner/lubricant such as Jif or WD-40 to prevent corrosion. Be careful not to spray any of the terminals (pins or jacks) inside the connectors; residue from the sprays could cause intermittent or failed connections.

5.2 Reactivation of the Desiccators

The 4250 has a reusable desiccant canister held by a steel clamp on the inside of the case lid. There is also a tubular desiccant cartridge on the top of the case next to the connectors. The canister contains silica gel that adsorbs moisture trapped inside the flow meter's case when it is closed. This keeps the inside of the case completely dry during shipment, storage and use. If you leave the case open, the desiccant will quickly absorb moisture from the surrounding air and will soon be saturated. It will no longer be able to protect the flow meter. Both desiccators use a color indicator that changes from blue to pink, or yellow to green, when saturated. The external desiccant cartridge vents the reference port of the pressure transducer.

5.2.1 When to Recharge the Desiccant in the Tubes

Both the 4250 and the optional Quick Disconnect Box dry the probe's vent tube with a desiccant tube. Inspect the desiccant tube frequently. Exposed to humid air constantly, the desiccant will become saturated quickly. If the desiccant is unable to dry the vent tube and the tube becomes blocked with moisture, the level readings will be unreliable, and the probe can suffer permanent internal damage.

Teledyne Isco uses silica gel (SiO_2) in the desiccant tubes and canisters:

- One looks like small beads or pellets that are blue-black when dry, pale pink to transparent when saturated.
- The other looks like coarse sand, yellow when dry, dark green when saturated.

Regenerate silica gel before all the desiccant in the tube turns pink or green by heating.

Another type of desiccant may be used in the tubes: anhydrous calcium sulfate ($CaSO_4$). Calcium sulfate looks like rough chips of tinted plaster and changes from blue when dry to rose-red when saturated. Regenerate the calcium sulfate desiccant before all the desiccant in the tube turns rose-red. **Do not put calcium sulfate in the metal desiccant cartridge.**

The filters in the ends of the desiccant tube prevent desiccant particles from entering the vent line. When they become soiled, replace them with cotton balls.

The desiccant in the tube requires periodic recharging to dry it after it becomes saturated with moisture. After repeated recharging, it eventually requires replacement.

☑ ***Note***

Both desiccants, anhydrous calcium sulfate and silica gel, are regenerated in the same way but require different temperatures. Calcium sulfate requires temperatures of 400• to 450• F; silica gel requires temperatures of 212• to 350• F.
Either chemical may produce irritating fumes when heated. See Appendix D Material Safety Data Sheets for silica gel desiccant information.
To regenerate all desiccators safely, follow these guidelines:
Always use a vented, circulating forced air convection oven in

a well ventilated room.
DO NOT use a microwave oven to recharge the desiccant cartridge. Heating the metal cartridge case in a microwave oven will damage the oven.
Leave the room while heating the desiccant.
Avoid heating the desiccant longer than necessary.
Use the recommended temperature. Avoid heating the desiccant at higher than recommended temperatures.
Do not heat the plastic desiccant tube. It will melt in the oven.

5.2.2 Regenerating the Desiccant Canister

Look at the desiccant canister each time you open the case. The canister has a window on its side that appears blue or yellow when the desiccant is dry. As the desiccant absorbs moisture, the window will turn pale pink or green. When the window is pink or green, you need to regenerate the desiccant, or replace it with the spare canister provided in the flow meter accessory package. Remove the canister from the flow meter by pulling outward on the spring clamp, releasing its hold on the canister.

Remove the canister and heat it in a **vented** oven in a well-ventilated room at 300°F (150°C) for about three hours, or until the blue or yellow color returns. Do not use a microwave oven; the metal case of the canister could cause arcing. After cooling, reinstall the canister in the flow meter. Make sure the window on the side of the canister remains visible.

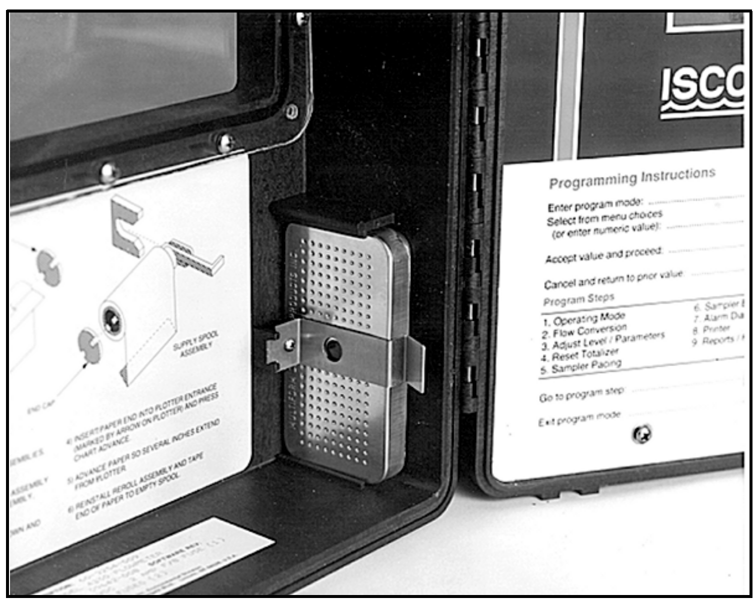


Figure 5-1 Location of the Desiccant Cartridge

MSDS (Material Safety Data Sheets) for these chemicals are provided at the back of this manual.

⚠ CAUTION

There have been reports of irritating fumes coming from the desiccant during regeneration. While our attempts to duplicate the problem have been unsuccessful, we still urge you to use caution.

- Use a vented oven in a well-ventilated room.
- Do not remain in the room while the regeneration is taking place.

To regenerate the desiccant cartridge:

1. Carefully snap it out of its bracket.
2. Pull the silicone tubing from the end of the cartridge.
3. Remove one of the end caps from the cartridge by twisting and pour the saturated desiccant into a metal, ceramic, or other heat-resistant container.
4. Identify the desiccant and heat it at the proper temperature two to three hours, or until the blue or yellow color returns.
5. Do not try to regenerate the desiccant inside the cartridge; the cartridge is plastic and will melt.
6. Refill the cartridge with the regenerated desiccant (or with the extra desiccant provided in the accessory package.
7. Replace the end caps.

Notice the foam filters in the end caps; they keep small pieces of the desiccant material from falling out of the cartridge. You can clean these filters from time to time using ordinary dish soap and water, then allow to dry.

☑ ***Note***

Regeneration of the desiccators is extremely important. Saturated desiccators let the flow meter draw moisture inside, exposing both mechanical and electronic components to water and/or chemical contamination. The air in many installations contains fumes that will form acids in the presence of moisture. These acids may corrode electrical components, particularly connectors and circuit boards.

Moisture drawn into the area-velocity probe's reference port vent tube will disable the probe.

Unseen damage caused by moisture will eventually ruin the flow meter. For maximum equipment life and reliability, inspect the desiccators regularly and regenerate them when necessary.

5.3 Care of the AV Sensor and Cables

The area-velocity sensor and its cable require little periodic maintenance unless there is a great deal of debris in your flow stream. Certain materials that swell when wet, such as sawdust, can clog the ports of the probe, blocking the hydrostatic pressure of the stream from reaching the transducer.

The pressure transducer is on the bottom of the probe. If you remove the mounting plate from the probe body, you will see a protective plate attached with two screws. The pressure transducer is behind this disk. In general, it should not be necessary to remove this disk, and Teledyne Isco strongly recommends that you do not. In the standard AV sensors, removing the plate will expose the paper-thin diaphragm of the transducer. Read the following sections carefully before attempting to disassemble the probe.

⚠ CAUTION

If you disassemble the AV sensor for cleaning, do not touch the stainless steel diaphragm with your fingers or tools. The diaphragm is very thin (<0.003"), and easily bent.
The slightest deformation may result in damage to the transducer or the placing of a permanent offset on it. In either case the AV sensor will be ruined. Do not drop the assembly or subject it to any physical abuse.

5.3.1 Low Maintenance

The pressure transducer, the ultrasonic transducers, and the electronic components of the area-velocity sensor are encapsulated in plastic resin and are not user-serviceable. If any part of the sensor fails, contact the Teledyne Isco Service Department.

It may be beneficial to periodically clean the flow stream up- and downstream from the area-velocity sensor to maintain the hydrostatic conditions on which the level measurements and level-to-area conversions are based. The sensor was designed to expose a small frontal area and a streamlined profile to the flow, and that reduces the possibility of accumulating deposits of solid materials.

5.3.2 Cleaning the Standard AV Probe

Rarely, organic materials may become jammed inside the AV sensor's liquid ports. If this material swells as it becomes saturated with water, it may cause inaccurate pressure transmission to the level sensor. In the unlikely event that both entrance ports in the AV sensor become blocked with material that does not permit the pressure above the probe to be transmitted to the pressure transducer, you can clean the sensor with the following procedure:

1. Remove the AV sensor from the flow stream.
2. Scrape any accumulated solids from the exterior of the sensor body with a brush.
3. Remove the three screws holding the sensor carrier plate to the bottom of the probe. Be careful not to lose the small

spacer disk between the the sensor mounting plate and the screw at the front of the sensor.

4. Flush the underside of the sensor with water. Do not remove the protective disk and round gasket from the level sensor unless you can see that the ports are blocked with solids.
5. If the ports are clogged and do not clear with the running water, you may have to **carefully** remove the disk and gasket. Removing the disk exposes the delicate, paper-thin metal diaphragm of the pressure transducer. **Do not touch the diaphragm with fingers or tools.**
6. Gently flush with water, without training the stream directly into the cavity. **Forcing water or air directly against the diaphragm can ruin the probe.**

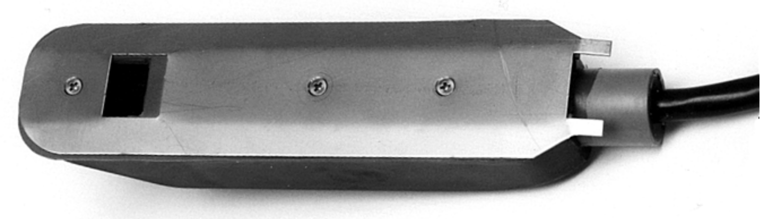


Figure 5-2 Standard AV Probe with Mounting Plate

Figure 5-3 Standard AV Probe, Protective Disk Exposed

5.3.3 Cleaning the Low Profile AV Probe

The low profile AV sensor is cleaned in the same manner as the standard AV sensor. However, the transducer is encased in stainless steel. Nevertheless, do not insert anything into the vent holes when cleaning the transducer area.

Figure 5-4 Low Profile AV Probe Without Mounting Plate

Figure 5-5 Low Profile Probe With Transducer Housing Revealed

5.3.4 Cable Inspection

Periodically inspect the AV sensor cable for wear caused by abuse or exposure to the elements. Damaged cables can affect the operation of the probe, particularly if the reference port vent tube inside the cable is collapsed or blocked. Unless the damage is very close to the connector, which can be replaced, a probe with a damaged cable is not repairable.

Keep connectors clean and dry. Although connectors are sealed, if moisture penetrated a loose connection or uncapped connector, the connector and/or probe could be ruined. In permanent installations, install the cables so they are not at risk of damage resulting from other activity taking place in the area.

In temporary installations, do not leave cables lying around where they may be run over by heavy equipment. Do not leave extra cable loose in the flow stream where it can tangle and trap debris.

In permanent installations, cables repeatedly subjected to rough environments will fail and should be installed in conduit for protection. The conduit will have to be large enough to pass the connector.

⚠ CAUTION

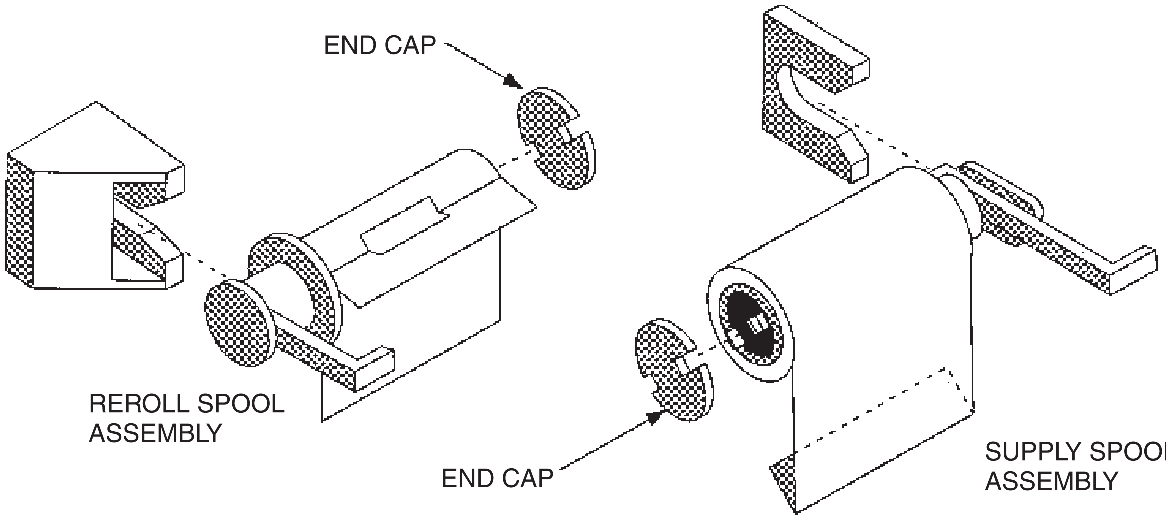
Avoid putting heavy pressure on the probe cable or making sharp bends in it when installing or servicing the probe. Excessive pressure may collapse the cable, crushing the reference vent tube. Sharp bends may cause the cable to kink, also blocking the vent.

When securing the cable with plastic cable ties, tighten them only enough to secure the cable; do not tighten them so much that the cable jacket is visibly deformed.

5.4 Maintenance of the Printer

The internal printer needs little maintenance beyond changing the chart roll and the ink ribbon.

Refer to the pictures provided for each section. Also refer to the label inside the cabinet.



1. REMOVE REROLL AND SUPPLY ASSEMBLIES, AND REMOVE WHITE CAPS.
2. PLACE EMPTY SPOOL ON REROLL ASSEMBLY AND NEW SPOOL ON SUPPLY ASSEMBLY. REPLACE BOTH END CAPS.
3. FOLD END OF NEW PAPER AS SHOWN AND REINSTALL SUPPLY ASSEMBLY.
4. INSERT PAPER END INTO PLOTTER ENTRANCE (MARKED BY ARROW ON PLOTTER) AND PRESS CHART ADVANCE.
5. ADVANCE PAPER SO SEVERAL INCHES EXTEND FROM PLOTTER.
6. REINSTALL REROLL ASSEMBLY AND TAPE END OF PAPER TO EMPTY SPOOL.

Figure 5-6 Changing the Chart Paper

5.4.1 Changing the Roll of Paper

To change the chart paper you will need:

- a new roll of paper
- a knife or a pair of scissors
- a small piece of tape

The printer will shut down when the paper runs out. The roll is nearly empty when a 1-inch wide pink band appears on the left side of the chart.

To remove the used roll:

1. Locate the handle on the left side of the take-up roll.
2. Pull straight out on this handle until the take-up roll slips off the printer.
3. Remove the paper roll from the take-up spool by holding the handle in one hand with your thumb pressed against one of the slots in the white end cap.
4. Snap the white end cap free from the two black catches on the end of the spool.
5. Pull the paper roll off the spool with your other hand.

6. Remove the feed spool by pulling on the handle extending from the right side of the printer.
7. Snap off the other white end cap as described previously. Save the white end caps; you will reuse them.
8. Remove the empty roll from the spool by holding the handle in one hand and pulling the roll from the spool with the other.

To install the new chart paper:

After you remove the empty roll,

1. Slide the new roll onto the feed spool so it unrolls from the back side - facing away from you.
2. Line up the slots in the cardboard tube with the raised guides on the spool.
3. Reattach the white end cap by wedging the two catches on the end of the spool into the two slots on the white end cap.
4. Peel the paper back gently so it will unroll freely. Using the knife or scissors, cut off the end of the roll if it is torn.
5. Fold the paper over on itself so the end is straight and stiffer than a single layer of paper would be.
6. Unroll a few inches of the paper and set the roll on top of the cabinet.
7. Use your fingers to feed the paper down the back of the internal printer to where it touches the roller. Make sure the paper gets past the lever for the paper sensing switch.
8. Press the Chart Advance key and hold it until the paper comes through the printer mechanism.
9. When the paper comes through, reinstall the feed spool with the new roll on it by snapping it into the printer assembly.
10. Run a few inches through the printer, using the Chart Advance key; then unfold the end.
11. Put the cardboard tube from the empty roll on the take-up spindle and reattach the white end cap by wedging the catches on the end of the spool into the two slots on the white end cap.
12. Use the piece of tape to attach the end of the new paper to the cardboard tube from the old roll.
13. Roll some of the paper onto the spool so that it will wind clockwise, facing away from you. Then reinstall the take-up roll into the top of the printer.
14. Be careful to push it all the way back in, so that the take-up gear on the end of the spool assembly will reengage.
15. When the take-up spool is back in place, push the Paper Reroll key; this will remove any slackness in the paper.

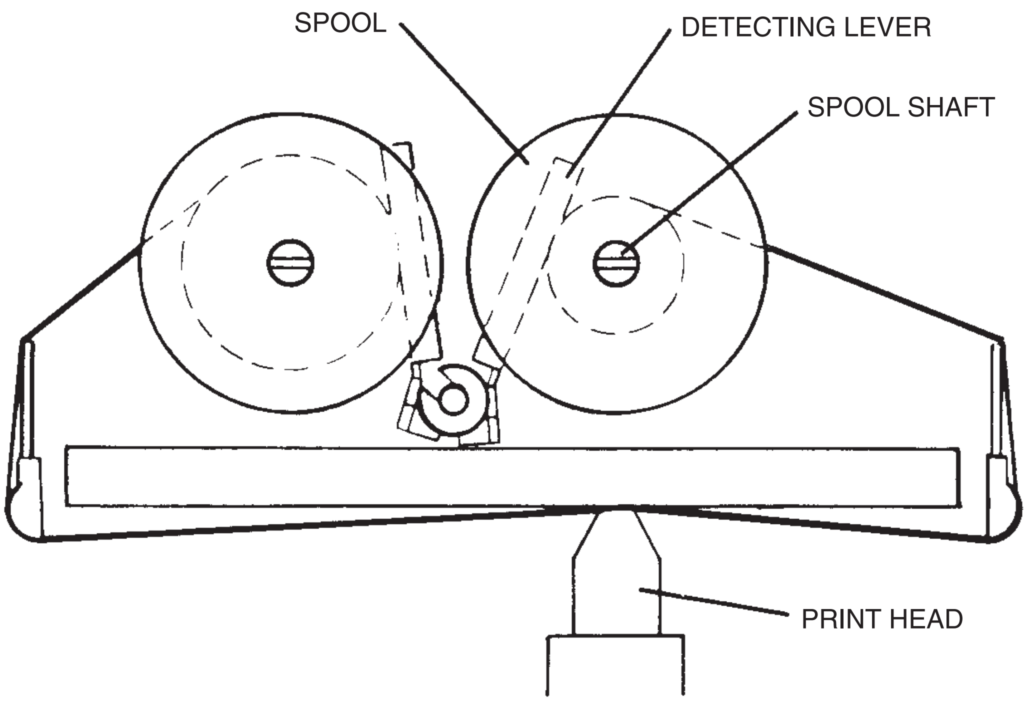


Figure 5-7 Changing the Ink Ribbon

5.4.2 Ink Ribbon Replacement

Ribbon life will vary greatly from one installation to another depending on how often the printer has to print. When the characters on the chart become difficult to read, you should replace the ribbon. If possible, try to replace the ribbon at the same time you change the paper roll, as it is easier to replace the ribbon when the roll of paper is out of the way.

To replace the ribbon:

1. Turn the unit off.
2. If there is paper in the unit, pull out the take-up spool and unroll enough paper to get it out of the way, so you can clearly see the two ribbon spools. Each spool has a ribbon-detecting lever pressing against the ribbon. Note the direction the ribbon leaves the left spool and how it winds onto the right spool.
3. Take hold of one of the spools and rotate it slightly, loosening the ribbon.
4. Hold the detecting lever away from the spool while gently pulling the spool until it comes free from its shaft. Do the same with the other spool.
5. Lift the chart and take-up spool out of the way and remove the ink ribbon from the printer mechanism, noting how it threads through the unit.
6. Thread the new ink ribbon through the printer mechanism.

7. Locate the three small pins on each spool of the ink ribbon and turn the spools so the pins face the gears on the two ribbon shafts.
8. Replace the two spools on their respective shafts, pushing the detector levers out of the way so the spools will easily re-engage their gears.
9. Gently rotate each spool to tighten the ink ribbon. Reinstall the paper take-up roll if necessary.

5.4.3 Do Not Disassemble or Lubricate the Printer

You do not need to oil the printer mechanism. As long as you keep the lid closed, keep the inside of the cabinet clean, and do not abuse the printer in any way, it should function normally. Teledyne Isco recommends you make no attempt to oil or disassemble the mechanism if it malfunctions.

Oil attracts dirt; some oils can become gummy over time and may cause parts to bind or stick. Do not attempt to disassemble the printer mechanism, as you may bend or distort the frame or component parts. This will certainly cause malfunction.

Do not force any part of the mechanism with tools or probes. If you disassemble the flow meter, do not lift the chassis from the case by holding on to any part of the printer. The internal printer contains no user-serviceable parts other than the paper and the ribbon. If the printer needs service, Teledyne Isco recommends you return the flow meter to the factory.

5.5 Servicing And Troubleshooting

The remainder of this section provides servicing information and a general troubleshooting guide. This information will help you decide whether to attempt to repair the flow meter yourself or return it to the factory.

Included are sections on removing the flow meter chassis and fuse replacement. There are also general comments on servicing electronic equipment with special consideration of CMOS circuitry.

5.5.1 Disassembling the Flow Meter

You can remove the flow meter chassis from the cabinet for inspection and servicing. Unscrew the four screws, two at the top, and two at the bottom, that hold the flow meter chassis in the cabinet. You can then lift the chassis out by inserting the thumb or index finger from each hand into the upper right and lower left corners of the opening for the internal printer.

Do not try to lift the flow meter out of its case by holding on to any part of the printer mechanism. This could bend or distort part of the printer, possibly damaging it. Once the chassis has cleared the case, you can hold onto the edges with both hands and lift it free of the case.

Note

If you disassemble the flow meter for servicing, you will also remove the aluminum chassis covers to access the circuitry. Always replace these covers when repairs have been completed. The covers protect the circuit boards and also reduce signal emissions that could interfere with the operation of nearby electronic equipment. For the same reason, do not remove any of the ferrite beads or alter the wiring harnesses inside the cabinet in any way.

Figure 5-8 Lifting the Flow Meter from the Case

5.5.2 Fuse Replacement

With the flow meter chassis out of the cabinet, you can locate and change fuses. The fuses are located on the printed circuit board directly behind the keypad. There is an aluminum cover over this board. Remove the cover by pressing against its surface with the palm of your hand and then pulling downward on it with your fingers. A plastic catch under the cover holds it in place. The fuses are labeled F1, F2, and F3. The proper size for each of these fuses is:

F1 - 5 amp., fast blow

F2 - 5 amp., fast blow

F3 - 2 1/2 amp., fast blow

Always replace a blown fuse with one of the same value. Using a larger value fuse could cause serious damage to the flow meter or to its power supply. Replace the protective cover, making sure the two ears on top of the cover slide into the mating slots on the chassis. There should be a noticeable snap when the plastic catch re-engages the cover.

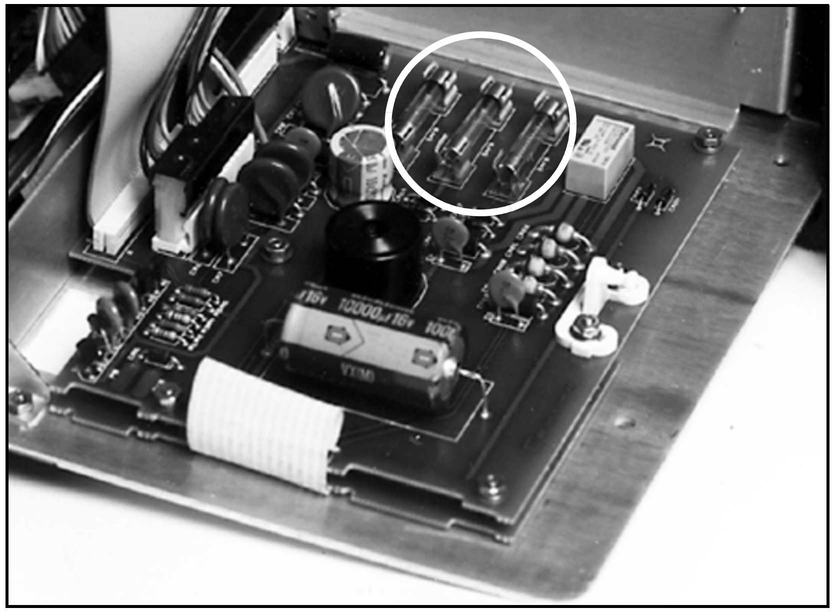


Figure 5-9 Location of the Three Fuses

5.5.3 Display Warnings

The LCD will show various warnings and error messages to warn of problems in the program, or difficulties inside the flow meter. Some messages request routine maintenance; others point out programming errors; still others indicate serious internal difficulties.

Following are typical warning messages displayed by the LCD:

CHECK PRINTER FUSE

PRINTER JAMMED

PAPER OUT

5.5.4 System Reset

If the flow meter does not appear to be operating normally, you can try to restart the processor by turning the unit off, waiting a few minutes, and then turning the unit back on. If that doesn't work, you can reset the software.

⚠ CAUTION

This procedure will cause most programmed entries and accumulated data stored in the 4250 to be lost, and the flow meter will revert to factory default settings. If this operation is performed, it will be necessary for you to reprogram the unit to meet the specifications of your installation. Use **Print Program** to keep a record of how you programmed the unit.

To reset the 4250 software:

1. Press **Print Program** for a record of your program setup.
2. Turn the flow meter off.
3. Hold down the **4** and **Exit Program** keys simultaneously.

4. While still pressing the **4** and **Exit Program** keys, turn the flow meter on again. Wait until the display reappears before releasing the keys.

Pressing **4** and **Exit Program** may leave some values programmed into the flow meter's computer. If you want to remove *all* programmed entries, hold down **1** and **Clear Entry** while powering up the flow meter.

The following messages describe serious internal problems, indicating service is required:

ROM CHECKSUM ERROR - or -

FOUND BAD RAM - CALL CUSTOMER SERVICE

If these messages appear, call the Teledyne Isco Customer Service Department at (800) 228-4373.

⚠ CAUTION

Do not attempt to disassemble or repair the 4250 Flow Meter (other than changing fuses) unless you are skilled in the evaluation and repair of microprocessor-based circuitry. Teledyne Isco recommends no attempt be made to disassemble or repair the printer mechanism or display module.

5.6 Preliminary Troubleshooting Steps

The electronic circuitry of the 4250 is solid-state and its reliability is high. If the unit should fail to operate properly, the problem is most likely a mechanical failure. Items such as a broken or intermittent connections in the power cable or wiring harness or (rarely) poor electrical connection through keypad switches should be suspected.

5.6.1 If Serious Problems Occur

If you suspect an electronic problem, Teledyne Isco recommends that you contact the Technical Service Department. **Contact information can be found on the Warranty page at the back of this manual.** Our Technical Service Department has trained technicians and specially designed equipment necessary for timely, efficient repair of the 4250 Flow Meter. If you still wish to attempt repairs, the Customer Service Department is available to provide additional advice and information on servicing.

5.6.2 Inspection Protocol

When attempting to isolate problems within the unit, you should assume that the CPU and memory are working properly until attempts to find problems in the peripheral circuitry have been exhausted.

This is for two reasons:

- The likelihood of failure is far greater on transistor drive circuits (heavier currents are handled here), than on the CPU or memory.
- The CPU and memory are not serviceable and must be replaced if found to be faulty.

Following are suggested areas to check before attempting to service the 4250's circuitry. Telephone consultation with Customer Service is strongly recommended. Look for the following:

1. Verify that the problem is in the flow meter and not caused by the area-velocity probe, probe cable, Quick-Disconnect Box, power supply, or other equipment connected to the flow meter.
   The flow meter could be all right and will appear to malfunction because of clogged or leaking tubes or other components; check these first. **Pay particular attention to the connectors and cable from the submerged probe.**
2. Check all 3 fuses to see if they are blown (see Figure 5-9).
3. Check the battery or power supply.
   Proper voltage to the unit should be from 10.5 to 14.5 VDC. If the unit is powered from the AC supply, make sure the branch circuit is delivering at least 110 VAC to the power supply cord.
4. Check the wiring harnesses, connectors, and solder joints. Under normal conditions these should stay in good condition. However, physical stress, or operation of the unit with the door open or the desiccator saturated could cause corrosion of the connectors in certain atmospheres.
5. Look for physical damage.
   Burnt, broken, or overly hot components, stuck or inoperative switches, or water damage, may be apparent if you look closely.
6. Look for shorted or open diodes and transistors, especially driver transistors.
7. Check the voltage regulators.
   The output voltage from the regulators should be within 5% of their rated value. Check to see that rated voltages are available at various places on the boards.
8. Look for excessive current draw from some or all the circuitry.
   This will usually be accompanied by an unusual amount of heat coming from some component or group of components, and the voltage on the power rails may well be depressed.
9. Check the input signals to the unit and see that they are correct.
   This may require the use of an oscilloscope. You may need to consult Customer Service for the proper appearance of wave forms.
10. Check to see that the crystal oscillator is operating and at the proper frequency.
11. Check the reset circuitry to see that it is working properly.

5.7 Precautions for Servicing CMOS Circuitry

Most of the circuitry in the 4250 Flow Meter is made up of CMOS components. Because of the oxide gate structure of these devices, they are extremely susceptible to destruction caused by the discharge of static electricity through their inputs.

Note that many of the driver transistors in the 4250 are power MOS devices; they are just as susceptible to static damage as CMOS ICs are. Because of this risk, certain precautions must be taken when working on these circuits.

5.7.1 Hazard of Static Electricity

The voltage levels present from static buildup due to walking over carpeted floors, movement of woolen or synthetic clothes over chair seats, workbenches, etc., are high enough to destroy CMOS circuitry when performing repair work.

Ideally, all tools, soldering irons, etc., should be grounded, and work should be conducted on a grounded metal workbench, with grounding straps worn on the wrists of personnel. It is recognized that in most field repair situations, such precautions are impractical. However, certain extreme hazards must be avoided.

- Never perform any work in a room with a carpeted floor.
- Always roll up sleeves so that your arms are in contact with the working surface.
- Avoid using a work surface made of an extremely good insulator.
  Plastic and glass are good insulators and should be avoided. A metal surface is best; a wood surface is acceptable. Conductive grounding mats are available for work stations and are worthwhile if much repair is to be done.
- The degree of hazard depends on the level of humidity. Be particularly careful if the work area is extremely dry, or if the work is being done in cold seasons, when indoor forced heating and outdoor low temperatures cause the relative humidity level to be very low.
- Keep yourself grounded when handling disassembled equipment.
  After a unit has been opened for repair, always touch the metal chassis before touching any of the circuit components.
- Be especially careful handling the CMOS integrated circuits when they are removed from the rest of the circuitry.
  Simply being connected to the rest of the circuitry provides some protection. Most of the circuitry is well-protected from damage caused by static discharge when the unit is powered up. However, an IC should never be replaced when the unit is turned on.
- Individual CMOS semiconductors and built-up printed circuit boards should always be transported in conductive packaging.
  Foil is satisfactory; metallized plastic bags work well. Ordinary plastic bags and pink poly are not satisfactory

unless the legs or leads are also stuck into a block of black conductive foam. If purchased replacement components do not come in marked, protective packaging, do not use them. They may already be destroyed.

- Once assembled and soldered, printed circuit boards are easily damaged by improper repair procedures.
  Do not attempt to remove components, particularly ICs, from printed circuit boards unless skilled at this procedure. After a defective component is replaced, the unit still may not work if excessive heat or pressure has broken the foil traces or pulled the cores from holes on the board.

5.8 Software Updates

Update Isco Instrument Software installs software in Isco instruments and modules. This application will transfer a binary file from your PC to the instrument's flash memory.

Updated binary files are available from Teledyne Isco when enhancements have been made to the instrument software. Contact the factory for help with obtaining these files.

⚠ CAUTION

Updating the instrument software or resetting the instrument may completely erase readings and reports stored in the instrument's memory. Collect the data from the instrument before proceeding.

5.8.1 Updating the Flow Meter Software

The flow meter should be powered and turned on.

Connect your computer to the flow meter using the Computer Connect Cable (Interrogator Cable) and start the program Update Isco Instrument Software.

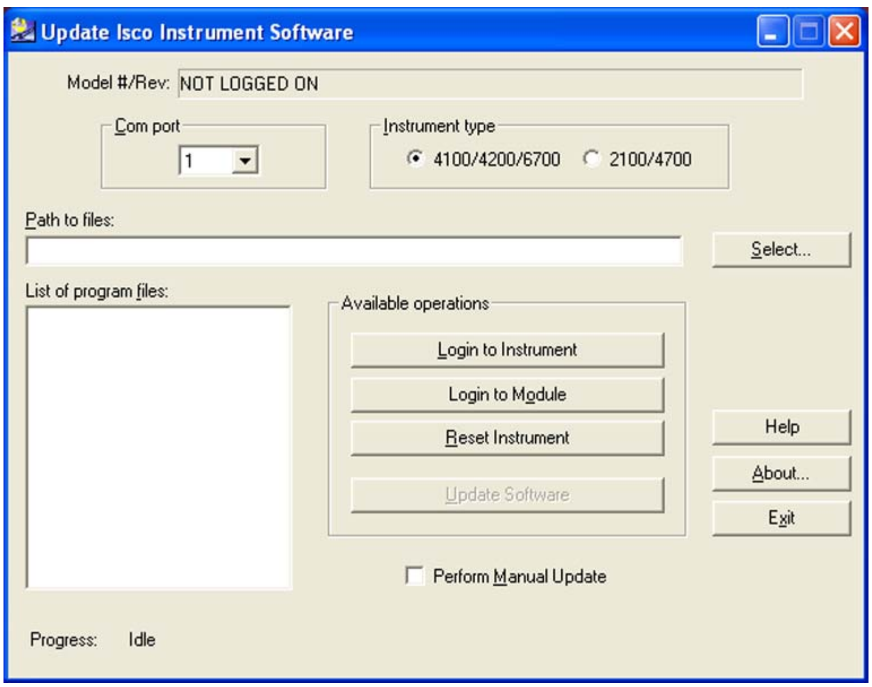


Figure 5-10 Open the software update program

Click the Help button and follow the steps listed under Update Instrument Software. Do not disturb the connection or stop the update while the file transfer is taking place. When the transfer is complete, the program displays an “Operation successful” message. Click OK and close the program.

Your flow meter’s software is now updated and ready for operation.

Isco Product Data

Isco 2150 Area Velocity Flow Module

The 2150 Flow Module uses continuous wave Doppler technology to measure mean velocity. The sensor transmits a continuous ultrasonic wave, then measures the frequency shift of returned echoes reflected by air bubbles or particles in the flow.

The 2150's "smart" area velocity probe is built on digital electronics, so the analog level is digitized in the sensor itself to overcome electromagnetic interference. The probe is also factory-calibrated for 10-foot (3 meter) span at different temperatures. This built-in calibration eliminates drift in the level signal, providing long-term level stability that reduces recalibration frequency and completely eliminates span recalibration.

In field use, the 2150 is typically powered either by two alkaline, or Isco Rechargeable Lead-acid batteries, within a 2191 Battery Module. Highly efficient power management extends battery life up to 15 months at 15-minute data storage intervals. Other power options (including solar) are available.

Applications

- Portable and permanent-site AV flow monitoring for inflow and infiltration, capacity assessment, sewer overflow, and other sewer studies.
- Measuring shallow flows in small pipes. Our low-profile area velocity sensor minimizes flow stream obstruction and senses velocity in flows down to 1 inch (25 mm) in depth.

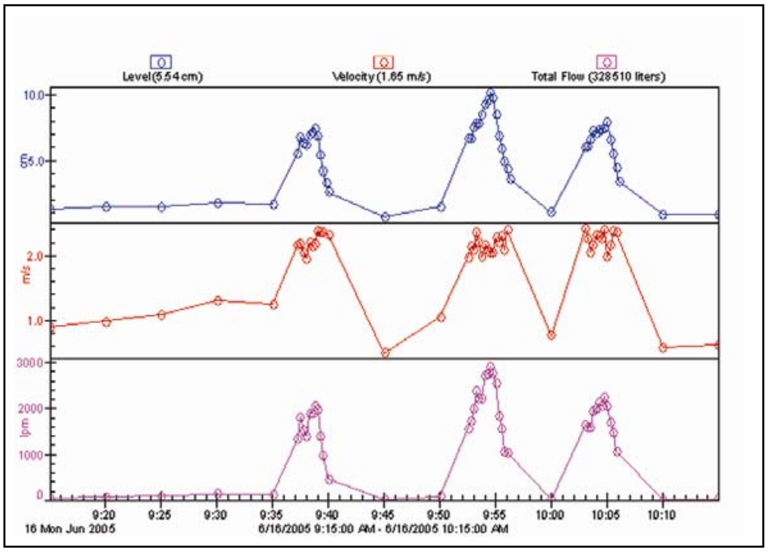
Standard Features

- Rugged, submersible enclosure meets NEMA 4X, 6P (IP68) environmental specs.
- Chemically resistant epoxy-encapsulated sensor withstands abuse, resists oil and grease fouling, and eliminates the need for frequent cleaning.
- Replaceable high-capacity internal desiccant cartridge and hydrophobic filter protect sensor reference from water entry and internal moisture.
- Pressure transducer vent system automatically compensates for atmospheric pressure changes to maintain accuracy.
- The quick-connect sensor can be easily removed and interchanged in the field without requiring recalibration.
- Up to four 2100 Series flow modules can be networked by stacking and/or extension cables.

Above left: Additional modules can be added for redundant or multi-stream measuring (Isco 2110 Ultrasonic Module shown). Right: Optional mounting rings provide quick, secure sensor installation in round pipes from 6 to 80 inches (150 to 2000 mm).

Software Features

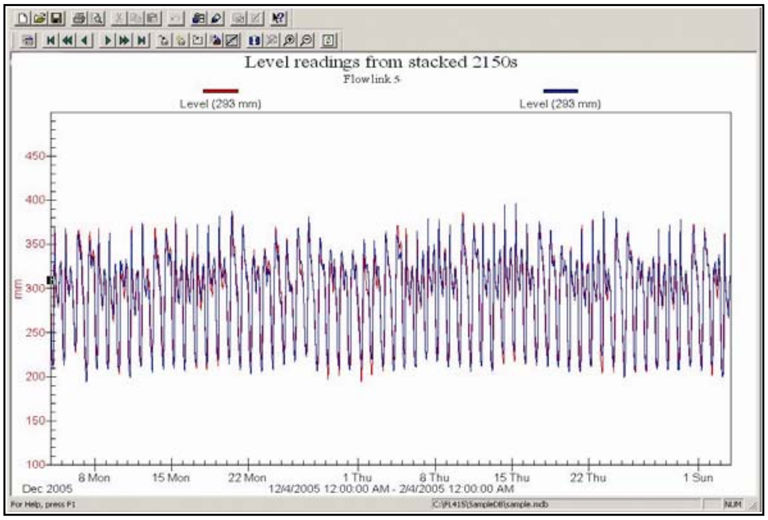
- Secure data storage. All data are continuously stored in flash memory to protect against loss in case of power failure
- Easy to upgrade. New operating software can be downloaded into non-volatile flash memory, without affecting stored program and data.
- Records and stores input voltage and temperature data.
- Variable rate data storage lets you change the data storage interval when programmed conditions occur. This feature assures maximum information about an exceptional event – such as an overflow – while conserving power and data capacity during normal conditions.
- 38,400 bps communication provides speedy setup and data retrieval.



Variable rate data storage

The 2150 flow module has the ability to automatically switch data storage rates based on varying conditions.

In the example at left, the 5-minute data storage rate automatically changed to 30 seconds when the flow rose above a programmed level.



Level stability

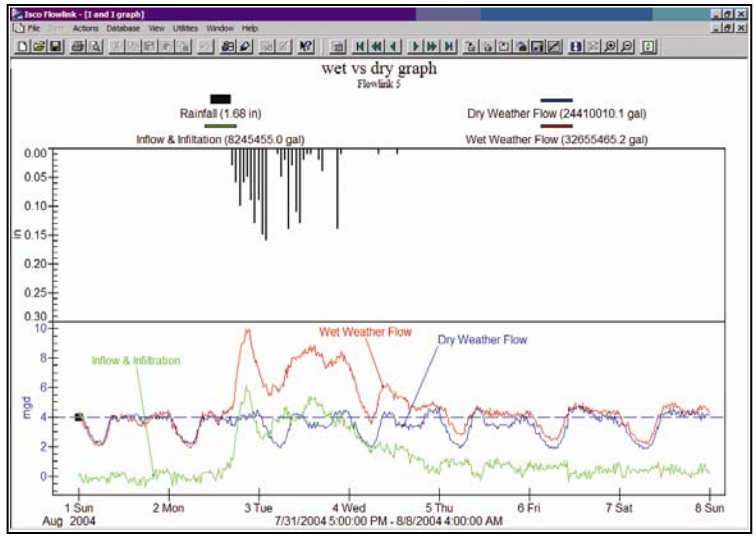
Frequent multipoint level recalibration is a requirement with other area velocity flow meters. Isco's exclusive "smart" sensor design in the area velocity probe yields exceptionally low drift in the level signal.

The 2150's factory-calibrated 3-meter span totally eliminates the need for cumbersome span recalibration in the field.

In the example at left, two area velocity probes were installed at the same site. The level readings from both sensors track closely without any drift, over an 8-week period.

Flowlink® Data Analysis

Isco Flowlink® Software is a powerful tool for analyzing flow and water quality data. It provides site setup, data retrieval, and comprehensive data analysis, as well as advanced reporting and graphing. See separate datasheets for details on Flowlink and Flowlink Pro software.



The Flowlink screen shown above gives a comparison of dry and wet weather flows, plus rainfall typical of an inflow & infiltration study

Information Delivery

Isco 2100 Series Flow Modules offer a wide variety of communication and retrieval options, to minimize the need for expensive on-site visits and confined space entry. These include:

Isco 2103 Land-line Modem Module
Reliable two-way dial-up communication between down-hole 2100 Flow Modules and your desktop computer, equipped with Isco Flowlink Software. A dial-out feature enables the system to transmit a text message alarm to your digital cell phone or pager.

Isco 2103c Cellular Modem Module
All the features of the 2103 Modem with the convenience of cell phone access. And the 2103c can automatically send data via the Internet to a designated server running Flowlink Pro software, using economical 1xRTT packet-switched data transmission.

Isco 2108 Analog Output Module
Provides current outputs for use with Isco 2100 Series Area Velocity and Ultrasonic Flow Modules. It allows easy interface with SCADA/DCS or other secondary instrument systems.

Modbus
2100 Series Flow Modules provide digital RS 232 Modbus output that can be used to interface with external communication modules, SCADA systems, or other devices.

On-site Data Retrieval

Isco Flowlink Software
Download and process data on-site. Enjoy unmatched data management capability, advanced data editing and analysis, powerful reporting and presentation choices, and a variety of downloading and data handling options.

Isco 2101 Field Wizard
A durable, weatherproof module for on-site data retrieval. Don't risk damage to your fragile notebook PC. The 2101 Field Wizard provides on-site display of current readings, information about stored data, diagnostics, and more.

Interrogate all 2100 Series Flow Modules in the stack at one time, and store more than 14 days' data from up to 20 modules!

Isco 2102 Communication Module
Connect with your Isco 2100 Series Flow Modules from the safety and convenience of your vehicle.

Digital spread-spectrum radio signals enable "drive-up" data retrieval, system configuration, and level calibration, with minimum power consumption. "Plug and Play" setup – no interfacing needed.

Specifications

2150 Flow Module	
Size (HxWxD):	2.9 x 11.3 x 7.5 in (74 x 287 x 191 mm)
Weight:	2.0 lb (0.9 kg)
Materials of construction:	High-impact polystyrene, stainless steel
Enclosure (self-certified):	NEMA 4X, 6P (IP68)
Temperature Range:	-40° to 140° F (-40° to 60° C) operating and storage
Power Required:	12 VDC nominal (7.0 to 16.6 VDC), 100 mA typical, 1 mA standby
Power Source:	Typically, an Isco 2191 Battery Module, containing 2 alkaline or 2 rechargeable lead-acid batteries. (Other power options are available; ask for details.)
Typical Battery Life:	Using 15-minute data storage interval Energizer® Model 529 alkaline - 15 months Isco rechargeable lead-acid - 2.5 months
Program Memory:	Non-volatile programmable flash; can be updated using PC without opening enclosure; retains user program after updating.
Built-in Conversions	
Flow Rate Conversions:	Up to 2 independent level-to-area conversions and/or level-to-flow rate conversions.
Level-to-Area Conversions:	Channel Shapes - round, U-shaped, rectangular, trapezoidal, elliptical, with silt correction; Data Points - Up to 50 level-area points.
Level-to-Flow Conversions:	Most common weirs and flumes; Manning Formula; Data Points (up to 50 level-flow points); 2-term polynomial equation
Total Flow Calculations:	Up to 2 independent, net, positive or negative, based on either flow rate conversion
Data Handling and Communications	
Data Storage:	Non-volatile flash; retains stored data during program updates. Capacity 395,000 bytes (up to 79,000 readings, equal to over 270 days of level and velocity readings at 15-minute intervals, plus total flow and input voltage readings at 24-hour intervals)
Data Types:	Level, velocity, flow rate 1, flow rate 2, total flow 1, total flow 2, input voltage, temperature
Storage Mode:	Rollover; 5 bytes per reading.
Storage Interval:	15 or 30 seconds; 1, 2, 5, 15, or 30 minutes; or 1, 2, 4, 12, or 24 hours Storage rate variable based on level, velocity, flow rate, total flow, or input voltage
Data Retrieval:	Serial connection to PC or optional 2101 Field Wizard module; optional modules for spread spectrum radio; land-line or cellular modem; 1xRTT. Modbus and 4-20 mA analog available.
Software:	Isco Flowlink for setup, data retrieval, editing, analysis, and reporting
Multi-module networking:	Up to four 2100 Series Flow Modules, stacked and/or remotely connected. Max distance between modules 3300 ft (1000 m).
Serial Communication Speed:	38,400 bps

2150 Area Velocity Sensor	
Size (HxWxD):	0.75 x 1.3 x 6.0 in (19 x 33 x 152 mm)
Cable (Length x Diameter):	25 ft x 0.37 in (7.6 m x 9 mm) standard. Custom lengths available on request.
Weight (including cable):	2.2 lbs (1 kg)
Materials of construction:	Sensor - Epoxy, chlorinated polyvinyl chloride (CPVC), stainless steel Cable - Polyvinyl chloride (PVC), chlorinated polyvinyl chloride (CPVC)
Operating Temperature:	32° to 140° F (0° to 60° C)
Level Measurement:	Method - Submerged pressure transducer mounted in the flow stream Transducer Type - Differential linear integrated circuit pressure transducer Range (standard) 0.033 to 10 ft (0.010 to 3.05 m); (optional) up to 30 ft (9.15 m). Maximum Allowable Level 34 ft (10.5 m) Accuracy ±0.01 ft from 0.033 to 10 ft, (±0.003 m from 0.01 to 3.05 m,) Long-Term Stability ±0.023 ft/yr (±0.007 m/yr) Compensated Range 32° to 122°F (0° to 50°C)
Velocity Measurement:	Method - Doppler ultrasonic, frequency 500 kHz Typical Minimum Depth 0.08 ft (25 mm) Range -5 to +20 ft/s (-1.5 to +6.1 m/s) Accuracy (in water with uniform velocity profile, speed of sound = 4850 ft/s, for indicated velocity range) ±0.1 ft/s from -5 to 5 ft/s (±0.03 m/s from -1.5 to +1.5 m/s) ±2% of reading from 5 to 20 ft/s (1.5 to 6.1 m/s)
Temperature Measurement:	Accuracy ±3.6° F (±2° C)

2191 Battery Module	
Size (HxWxD):	6.0 x 9.6 x 7.6 in (152 x 244 x 193 mm)
Weight (without batteries):	3.2 lb (1.4 kg)
Materials of construction:	High-impact polystyrene, stainless steel
Enclosure (self certified):	NEMA 4X, 6P, (IP68)
Batteries:	Two 6-volt Energizer Model 529* alkaline (25 Ahrs capacity) or Isco Rechargeable Lead-acid (5 Ahrs capacity) recommended. *Note – Energizer 529 ER does not give specified life.

2150 Ordering Information

Contact your Teledyne Isco representative for complete ordering details and information on other 2100 Series Modules.

Description	Part No.
2150 with AV sensor, 2191 Battery Module, and Handle	68-2050-002
2150 Module with AV sensor (only)	68-2050-001
Isco Flowlink® 5 Software	68-2540-200
Energizer® Model 529 Alkaline Lantern Battery (2 required)	340-2006-02
Isco Rechargeable Lead-acid Battery (2 required)	60-2004-041
Charger for Lead-acid Batteries (holds 2 batteries)	60-2004-040

ISCO®
Water is life. Protect it.

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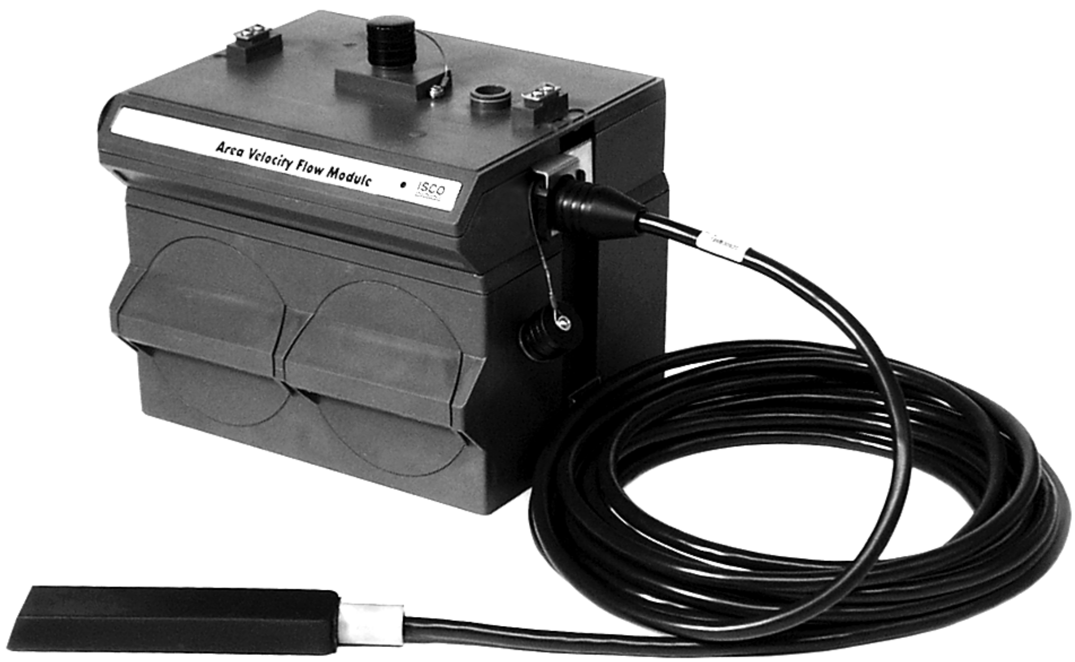
2150 Area Velocity Flow Module and Sensor

Installation and Operation Guide



TELEDYNE ISCO
A Teledyne Technologies Company

Part #60-2003-092 of Assembly #60-2004-038
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Revision X, October 21, 2008

Foreword

This instruction manual is designed to help you gain a thorough understanding of the operation of the equipment. Teledyne Isco recommends that you read this manual completely before placing the equipment in service.

Although Teledyne Isco designs reliability into all equipment, there is always the possibility of a malfunction. This manual may help in diagnosing and repairing the malfunction.

If the problem persists, call or e-mail the Teledyne Isco Technical Service Department for assistance. Simple difficulties can often be diagnosed over the phone.

If it is necessary to return the equipment to the factory for service, please follow the shipping instructions provided by the Customer Service Department, including the use of the **Return Authorization Number** specified. **Be sure to include a note describing the malfunction.** This will aid in the prompt repair and return of the equipment.

Teledyne Isco welcomes suggestions that would improve the information presented in this manual or enhance the operation of the equipment itself.

Teledyne Isco is continually improving its products and reserves the right to change product specifications, replacement parts, schematics, and instructions without notice.

Contact Information

Customer Service

Phone:	(800) 228-4373	(USA, Canada, Mexico)
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Email:	IscoCSR@teledyne.com	

Technical Service

Phone:	(800) 775-2965	(Analytical)
	(800) 228-4373	(Samplers and Flow Meters)
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Return equipment to: 4700 Superior Street, Lincoln, NE 68504-1398

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Web site:	www.isco.com

Revised September 15, 2005

Radio Interference Statement

FCC

This equipment has been tested and found to comply with the limits for a class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which the user will be required to correct the interference at his own expense.

Canada

This ISM apparatus meets all requirements of the Canadian Interference-Causing Equipment Regulations.

Ce générateur de fréquence radio ISM respecte toutes les exigences du Règlement sur le materiel brouilleur du Canada.

Caution

Changes or modifications not expressly approved by the party responsible for compliance (Isco, Inc.) could void your authority to operate the equipment.

This equipment should be installed and operated using Isco's cables, such as the Flowlink Communication Cable or the optional Module-to-module Cable. Isco cables are listed in Appendix B, *Accessories*.

General Warnings

Before installing, operating, or maintaining this equipment, it is imperative that all hazards and preventive measures are fully understood. While specific hazards may vary according to location and application, take heed in the following general warnings.

This product is often installed in confined spaces. Some examples of confined spaces are manholes, pipelines, digesters, and storage tanks. These spaces may become hazardous environments that can prove fatal for those unprepared. These spaces are governed governed by OSHA 1910.146 and require a permit before entering.

Hazard Severity Levels

This manual applies *Hazard Severity Levels* to the safety alerts, These three levels are described in the sample alerts below.

⚠ CAUTION

Cautions identify a potential hazard, which if not avoided, may result in minor or moderate injury. This category can also warn you of unsafe practices, or conditions that may cause property damage.

⚠ WARNING

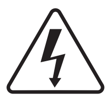
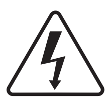
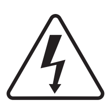
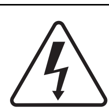
Warnings identify a potentially hazardous condition, which if not avoided, could result in death or serious injury.

⚠ DANGER

DANGER – limited to the most extreme situations to identify an imminent hazard, which if not avoided, will result in death or serious injury.

Hazard Symbols

The equipment and this manual use symbols used to warn of hazards. The symbols are explained below.

Hazard Symbols	
Warnings and Cautions	
	The exclamation point within the triangle is a warning sign alerting you of important instructions in the instrument's technical reference manual.
	The lightning flash and arrowhead within the triangle is a warning sign alerting you of "dangerous voltage" inside the product.
Symboles de sécurité	
	Ce symbole signale l'existence d'instructions importantes relatives au produit dans ce manuel.
	Ce symbole signale la présence d'un danger d'électocution.
Warnungen und Vorsichtshinweise	
	Das Ausrufezeichen in Dreieck ist ein Warnzeichen, das Sie darauf aufmerksam macht, daß wichtige Anleitungen zu diesem Handbuch gehören.
	Der gepfeilte Blitz im Dreieck ist ein Warnzeichen, das Sei vor "gefährlichen Spannungen" im Inneren des Produkts warnt.
Advertencias y Precauciones	
	Esta señal le advierte sobre la importancia de las instrucciones del manual que acompañan a este producto.
	Esta señal alerta sobre la presencia de alto voltaje en el interior del producto.

2150 Area Velocity Flow Module

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Section 3 Preparation and Installation

Section 4 Programming

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2150 Area Velocity Flow Module

Section 1 Quick Start Guide

1.1 Getting Started

This Quick Start Guide provides a basic introduction to the Area Velocity and Battery Modules.

In this section we discuss:

- Identifying key components of the 2150 Flow Module
- How to operate latches
- Module connectors and caps
- Attaching the Area Velocity Sensor cable
- Identifying key components of the 2191 Battery Module
- How to install batteries
- How to stack modules

The intent of this section is only to familiarize you with the basics. Detailed information about the installation and operation of this system can be found in the following sections and appendices:

- Section 2, *Introduction*
- Section 3, *Preparation and Installation*
- Section 4, *Programming*
- Section 6, *Maintenance*
- Appendix A, *Replacement Parts*
- Appendix B, *Accessories*
- Appendix C, *Material Safety Data Sheets*
- Appendix D, *Safety Information*

1.2 Area Velocity Module

1.2.1 Identifying Module Components

Figures 1-1 and 1-2 identify key components of the 2150 Area Velocity Flow Module.

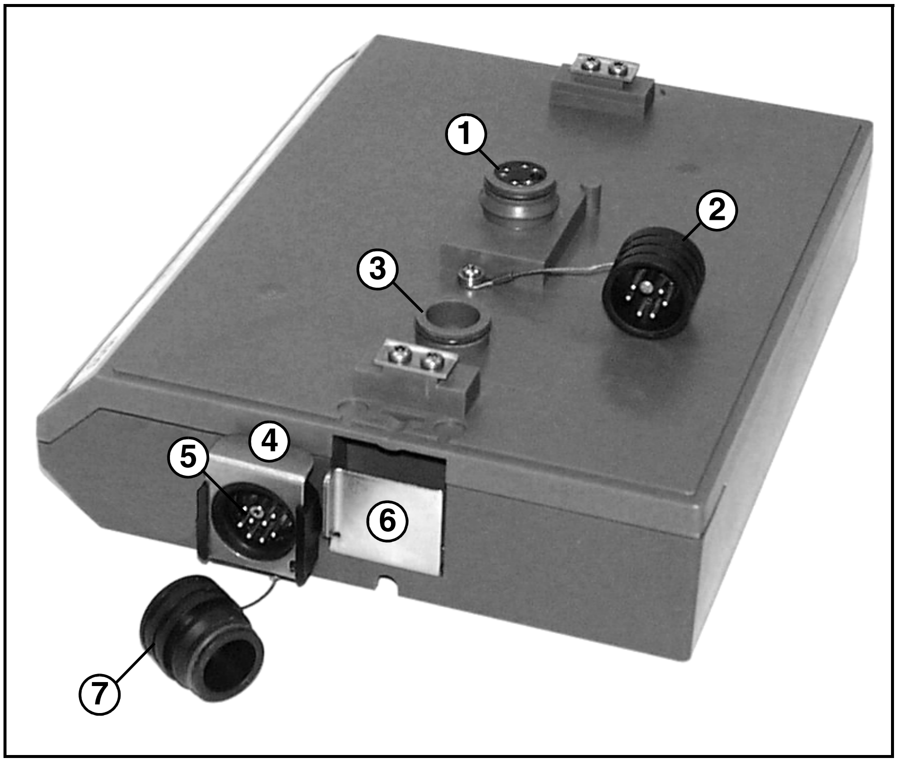


Figure 1-1 2150 Module Components: Top View

Table 1-1 Area Velocity Module Components - Top View	
Item No. Fig. 1-1	**Name**
1	Communication Connector
2	Cap
3	Cap Holder
4	Sensor Release
5	Sensor Receptacle
6	Latch Release
7	Sensor Plug

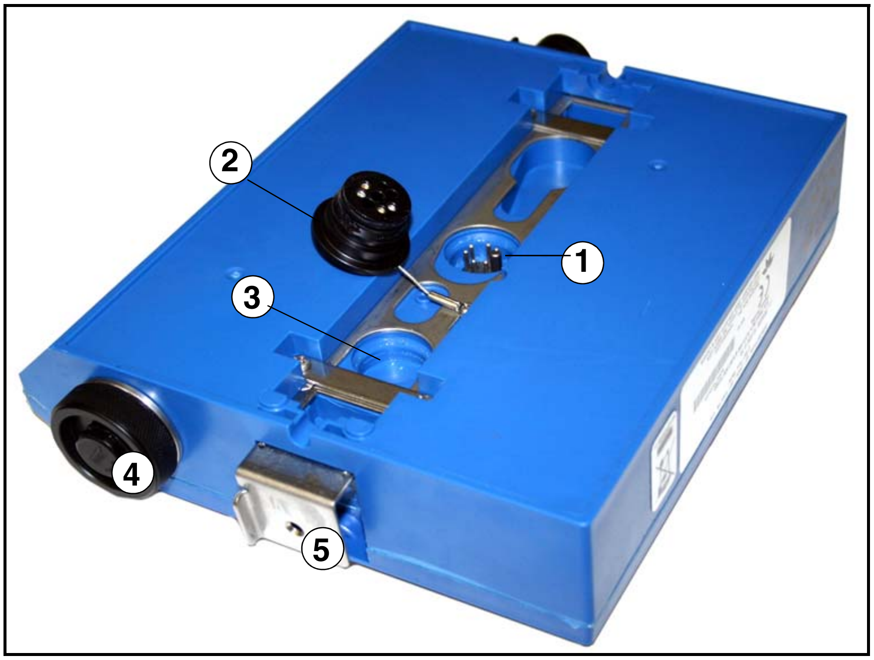


Figure 1-2 2150 Module Components: Bottom View

Table 1-2 Area Velocity Module Components - Bottom View	
Item No. Fig. 1-2	**Description**
1	Communication Connector
2	Plug
3	Plug Holder
4	Desiccant Cartridge and Hydrophobic Filter
5	Latch

1.2.2 Latches - Locking and Unlocking

Latches must be operated to stack and unstack the modules, and to gain access to the vent screw. Take a moment to familiarize yourself with operating the latches. The latch is operated by pushing on one of the sides — the right side to unlock, and the left side to lock.

⚠ CAUTION

The latch can be damaged by applying too much force. Never press on both sides at the same time. Do not force the latch if it is obstructed. While some degree of pressure must be applied to slide the latch, the ends of the latches should never bend more than 1/8".

Locate the latch release on the right side of the module. Push in to slide the latch toward the left of the module.

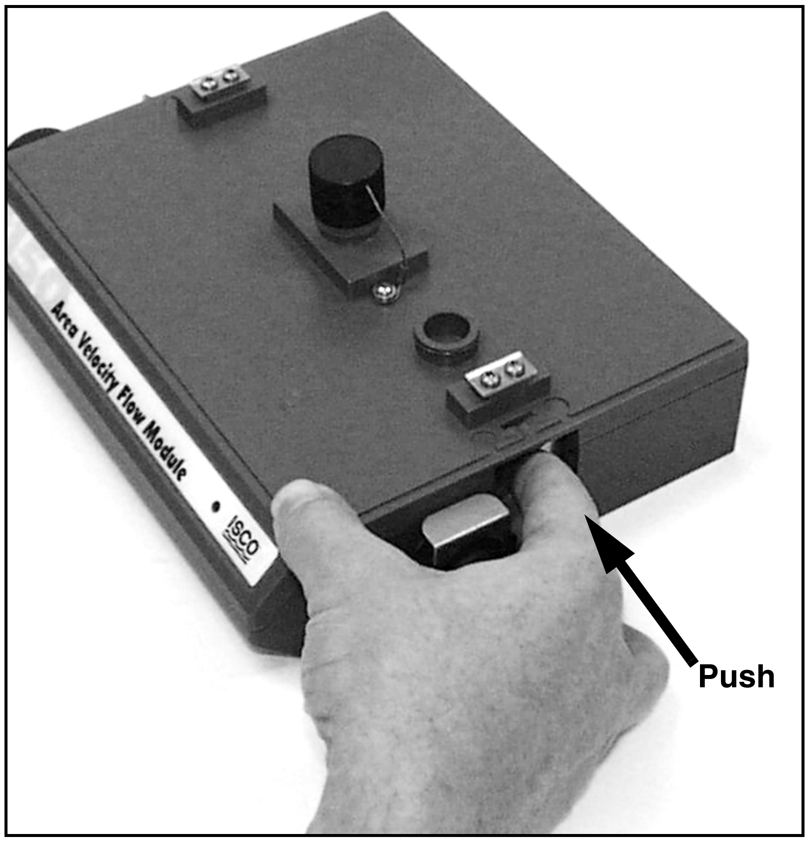


Figure 1-3 Unlocking the Latch

Figure 1-3 shows how to unlock the latch. You must unlock the latch to place the module on top of a stack, or to gain access to the vent screw. Otherwise, the latch is normally locked.

Figure 1-4 shows how to lock the latch.

☑ Note

Latches will “click” when they are fully locked and unlocked.

Locate the latch extending from the left side of the module. Push in to slide the latch toward the right of the module.

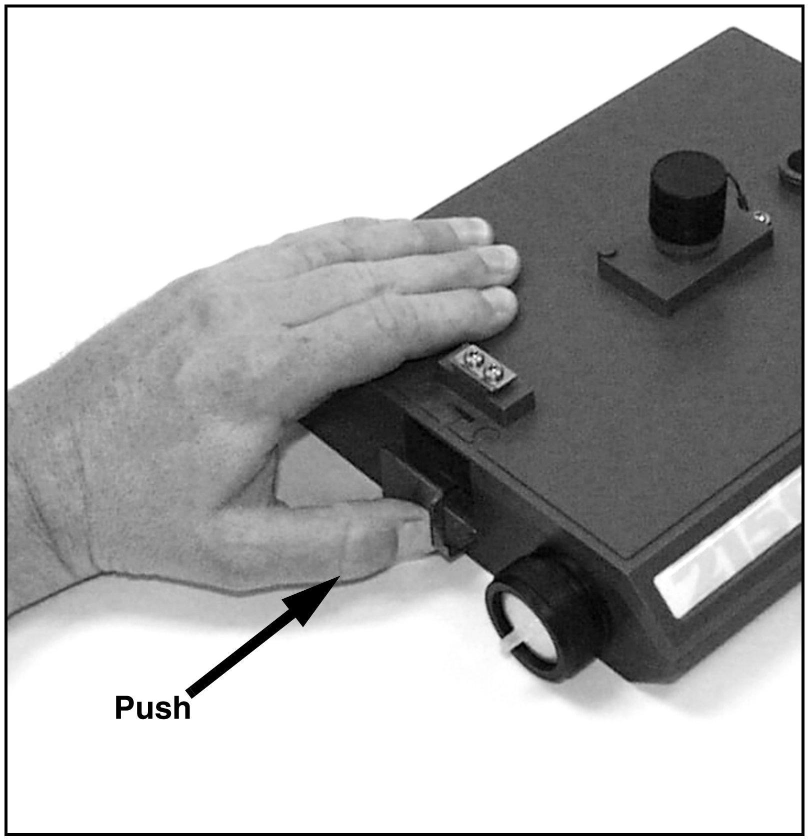


Figure 1-4 Locking the Latch

1.2.3 Communication Connectors

When a communication connector is not in use, the connector should always be capped (Figures 1-5 and 1-7). The cap will seal the connector to prevent corrosion, prevent moisture from entering the unit, and improve communications.

When a communication connector is in use, store the cap on the holder next to the connector (Figures 1-6 and 1-8). The communication connector will be sealed by its mating connector.

⚠ CAUTION

Caps **PUSH ON** and **PULL OFF**. Do not rotate the caps to remove them from the connectors.

☑ Note

For modules to correctly stack and lock together, protective caps between the modules must be stored on the holders. Section 1.4 shows how to store the caps so that you can stack the modules.

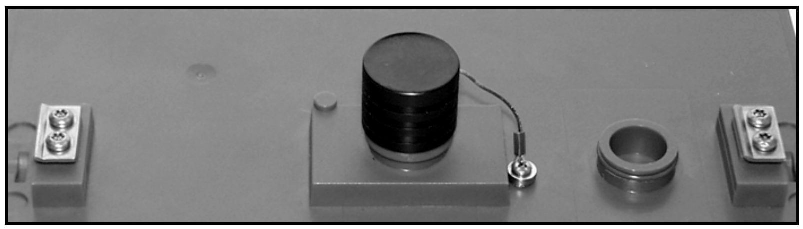


Figure 1-5 Flow Module - Upper Connector, Capped

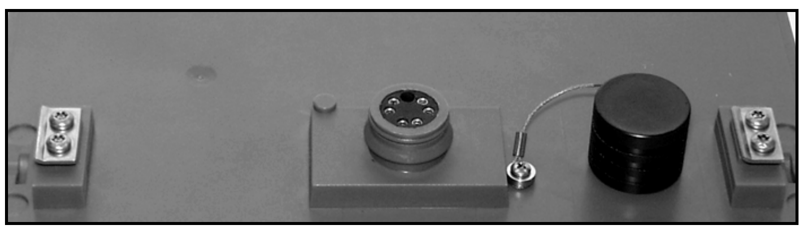


Figure 1-6 Flow Module - Upper Connector, Uncapped

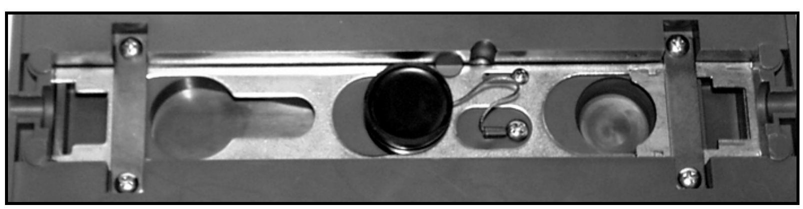


Figure 1-7 Flow Module - Lower Connector, Plugged

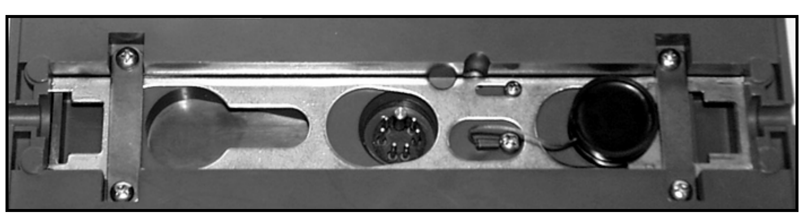


Figure 1-8 Flow Module - Lower Connector, Unplugged

1.2.4 Connecting the Sensor

To attach the Area Velocity Sensor to the 2150 Flow Module, follow steps in Figures 1-9 and 1-10.

1. Prepare the A-V Module's sensor connector by removing the plug. To do so, push down on the Sensor Release and pull out the plug.
2. Prepare the sensor cable's connector by removing the cap.

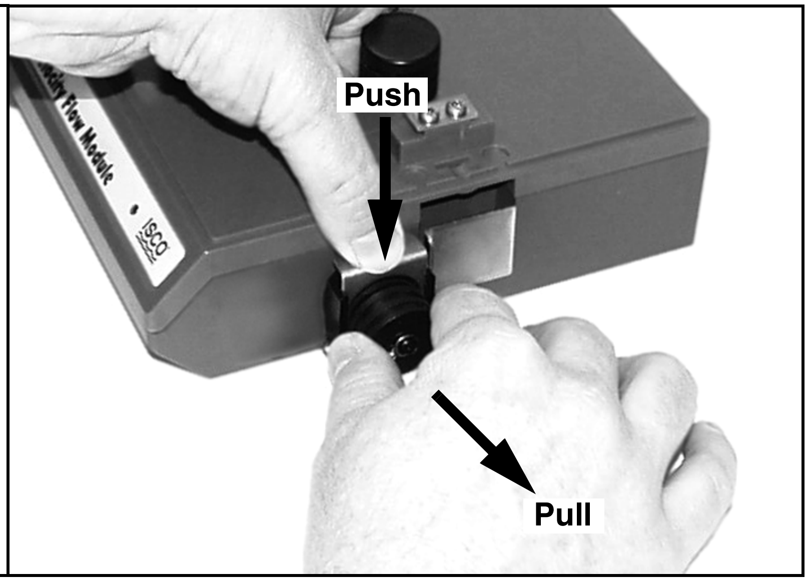


Figure 1-9 Flow Module - Preparing the Probe Connectors

1. Align the pins on the sensor cable with those in the sensor receptacle.
2. Push the sensor connector into the receptacle until the sensor release clicks.
3. To be certain that the connectors are locked, lightly pull on the cable connector; the cable should be held in place by the sensor release clip.
4. Push the protective caps on the module and sensor together.

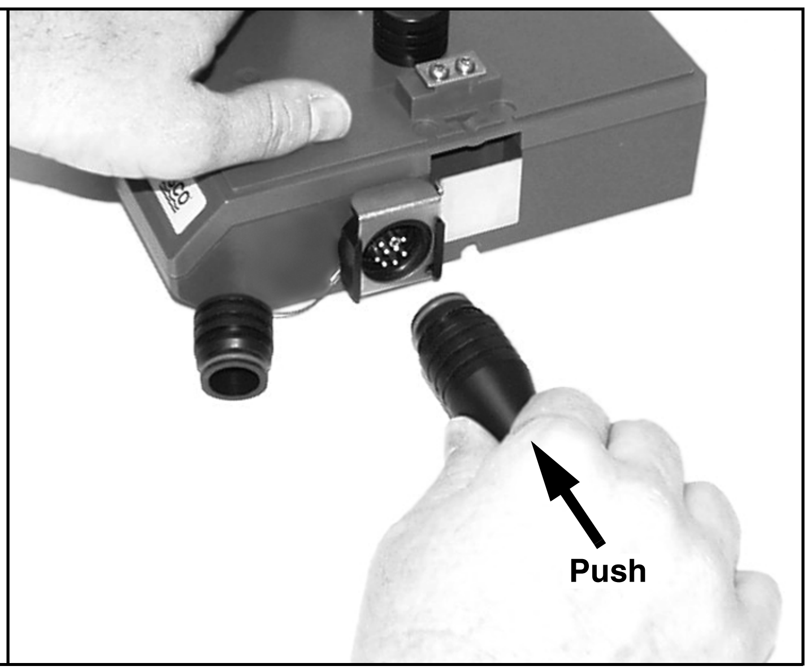


Figure 1-10 Flow Module - Connecting the Probe

1.3 Battery Module

1.3.1 Identifying Module Components

Figures 1-11 and 1-12 identify key components of the Battery Module.

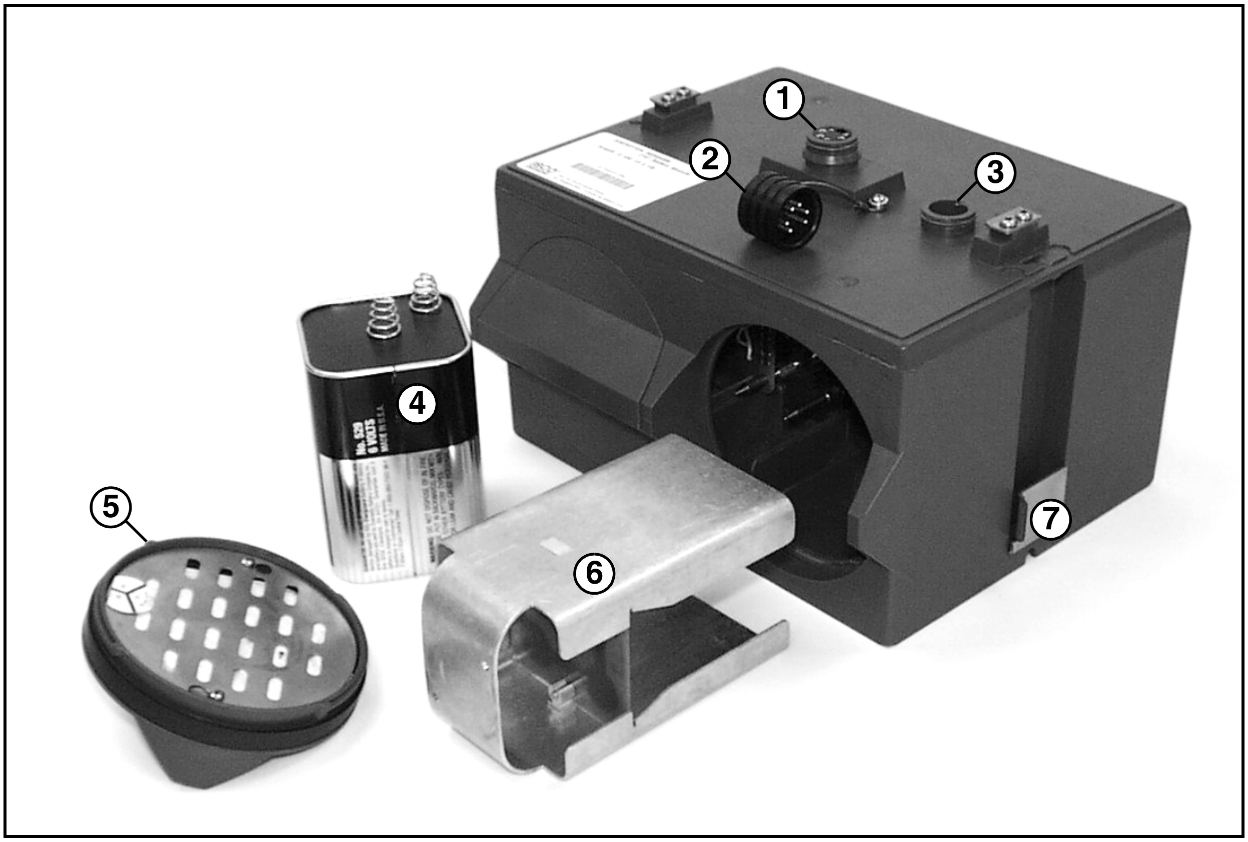


Figure 1-11 Battery Module Components, Top View

Table 1-3 Battery Module Components - Top View	
Item No. Fig. 1-11	**Description**
1	Communication Connector
2	Cap
3	Cap Holder
4	Lantern Battery (Alkaline shown)
5	Door
6	Battery Carrier
7	Latch Release

Figure 1-12 Battery Module Components, Bottom View

Table 1-4 Battery Module Components - Bottom View	
Item No. Fig. 1-12	**Description**
1	Communication Connector
2	Plug
3	Plug Holder
4	Latch

1.3.2 Installing the Batteries

The Battery Module requires two lantern batteries. The figures below show a 6 VDC alkaline battery. Rechargeable 6 VDC lead-acid batteries are also available for the module.

To install the batteries, follow the instructions in Figures 1-13 through 1-16.

Load the Lantern Battery into the Carrier.

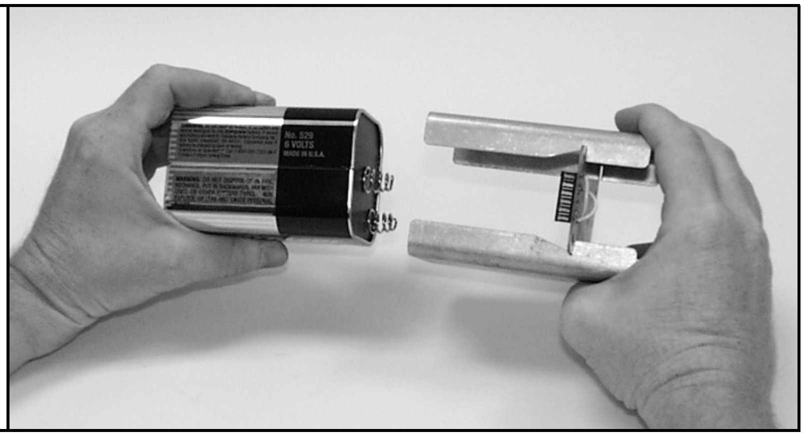


Figure 1-13 Insert Battery in Carrier

Insert the carrier and battery into the module. Note the position of the carrier's connector; it must be aligned toward the center of the module.

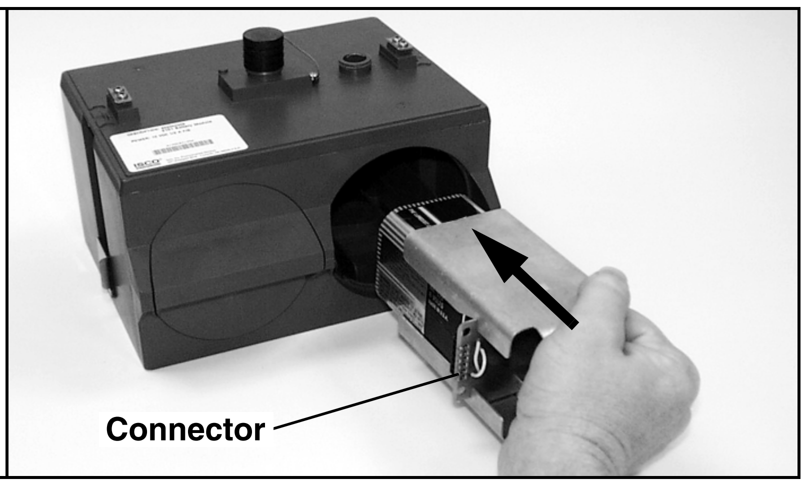


Figure 1-14 Battery Module - Inserting Carrier

While holding the door in your right hand, align the marks and insert the door.	

Figure 1-15 Battery Module - Aligning the Door

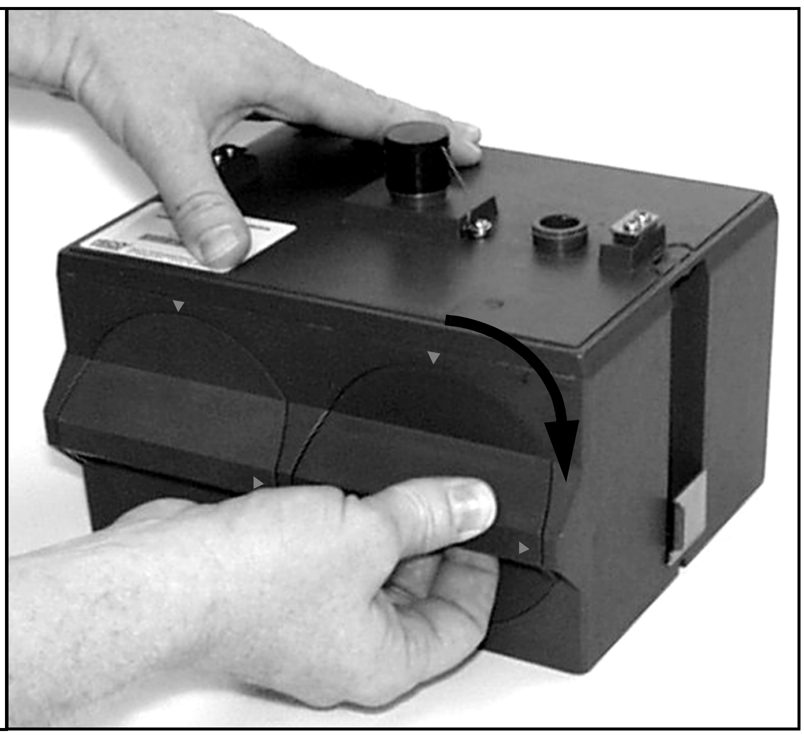
Rotate the door 1⁄4 turn clockwise. Repeat the steps in Figures 1-13 through 1-18 to install the second battery.	

Figure 1-16 Battery Module - Closing the Door

1.4 Stacking Modules

To stack a 2150 Flow Module on a Battery Module, follow the instructions in Figures 1-17 through 1-25.

Unlock the latch to release the lower plug.

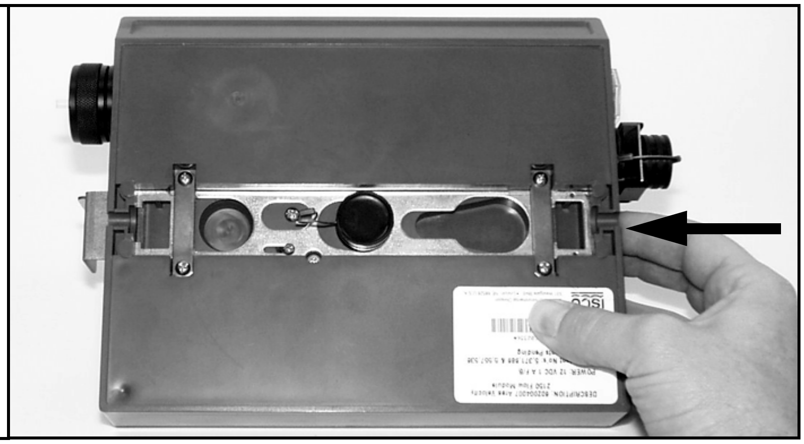


Figure 1-17 Flow Module - Unlocking the Latch

Pull the plug out of the connector.

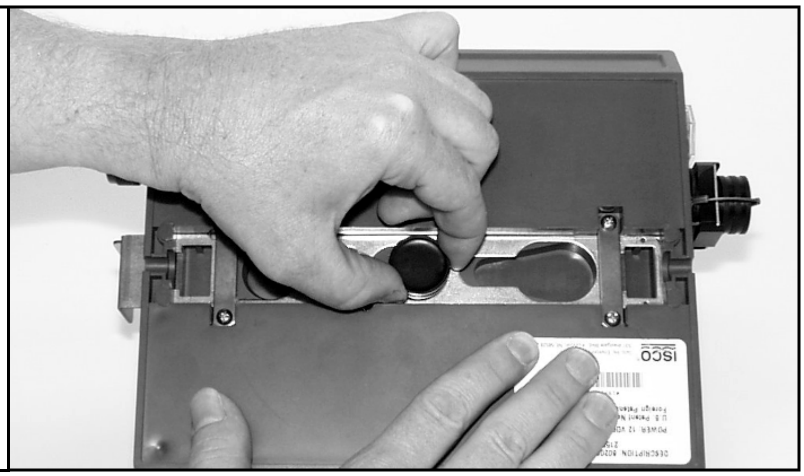


Figure 1-18 Flow Module - Unplugging the Connector

Push the plug into the holder.

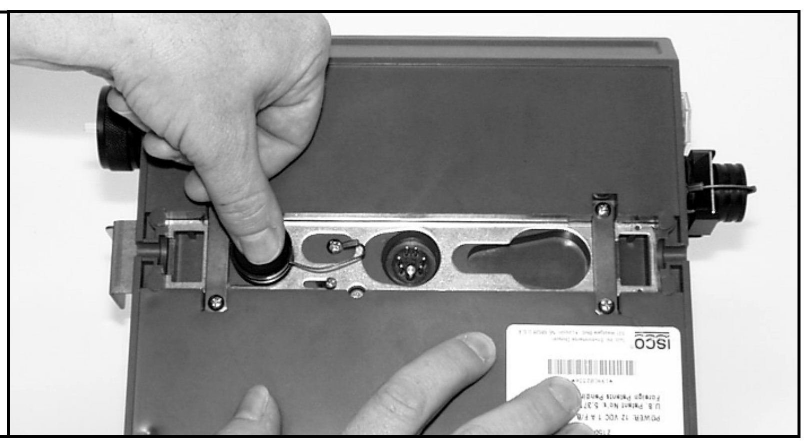


Figure 1-19 Flow Module - Pushing Plug into Holder

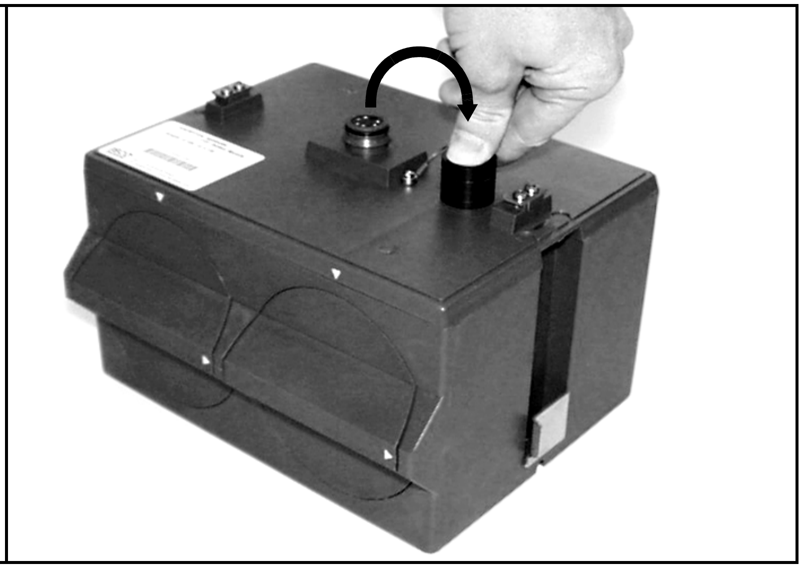
On the Battery Module, uncap the connector. Store the cap on the holder.	

Figure 1-20 Battery Module - Uncapping the Connector

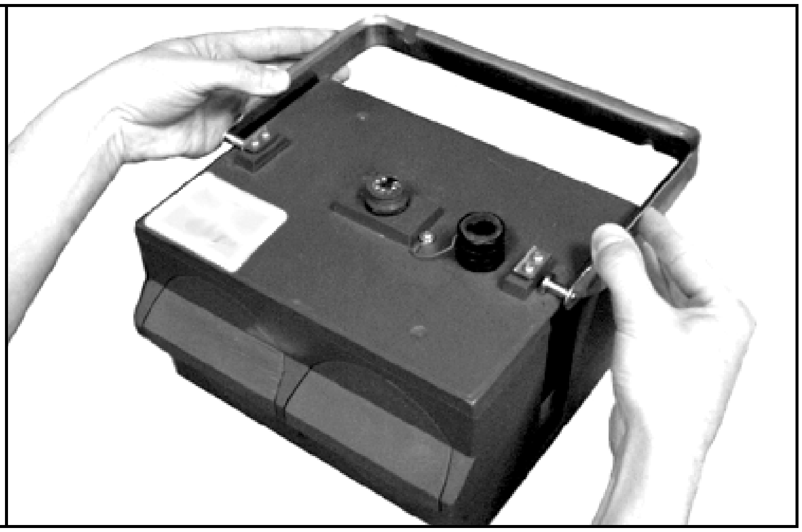
Place the handle on the Battery Module. The handle must rest towards the back of the module, otherwise its movement will be obstructed by the sensor cable, desiccant cartridge, and latches.	

Figure 1-21 Battery Module - Inserting the Handle

Align the modules and gently press the Flow Module onto the Battery Module.

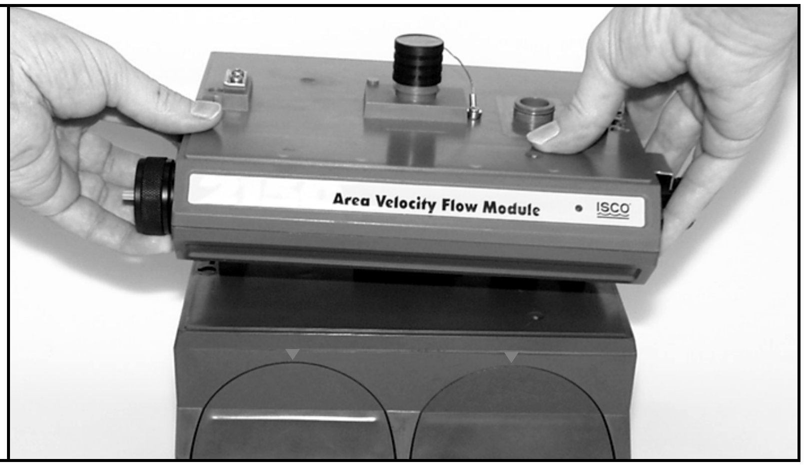


Figure 1-22 Aligning the Modules

While gently pressing down on the stack, lock the Flow Module latch.

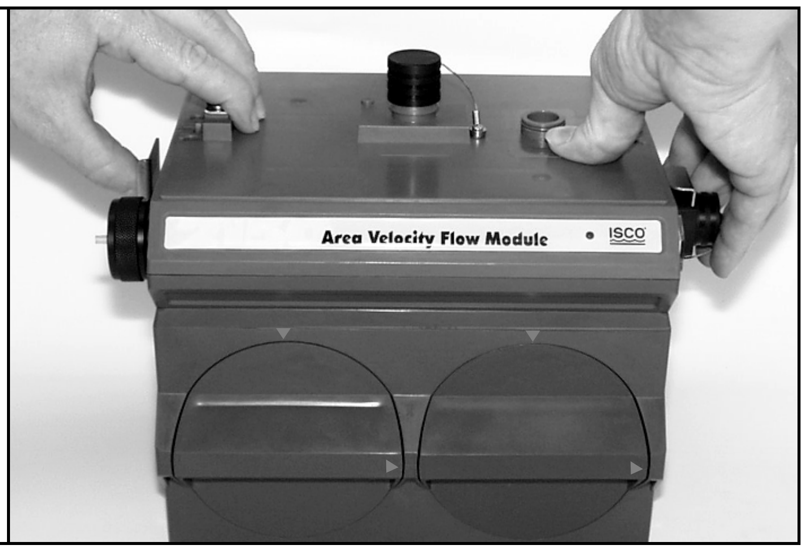


Figure 1-23 Aligning the Modules: Push Down and Lock the Latch

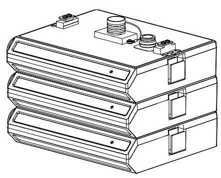
2150 Area Velocity Flow Module

Section 2 Introduction

2.1 Product Description

The 2150 Area Velocity Module is part of Isco's 2100 Series system. The 2100 Series system measures parameters of open channel flow streams.

The 2100 Series system is designed to be modular so that you can expand the system to meet your data collection needs. By stacking the 2100 Series modules, a single site can measure multiple flow channels, collect redundant data, or add other available measurement capabilities. A site can include remote measurement points, as distant as 3300 feet, by connecting modules with cables. Even with several remote modules configured as a site, you can still retrieve all of the measurement data from a single connection.



A 3-module site

The 2100 Series System is paired with Isco's *Flowlink for Windows* software. With this full-featured application, you can quickly set up modules, retrieve measurement data, manage the sites and analyze the data.

The module's data storage memory is quite flexible, able to store the measurements in intervals from 15 seconds to 24 hours. The modules can also be configured for variable rate data storage. Variable rates allow you to store data at a different interval when a programmed condition occurs.

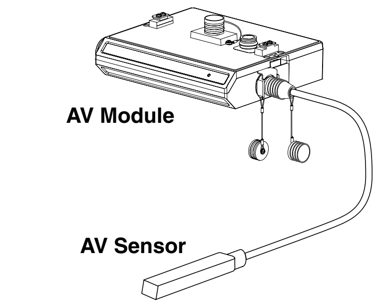
The module's program and collected data are stored in *flash* memory for security. Flash memory retains data without the concern of power failures or aging backup batteries. Its capacity is more than sufficient for many applications. The data storage memory can hold approximately 79,000 readings – the equivalent of nine months of level and velocity data when stored at fifteen minute intervals. The flash memory also stores sensor calibration information. A separate flash memory device inside the module stores the operating firmware.

The rugged 2100 series components are rated NEMA 4X, 6P (IP68). The permanently sealed enclosures are designed to meet the environmental demands of many sewer flow monitoring applications. All connections between modules, sensors, and communication cables “lock” in place. Each locking mechanism strongly secures the components and ensures a watertight seal.

The flow information from a 2150 can be used to pace an Isco 3700, GLS, or 6700 Series sampler. The connection is made using a 2100 Series Sampler Interface Cable (PN 60-2004-260). A flow pulse is sent out every 100 gallons or 500 liters of flow, depending on how the 2150 is configured.

2.2 2150 Module Overview

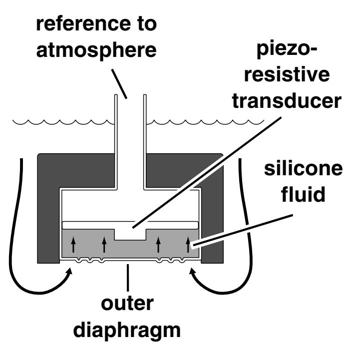
The 2150 measures liquid level and average stream velocity, and calculates the flow rate and total flow. The liquid level and velocity measurements are read from an attached AV Sensor that is placed in the flow stream. Flow rate calculations are performed internally using the measured parameters from the AV Sensor. Additionally, the AV Module can measure its input voltage – a service feature.



The 2150 is designed to provide durable operation with only a minimal amount of routine maintenance, all of which may be performed in the field. Typically, the AV Module and its AV Sensor will only require that you keep the stream free from excessive debris, and replace or recharge spent desiccant and batteries.

Sections 2.2.1 through 2.2.6 describe the module and sensor in greater detail.

2.2.1 Level

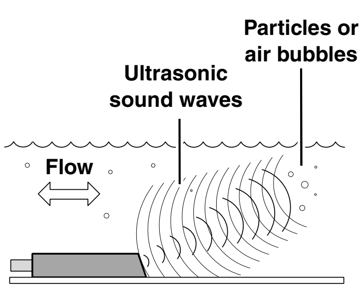


The AV Sensor's internal differential pressure transducer measures the liquid level. The transducer is a small piezo-resistive chip that detects the difference of the pressures felt on the inner and outer face.

The stainless steel outer diaphragm is exposed to the flow stream through the ports under the AV Sensor. The pressure felt on the outer diaphragm is transferred to the outer face of the transducer through a silicone fluid medium. The outer diaphragm and fluid isolate the sensitive transducer from direct exposure to the stream. The inner face of the transducer is exposed, or referenced, to the atmosphere through the internal vent tube that runs the full length of the AV Sensor's cable.

The difference between the pressures exerted on the transducer is the hydrostatic pressure. Hydrostatic pressure is proportional to the level of the stream. The analog representation of the hydrostatic pressure is digitized and sent to the AV Module as an RS-485 half-duplex signal.

2.2.2 Velocity



The AV Sensor measures average velocity by using ultrasonic sound waves and the Doppler effect. The Doppler effect states that the frequency of a sound wave (or other wave) passed from one body to another is relative to both their motions. As the two approach each other, the frequency increases; as they move apart, the frequency decreases.

The AV Sensor contains a pair of ultrasonic transducers. One transducer transmits the ultrasonic sound wave. As the transmitted wave travels through the stream, particles and bubbles carried by the stream reflect the sound wave back towards the AV Sensor. The second transducer receives the reflected wave.

Circuits internal to the module compare the frequencies of the sound waves and extract the difference. An increase or decrease in the frequency of the reflected wave indicates forward or reverse flow. The degree of change is proportional to the velocity of the flow stream.

2.2.3 Flow Rate

Using measurements from the AV Sensor, the AV Module can calculate the flow rate. The AV Module supports many different flow rate conversion methods:

- Area Velocity
- Data Points
- Manning Formula
- Two-term Polynomial Equations
- Flumes
- Weirs

Often the Model 2150 Area Velocity Flow Module is chosen for applications where a primary device is not available, nor is it practical to install a primary device. Therefore, area velocity is usually the conversion method of choice.

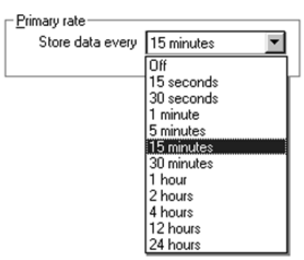
The AV Module is capable of calculating and storing any two conversion methods simultaneously. This feature is useful when it is necessary to validate a flow conversion method. For example, the flow rate at a new site programmed for area velocity conversion can be directly compared to the flow rate calculated using a Manning formula.

2.2.4 Total Flow

The AV Module can calculate and report the total flow. You can set up the module to monitor *net, positive,* or *negative* total flow from either of the calculated flow rates.

2.2.5 Data Storage

Through Flowlink, you configure which type of data is logged and the storage rate. For each measurement, the *Data Storage Setup* window lets you turn the primary rate off, or select a rate from 15 seconds to once every 24 hours. If the primary rate is turned off, the AV Module will not store the measurement (unless a secondary rate is selected). However, the AV Module will still take readings if that measurement type is necessary for a calculation.



Secondary rates are used to log data at a different rate when a user-defined condition exists. For example, a secondary rate can be used to increase the level and velocity data storage rate when level is greater than or equal to a point of interest. Secondary rates give you the best resolution of data, but only when it is needed. Until the condition is met, the module will conserve power and memory by storing the data at the primary storage rate. Like the primary rate, you can turn the secondary rate off, or select a storage rate of 15 seconds to every 24 hours.

Time Resolution

The time resolution of each measurement is one second. That is, readings are taken at the same time as the time stamp, not collected and averaged over a period of time before the stamp.

Rollover Memory

Whether the measurements are stored at the primary or secondary rate, they are stored in a *rollover* type of memory. When full, the module overwrites the oldest data with the newest readings.

2.2.6 Input Voltage

The AV Module measures the input voltage so that it can be reported to the user. Input Voltage measurements are useful when estimating the remaining battery life and determining when the system must be serviced. You can log the Input Voltage readings in data storage to chart power consumption.

2.3 2191 Battery Module Overview

The Battery Module uses two 6 volt lantern batteries to supply 12VDC to Model 2100 system modules.

The Battery Module's only role is to supply DC power, yet it still supports communications between other modules. The upper and lower connectors pass along communications between modules attached above and below.

You can stack Battery Modules to increase the power available to a module or a stack of modules.

2.4 Applications

Typical applications for the 2150 Module include:

- Sewer Flow
- Inflow and Infiltration (I&I) studies
- Storm Water Runoff Monitoring
- Combined Sewer Overflow (CSO) Monitoring.

2.5 Controls, Connectors, and Indicators

The controls, connectors, and indicators on the 2150 Module, AV Sensor, and 2191 Battery Module are shown in Figures 2-1 through 2-3. Items referenced in the figures are briefly discussed in Tables 2-1 through 2-3.

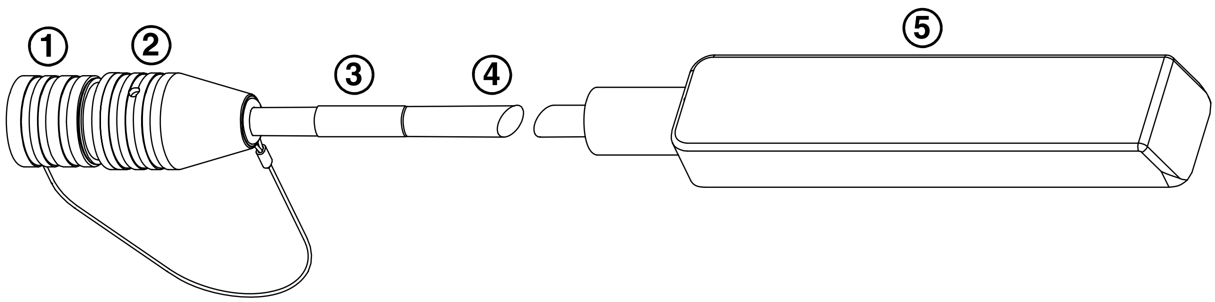


Figure 2-1 2150 Area Velocity Sensor Parts

Table 2-1 2150 Area Velocity Sensor Parts and Descriptions

Item No. Fig. 2-1	Name	Description
1	Connector Cap	Protects the connector. When the connector is not in use, this cap must be in place to prevent damage to the connector pins and reference air tubing.
2	Connector	Attaches to the AV Sensor receptacle on the AV Module.
3	Serial Number Label	Lists product ID and unit serial numbers.
4	Cable	394 in (10 m) cable containing the reference air tubing and conductors to transfer level data, velocity data, and AV Sensor power.
5	AV Sensor Body	The AV Sensor Body is placed in the flow stream to measure level and velocity.

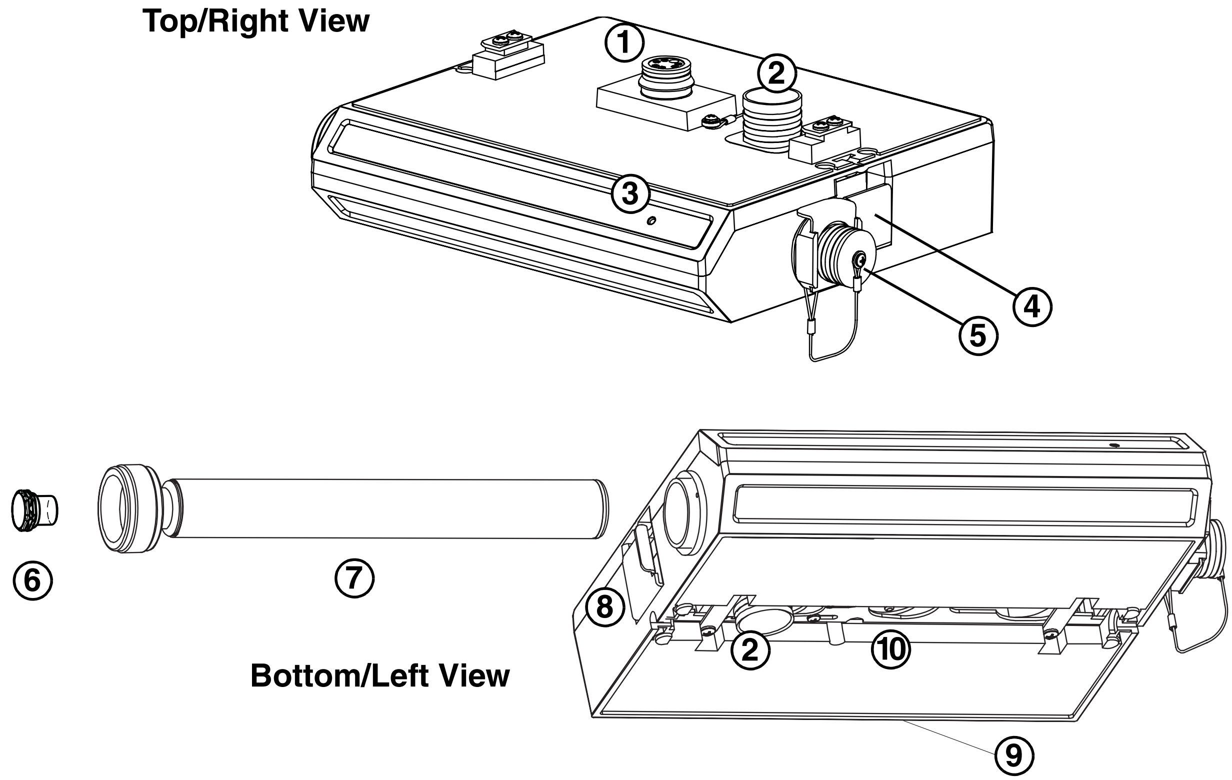


Figure 2-2 Controls, connectors, and indicators – 2150 Flow Module

Table 2-2 Controls, connectors, and indicators – 2150 Flow Module

Item No. Fig. 2-2	Name	Description
1	Communication Connector	Upper communication port. The connection transfers data and 12 VDC power to other modules. The port is also used to connect to a PC running Flowlink software.
2	Connector Caps	Insert into unused communication connectors to terminate the network and protect them from moisture damage. When communication connectors are in use, the caps must be stowed as shown in Figure 2-2 to protect the terminating components inside the caps.
3	Communication Indicator	Illuminates when the module is active. With Flowlink, a user can turn on this light-emitting diode (LED) to identify the module at a multiple-module site.
4	Latch Release	Push in to release the module from a stack.
5	AV Sensor Receptacle	Port used to attach the AV Sensor. Insert the protective cap when not in use.
6	Hydrophobic Filter	Prevents moisture from entering the reference line.
7	Desiccant Cartridge	Container holding desiccant that dries the reference air. (See Section 3.3.3).
8	Latch	Push in to lock the module in a stack.
9	Serial Number Label	On back of unit - lists product ID and unit serial numbers.
10	Communication Connector	Lower communication port. The connector transfers data and 12 VDC power to other modules.

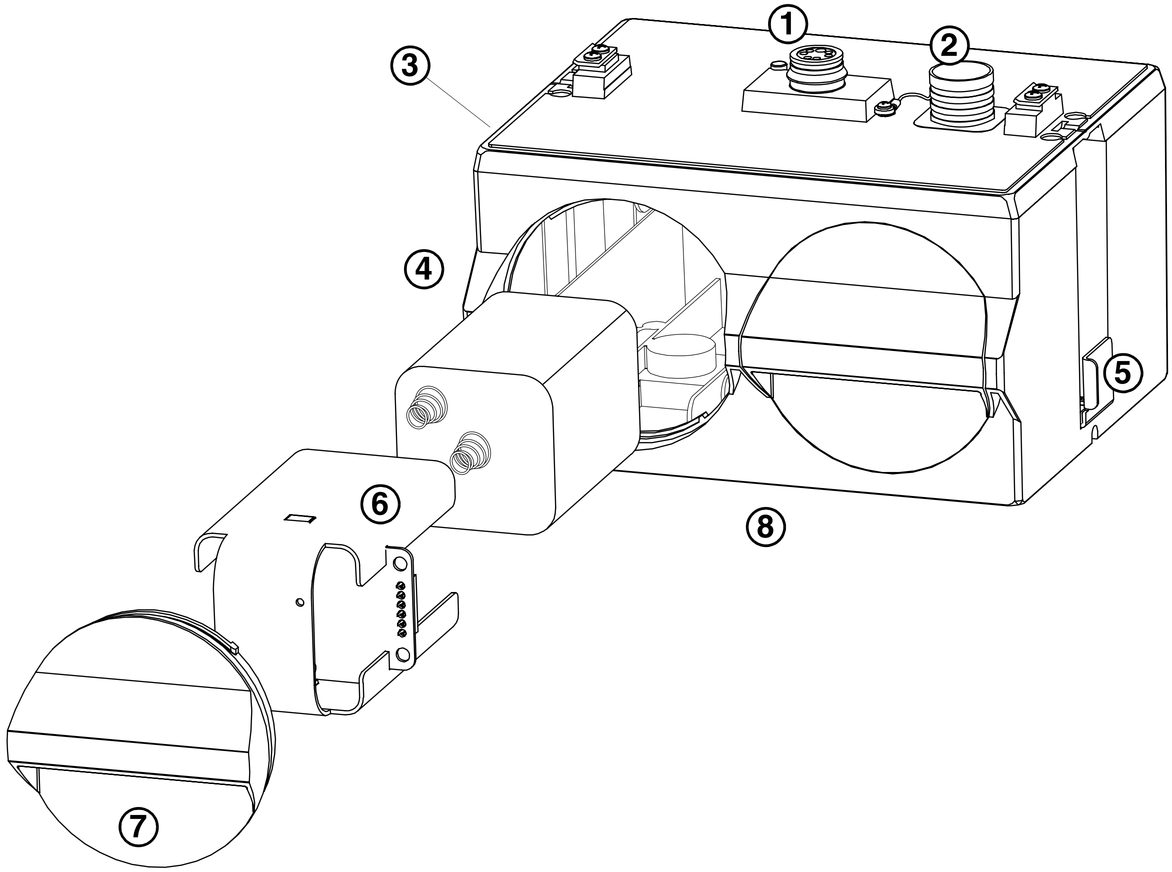


Figure 2-3 Controls, connectors, and indicators – 2191 Battery Module

Table 2-3 Controls, connectors, and indicators – 2191 Battery Module

Item No. Fig. 2-3	Name	Description
1	Communication Connector (upper)	Upper communication port. The connector transfers data and 12 VDC power to other modules. Also used to connect to a PC running Flowlink software.
2	Connector Caps	Insert into unused connectors and receptacles to terminate the network and protect them from moisture damage. When communication connectors are in use, the caps must be stowed as shown in Figure 2-3 to protect the terminating components inside the caps.
3	Serial Number Label	On back of unit - lists product ID and unit serial numbers.
4	Latch *(not visible)*	Push in to lock the module in a stack.
5	Latch Release	Push in to release the module from a stack.
6	6 Volt Lantern Battery Carrier	Adapter to hold the battery in place. The carrier is necessary when using 6 volt lantern-style batteries.
7	Battery Door	Quarter-turn door seals the battery cavity. Inside each door is a humidity indicator and a bag of desiccant to prevent internal moisture damage. (See Section 6.4)
8	Communication Connector (lower - *not visible*)	Lower communication port. The connector transfers data and 12 VDC power to other modules.

2.6 Technical Specifications

The following tables provide technical information about the 2150 Module and its related components.

- Table 2-4 lists the technical specifications of the 2150 Area Velocity Flow Module
- Table 2-5 lists the technical specifications of the 2150 Area Velocity Sensor
- Table 2-6 lists the technical specifications of the 2191 Battery Module
- Figure 2-4 and Table 2-7 lists information about the 2150 Module's communication connector.

Table 2-4 Specifications – 2150 Area Velocity Flow Module			
Size (H×W×D)	2.9 × 11.3 × 7.5 in.	7.4 × 28.7 × 19.1 cm	
Weight	2.0 lbs	0.9 kg	
Material	High-impact polystyrene, stainless steel		
Enclosure (self-certified)	NEMA 4X, 6P	IP 68	
Power	7 to 16.6 VDC, 100 mA typical at 12 VDC, 1 mA standby		
Typical Battery Life (one module)	Data Storage Interval 15 minutes 5 minutes 1 minute	Alkaline Batteries 15 months 8 months 2 months	Lead-Acid Batteries 2.5 months 1.5 months 11 days
Program Memory	Non-volatile, programmable flash; can be updated using PC without opening enclosure; retains user program after updating		
Number of Modules	Up to 4, field interchangeable		
Maximum Distance between Remote Modules	3300 ft	1000 m	
Wiring between Modules	Twisted pair for communication, pair for power, gauge dependent on distance		
Flow Rate Conversions	Up to 2 independent level-to-area and/or level-to-flow rate conversions		
Level-to-Area Conversions			
Channel Shapes	Round, U-shaped, rectangular, trapezoidal, elliptical, with silt correction		
Data Points	Up to 50 level-area points		
Level-to-Flow Rate Conversions			
Weirs	V-notch, rectangular, Cipolletti, Isco Flow Metering Inserts, Thel-Mar		
Flumes	Parshall, Palmer-Bowlus, Leopold-Lagco, trapezoidal, H, HS, HL		
Manning Formula	Round, U-shaped, rectangular, trapezoidal		
Data Points	Up to 50 level-flow rate points		
Equation	2-term polynomial		
Total Flow Calculations	Up to 2 independent, net, positive or negative, based on either flow rate conversion		
Data Storage Memory	Non-volatile flash; retains stored data during program updates		

Table 2-4 Specifications – 2150 Area Velocity Flow Module (Continued)		
Capacity	395,000 bytes (up to 79,000 readings, equal to over 270 days of level and velocity readings at 15 minute intervals, plus total flow and input voltage readings at 24 hour intervals)	
Data Types	Level, velocity, flow rate 1, flow rate 2, total flow 1, total flow 2, input voltage	
Storage Mode	Rollover with variable rate data storage based on level, velocity, flow rate 1, flow rate 2, total flow 1, total flow 2, or input voltage	
Storage Interval	15 or 30 seconds; 1, 2, 5, 15 or 30 minutes; or 1, 2, 4, 12 or 24 hours	
Bytes per reading	5	
Setup and Data Retrieval	Serial connection to computer with Isco Flowlink for Windows software	
Baud Rate	38,400	
Temperature Range	-40° to 140°F	-40° to 60°C operating & storage

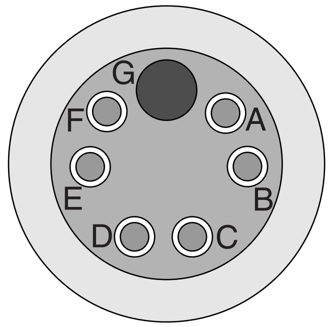
Table 2-5 Specifications – 2150 Area Velocity Sensor		
Size (H×W×D)	0.75 × 1.31 × 6.00 in.	1.9 × 3.3 × 15.2 cm
Cable Length	394 in.	10 m
Cable Diameter	0.37 in.	0.9 cm
Weight *(including cable)*	2.1 lbs	0.95 kg
Level Measurement		
Method	Submerged pressure transducer mounted in the flow stream	
Transducer Type	Differential linear integrated circuit pressure transducer	
Range[1]	0.033 to 10 ft. (optionally) up to 30 ft.	0.010 to 3.05 m 9.15m
Maximum Submersible Depth	34 ft.	10.5 m
Accuracy[2]	± .010 ft.	± 0.003 m
Typical Long Term Stability	± 0.023 ft./yr	± 0.007m/yr
Compensated Temperature Range	32 - 122°F	0 - 50°C
Velocity Measurement		
Method	Doppler Ultrasonic	
Frequency	500 kHz	
Transmission Angle	20° from horizontal	
Typical Minimum Depth for Velocity Measurement	0.08 ft.	25 mm
Range	-5 to +20 ft./s	-1.5 to +6.1 m/s
Accuracy[3]	Velocity	Error
	-5 to +5 ft./s (-1.5 to +1.5 m/s) 5 to 20 ft./s (1.5 to 6.1 m/s)	±0.1 ft./s (±0.03 m/s) ±2% of reading

Table 2-5 Specifications – 2150 Area Velocity Sensor (Continued)		
Operating Temperature	32° to 160°F	0° to 71°C
Temperature Measurement Accuracy	± 3.6°F	± 2 °C
Materials		
Sensor	Epoxy, chlorinated polyvinyl chloride (CPVC), stainless steel	
Cable	Polyvinyl chloride (PVC), chlorinated polyvinyl chloride (CPVC)	

Notes:

1. Actual vertical distance between the area velocity sensor and the liquid surface
2. Maximum error within compensated temperature range (per degree of change from calibration temperature)
3. In water with a uniform velocity profile and a speed of sound of 4850 ft./s (1480 m/s)

Table 2-6 Specifications – 2191 Battery Module		
Size (H×W×D)	6.0 × 9.6 × 7.6 in.	15.2 × 24.4 × 19.3 cm
Weight *(without batteries)*	3.2 lbs.	1.4 kg
Materials	ABS plastic, stainless steel	
Enclosure *(self-certified)*	NEMA 4X, 6P	IP68
Batteries	6V alkaline lantern or lead-acid lantern, quantity 2	
Capacity		
Alkaline Lantern Batteries	25 Ahrs	
Lead-acid Lantern Batteries	5 Ahrs	



Communications Port
(upper connector shown)

Figure 2-4 2150 Module Connector Pins

Table 2-7 AV Module Connector Pins

Pin	Name	Description
A	LONA	Neuron differential transceiver Data A
B	LONB	Neuron differential transceiver Data B
C	VIN+	Positive power supply voltage input (+12 VDC nominal)
D	VIN–	Negative power supply voltage input (0 VDC nominal)
E	RCVUP	PC data receiver RS-232 level input
F	XMTUP	PC data transmit RS-232 level output
G	Key	Aligns connector pins

2150 Area Velocity Flow Module

Section 3 Preparation and Installation

3.1 Unpacking Instructions

When the system arrives, inspect the outside packing for any damage. Then carefully inspect the contents for damage. If there is damage, contact the delivery company and Teledyne Isco (or its agent) immediately.

⚠ WARNING

If there is any evidence that any items may have been damaged in shipping, do not attempt to install the unit. Please contact Teledyne Isco (or its agent) for advice.

Teledyne Isco, Inc.
Customer Service Dept.
P.O. Box 82531
Lincoln, NE 68501 USA

Phone:(800) 228-4373
Outside USA & Canada call:
(402) 464-0231

FAX: (402) 465-3022

E-mail:
IscoInfo@teledyne.com

When you unpack the system, check the items against the packing list. If any parts are missing, contact the delivery company and Teledyne Isco's Customer Service Department. When you report missing part(s), please indicate them by part number. In addition to the main packing list, there may be other packing lists for various sub-components.

It is recommended that you retain the shipping cartons as they can be used to ship the unit in the event that it is necessary to transport the system.

Please complete the registration card and return it to Teledyne Isco, Inc.

3.2 Preparing for Installation

3.2.1 Safety

⚠ **WARNING**

The installation and use of this product may subject you to hazardous working conditions that can cause you serious or fatal injuries. Take any necessary precautions before entering a worksite. Install and operate this product in accordance with all applicable safety and health regulations, and local ordinances.

The 2100 Series components are often installed in confined spaces. Some examples of confined spaces include manholes, pipelines, digesters, and storage tanks. These spaces may become hazardous environments that can prove fatal for those unprepared. These spaces are governed by OSHA 1910.146 and require a permit before entering.

3.2.2 Locating the Site

The 2150 Flow Module is designed to measure flow in open channels with or without a primary device. A primary device is a hydraulic structure, such as a weir or a flume that modifies a channel so there is a known relationship between the liquid level and the flow rate. Although the AV Module supports flow-rate conversion in channels with a primary device, its level and velocity measurement capabilities are best suited for channels *without* a primary device.

☑ ***Note***

Primary devices limit the usefulness of the AV Sensor's readings. In most cases, levels and velocities near these structures do not represent what normally occurs in the channel. If you must use area velocity flow conversion, or if your interest is the stream's velocity, do not install the AV Sensor near a primary device. Move the AV Sensor away to where the flow is unaffected by the primary device.

3.2.3 Channels Without a Primary Device

When the AV Sensor is installed without a primary device, find a section of channel with a minimum of disturbances to the flow. Avoid areas with elbows, outfalls, inverts, junctions, etc. that create turbulence near the AV Sensor. The AV Sensor should be located away from these disturbances to a point where the flow has stabilized. For best results, install the AV Sensor where the flow is most uniform. Uniform flow is a condition where the water surface is parallel to the bottom of the channel.

3.2.4 Channels With a Primary Device

If the AV Sensor is installed in a primary device, its location depends on the type of primary device. Most primary devices have a specific place for the head (level) measurement sensor. For more details about the location of the head measuring point, refer to the *Isco Open Channel Flow Measurement Handbook*, or to information provided by the manufacturer of the primary device.

Note

When you install the AV Sensor for use within a primary device, a Level-to-Flow conversion method should be used. (See Programming, Section 4.)

3.2.5 AV Module and AV Sensor Mounting Considerations

Ideal sites are easily accessible for service and data collection, while still providing protection for the 2100 Series devices. The 2100 Series devices are rated NEMA 4X, 6P, and constructed of materials that can withstand harsh environments. However, continual exposure to UV light, or periodic submersion should be avoided to extend the life of the components.

Typically, the AV Module is suspended inside a manhole. Suspending the AV Module near the opening will protect it from the elements, minimize the chance of submersion, and allow it to be easily retrieved without entering the manhole.

The AV Sensor should be installed within 25 feet (7.6 m) of the AV Module. Distances greater than 25 feet require custom length cables. Call the factory or your representative.

3.3 Installation Procedures

3.3.1 Install Battery Module Batteries

The Battery Module requires two 6V lantern-type batteries. The following batteries may be used in the Battery Module:

- commercially available 6VDC alkaline lantern batteries (Isco P/N 340-2006-02)
- rechargeable 6VDC lead-acid battery in a lantern-style case. This 5.0 ampere-hour battery can be ordered from Isco (P/N 60-2004-041).

To install batteries (refer to Figure 3-1):

1. Remove the battery door. To remove the door, turn it $^1/_4$ turn counter-clockwise and pull it from the Battery Module.
2. Pull the lantern battery carrier out of the Battery Module.
3. Remove the old battery from the carrier.
4. Insert a fresh battery in the carrier. Slide in the battery so that the springs contact the plate inside the carrier.
5. Align the connectors and insert the battery carrier into the Battery Module.
6. Check the humidity indicator disk inside the door. (See section 3.3.2.)
7. Replace the door.

Repeat steps 1 through 7 to install the second battery.

Note

The batteries should always be replaced as a pair. Never mix old and new batteries.

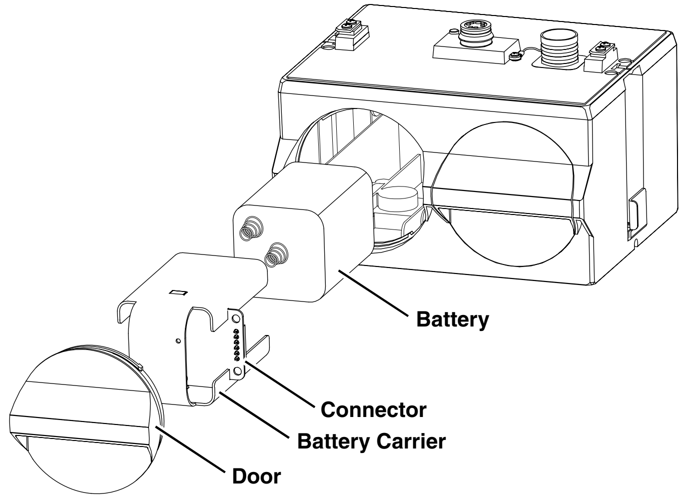
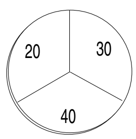


Figure 3-1 Installing a Battery

3.3.2 Inspect the Desiccant – Battery Module



A humidity indicator is mounted inside each battery cap on the Battery Module. The humidity indicators have regions that display 20, 30, and 40 percent humidity levels. Ideally each region should be completely blue. As the desiccant becomes saturated, the humidity levels will increase and the regions turn pink. When the 40 percent region turns pink, the Battery Module is no longer adequately protected and the desiccant must be replaced. Refer to section 6.4 for replacement instructions.

3.3.3 Inspect the Desiccant – AV Module

A desiccant cartridge is inserted into the side of the AV Module. The cartridge is filled with silica gel beads that will indicate when they are saturated. When dry, the beads are yellow or blue. As the desiccant becomes saturated, the humidity levels will increase and the beads turn green or pink. If the entire length of the desiccant cartridge turns green or pink, the reference air is no longer adequately protected and the desiccant must be replaced. Refer to section 6.4 for replacement instructions.

⚠ CAUTION

Operating the AV Module and sensor with saturated desiccant can cause many problems such as drifting level readings and permanent damage. It is important that the equipment is serviced often enough to prevent the entire desiccant cartridge from becoming saturated.

3.3.4 Connecting the Modules

The 2100 Series System is modular; you build the system by connecting modules together. The instructions in this section describe how to connect an AV Module to a Battery Module in its most basic configuration — by stacking the two modules. Either module may be stacked on the other, but you may find it more convenient if you place the Battery Module at the bottom of the stack. This keeps the heavier items lower in the stack making it easier to transport or store.

Other modules may be attached to this stack to increase the site's functions. You can add many modules to the stack as long as each module uses a unique module name (Section 4.2.1), and as long as you observe the power requirements of the extra modules.

Connection options

Keep in mind that stacking is not the only way to connect modules. The modules may be placed in remote locations and still operate as a single site. If you would like to use remote modules for your application, please consult with the factory or your representative to realize the full potential of your system.

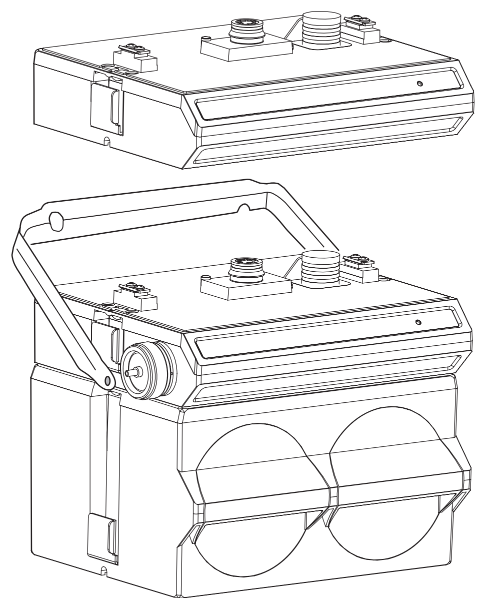


Figure 3-2 Assembling a system (shown: 2 flow modules with 1 battery module)

Connecting the Modules

To connect the AV and Battery modules, refer to the following instructions and Figure 3-2.

1. On the top of the Battery Module, remove the cap and stow it on the holder. This exposes the communication connector on the Battery Module.
2. Prepare the Battery Module's communication connector:
   a. Inspect the connector. It should be clean and dry. Damaged O-rings must be replaced. Spare O-rings (Isco P/N 202-1006-69) are supplied in the maintenance kit (60-2099-001).
   b. Spray the O-ring's sealing surface with a *silicone* lubricant.

Note

Do not use petroleum-based lubricants. Petroleum-based lubricants will cause the O-ring to swell and eventually deteriorate. Aerosol silicone lubricant sprays often use petroleum based propellants. If you are using an aerosol spray, allow a few minutes for the propellant to evaporate before proceeding.

3. Place the carrying handle on the Battery Module. (If you are stacking several modules, it is recommended that you position the handle between the top two modules.)
4. Unlock the AV Module's latch by pressing in on the latch release (right side).
5. Underneath the AV Module, remove the cap from the lower communication connector and stow it in the holder.
6. Lock the latch. Locking the latch correctly seats and aligns the lower cap in its holder.
7. Position the AV Module over the Battery Module. Align the connectors and lower the AV Module onto the Battery Module.
8. Unlock the AV Module's latch by pressing in on the latch release (right side).
9. Firmly press the modules together and lock the AV Module's latch (left side).

The Communications indicator will blink during the start-up routine to indicate the AV Module is operating.

Note

Unused communication ports on the top and bottom of the stack must be capped. The connector caps terminate the communication lines and protect the pins.

3.3.5 Installing the modules

The modules should be secured at the site. This prevents damage caused by accidental falls and from being swept away if the channel is flooded. In manholes, the modules are often secured to a ladder rung, or suspended from a spreader bar. Teledyne Isco's Customer Service Department or your local representative can assist you with installation options.

As you complete the installation, the following should be checked before leaving the site unattended:

1. The modules should be positioned where they will be protected from submersion. Should the modules become submerged, level readings may drift and the hydrophobic filter will seal to protect the reference air line. If the possibility of *short-term* submersion cannot be avoided, you can prevent the drifting level readings and damage to the hydrophobic filter. Attach a length of $^1\!/_8$ inch I.D. tubing (Isco P/N 60-2003-104) to the hydrophobic filter. Route the other end of the tubing to a dry location.

Note

To protect the AV Module and sensor, the hydrophobic filter seals off the reference air line when it is exposed to excessive moisture. When sealed, the filter prevents irreparable damage, yet may cause the level readings to drift. This single-use filter must be replaced once it becomes sealed. See Section 6.6.1 for more information.

CAUTION

Long-term submersion (several hours or more), may permanently damage the modules and sensors.

2. Ensure that all of the protective caps are in place. Unused upper and lower communication connections must be capped. The caps prevent damage and terminate the communication lines. Caps for any communication connectors that are in use should be properly stowed. Like the module and sensor connections, the protective caps and their O-rings should be cleaned and coated with a silicone lubricant. Damaged O-rings must be replaced (Isco P/N 202-1006-69).
3. Carefully route cables. Protect them from traffic in the area. Avoid leaving excess AV Sensor cable in the flow stream where it may collect debris.

3.3.6 Connecting the AV Sensor

The AV Sensor cable attaches to sensor receptacle on the AV Module.

To connect the AV Sensor (refer to Figure 3-3):

1. Remove the protective caps:
   a. On the AV Module, push down on the sensor release while pulling the protective cap from the receptacle.
   b. On the AV Sensor cable, pull the cap from the end of its connector.
2. Prepare the AV Sensor connector:
   a. Inspect the connector. It should be clean and dry. Damaged O-rings must be replaced. Spare O-rings (Isco P/N 202-1006-69) are supplied in the maintenance kit (60-2059-001).
   b. Spray the O-ring's sealing surface with a *silicone* lubricant.

Note

Do not use petroleum-based lubricants. Petroleum-based lubricants will cause the O-ring to swell and eventually deteriorate. Aerosol silicone lubricant sprays often use petroleum based propellants. If you are using an aerosol spray, allow a few minutes for the propellant to evaporate before proceeding.

3. Align and insert the connector. The sensor release will "click" when the sensor connector is fully seated.
4. Connect the two caps together.

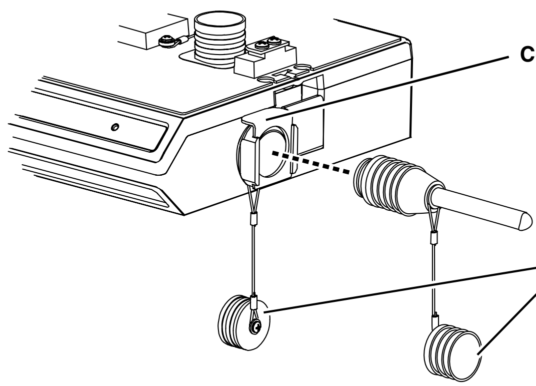
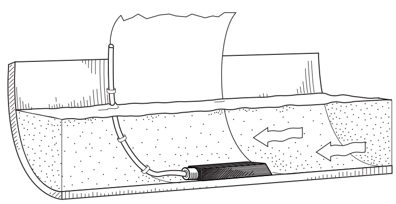


Figure 3-3 Connecting the AV Sensor

3.3.7 Installing the AV Sensor

See Section 3.5 for a summary of sensor mounting options for round pipe installations. Sensor installation is discussed in detail in *Isco's Mounting Rings Instruction Manual*. The manual explains how to mount the low profile AV Sensor in flow streams using spring rings, scissors rings, a street level installation tool, and mounting plates.



Ideal Conditions - Uniform Flow

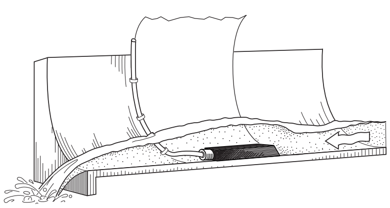
Several factors concerning the AV Sensor's installation may affect your system's performance. Please review the following to understand how to obtain the best results:

Uniform flow - The AV Sensor provides the best results in flow streams with uniform flow. An example of uniform flow is shown in the margin.

Avoid poor channel conditions - Poor channel conditions may cause incorrect or erratic readings. Areas to avoid are:

- outfalls or channel intersections
- flow streams at very low levels with high flow rates
- turbulence
- channel sections that are apt to collect debris or silt
- depths that consistently run below 1 inch (25 mm).

Install the AV Sensor in streams where the liquid covers the sensor. The AV Sensor can detect levels above approximately 0.033 feet (0.4 inch or 1.0 cm) and typically can measure velocities in streams as low as 0.08 ft (1 inch or 25 mm). Streams that run consistently below 1 inch are not a good application for the 2150 Module and AV Sensor.



Poor Conditions

The example in the margin shows a few of these poor conditions. The outfall is drawing down the liquid level and the AV Sensor is disturbing the flow. In this example, the AV Sensor should be moved forward to avoid the drawdown near the outfall.

Offsets - You can install the AV Sensor above the bottom of the flow stream or along the side of the channel, as long as it will be continually submerged. The AV Module can be calibrated to measure level with the AV Sensor at nearly any depth. The AV Sensor cannot, of course, measure a liquid level that falls below its position in the flow stream. Installing the AV Sensor above the bottom has several advantages:

- It avoids heavy concentrations of silt, sand, or other solids.
- It aids installation in narrow or hard-to-reach locations.
- It maximizes level resolution over a specific level range.
- It can avoid obstructions in the flow stream.

When the AV Sensor is installed above the bottom of the channel, a *Zero Level Offset* must be entered in the program settings.

Liquid properties - Velocity measurements depend on the presence of some particles in the stream such as suspended solids or air bubbles. If the stream lacks particles it may be necessary to aerate the water upstream from the sensor.

Handle with care - Abusive handling will damage the AV Sensor. Although the AV Sensor will survive normal handling and installation, treat the sensor with reasonable care. The internal components cannot be repaired.

Protect the cable - There is a vent tube inside the cable that must remain open. Do not kink the cable or overtighten the plastic ties while securing the cable.

Secure the cable - Teledyne Isco recommends that you secure the cable in place. Tying off the cable can often prevent lost equipment if excessive flow dislodges the sensor and its mounting.

3.3.8 Program the Module

After you have installed the AV Sensor in the flow stream, the flow stream properties must be defined. To do this, connect to the AV Module with *Flowlink for Windows* software and define the stream properties in the AV Module's program settings. These ensure that the system correctly reads the liquid level and converts the measured level to flow rate.

☑ Note

The 2100 System requires Flowlink 4.1or later. Earlier versions do not support 2100 System instruments.

Referring to Section 4, define the following properties:

- **Level** – Enter a liquid level measurement to calibrate the level readings from the AV Sensor (4.3.1).
- **Zero Level Offset** – If the AV Sensor is not installed in the bottom-center of the channel, an offset distance must be entered (4.3.2).
- **Set Flow Rate to zero if no velocity data checkbox** - Determines how the AV Module reports flow rates if stream velocity data is not available (4.3.3).

- **Prevent velocity signal interference** – When more than one sensor is measuring the same section of channel, the ultrasonic sound waves can interfere with each other. AV Modules can be synchronized to prevent velocity signal interference (4.3.4).
- **Flow Conversion** – The AV Module can store flow rate readings. To correctly convert the measured level and velocity readings to a flow rate, the flow conversion method and channel properties should be defined (4.3.5).
- **Silt Level** – *(Area Velocity Flow Conversion Only)* The AV Module can compensate for a build up of silt around the AV Sensor (4.3.6).

These six settings should be considered a minimum requirement. Other settings, such as *Data Storage Rates*, *Site Name*, and *Module Names*, also may be set using Flowlink. Section 4 describes how you can modify these other settings.

3.3.9 Basic Installation Checklist

As a review, the following steps may be used as a guide to install a 2150 Module at a basic site. In this example, a basic site is a single AV Module and AV Sensor, and a Battery Module. Your steps may differ if you have selected an alternative power source, or if you are installing additional modules.

1. Prepare the Battery Module.
   a. Install batteries (Section 3.3.1).
   b. Inspect desiccant (3.3.2).
2. Inspect AV Module desiccant (3.3.3).
3. Assemble the system.
   a. Connect the modules (3.3.4).
   b. Attach the AV Sensor cable to the AV Module (3.3.6).
4. Install the AV Sensor in the flow stream. Refer to *Isco Mounting Rings Instruction Manual* (3.3.7).
5. Connect to the site with *Flowlink for Windows* software (3.3.8).
   a. Create the site by Quick Connecting to the modules.
   b. Set up the site and module settings.
   c. Calibrate the level measurement.
6. Disconnect from the site and replace all protective caps.
7. Mount or suspend the modules (3.3.5).

3.4 Site Example

Figure 3-4 illustrates a visit to a round-pipe site that uses several optional components. Key items are explained below:

The computer running **Flowlink** communicates with the modules. With Flowlink, you can name the site, set up its operation, and adjust the level measurement. To assist with servicing, Flowlink also will display input power voltage (an indication of remaining battery life) and collect diagnostic reports.

A **communication cable** connects the computer and site. The cable supports the data transfers between the two.

A **spreader bar** is used to suspend the modules in a manhole. Spreader bars are adjustable to fit openings from 22.5 to 48 inches (60 to 120 cm).

The **2150 Area Velocity and Battery Modules** measure and store the stream data.

The **Street Level Installation Ring Release Strap** is tied to a rung inside the manhole. When it is necessary to retrieve the AV Sensor and mounting ring, pulling on the strap releases the ring from the pipe so you can lift it from the manhole.

The **AV Sensor cable** is routed carefully without kinks or sharp bends. Any excess cable is kept out of the channel to prevent debris from collecting.

The **Street Level Installation Ring** was set in place using Isco's Street level Installation Tool. The tool is an adjustable, multi-section pole that allows you to insert the ring and AV Sensor into a round pipe without entering the manhole.

The **AV Sensor** is positioned in the flow stream to measure liquid level and velocity.

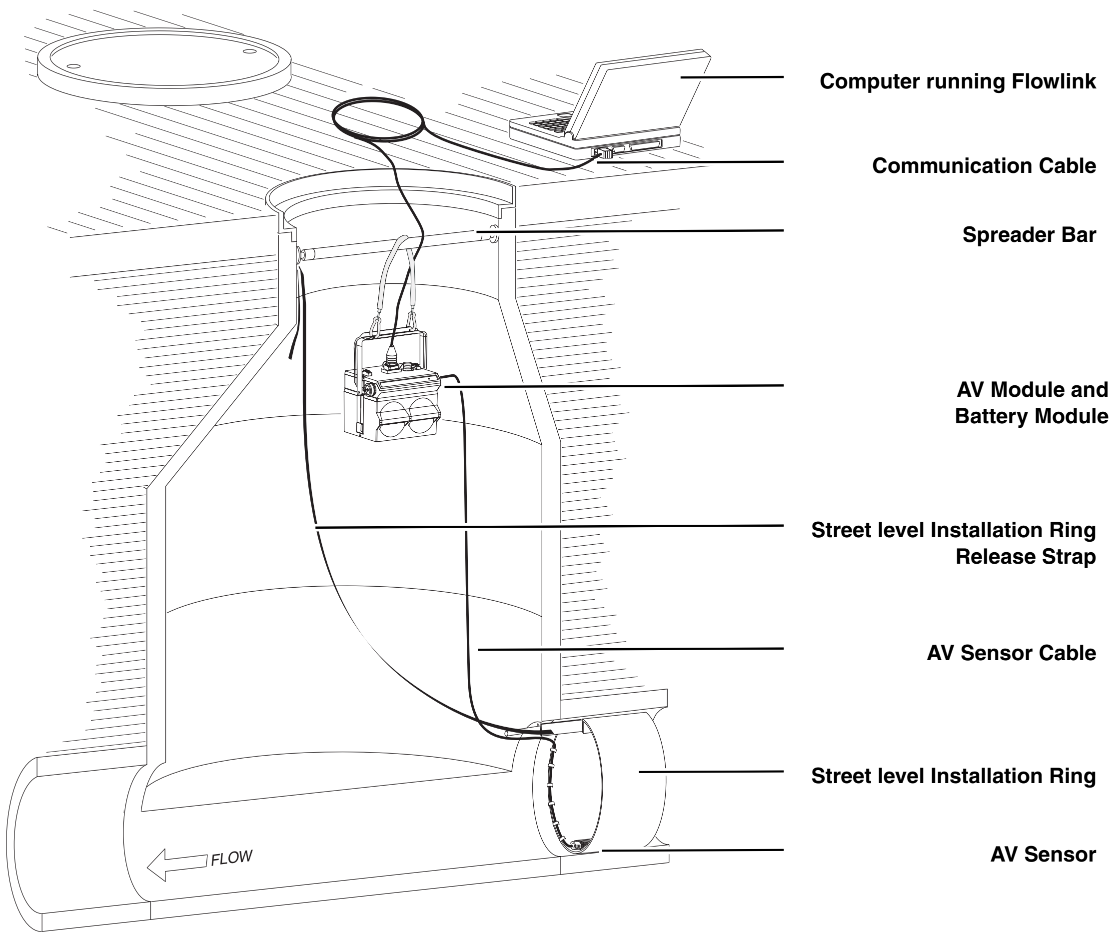


Figure 3-4 Typical Round-pipe Installation

3.5 Mounting Rings

Consult your Isco Mounting Rings Installation and Operation Guide for detailed hardware information.

The following sections describe sensor installation using the two options available for mounting the AV sensor in pipes or round-bottomed flow streams. For pipes up to 15" (38 cm) in diameter, **stainless steel self-expanding mounting rings** (**Spring Rings**) are available. For pipes larger than 15" in diameter, Teledyne Isco offers the **Scissors Rings (Universal Mounting Rings)**. Area velocity sensors can also be installed using primary measuring devices.

3.5.1 Spring Rings

To install a spring ring, compress the ring, slip it inside the pipe, and then allow it to spring out to contact the inside diameter of the pipe. The inherent outward spring force of the ring firmly secures it in place. A typical self-expanding mounting ring (with a probe mounted on it) is shown in Figure 3-5.

These mounting rings are available for use in pipes with inside diameters of 15.2 cm (6"), 20.3 cm (8"), 25.4 cm (10"), 30.5 cm (12"), and 38.1 cm (15"). The Isco part numbers for the various size mounting rings available are listed in Appendix B. These part numbers include not only the ring, but also the miscellaneous hardware necessary to mount the sensor on the ring.

⚠ CAUTION

Always wear leather gloves when handling the rings (either type). The metal is finished, but there is still a possibility of cutting your hands on the edges.

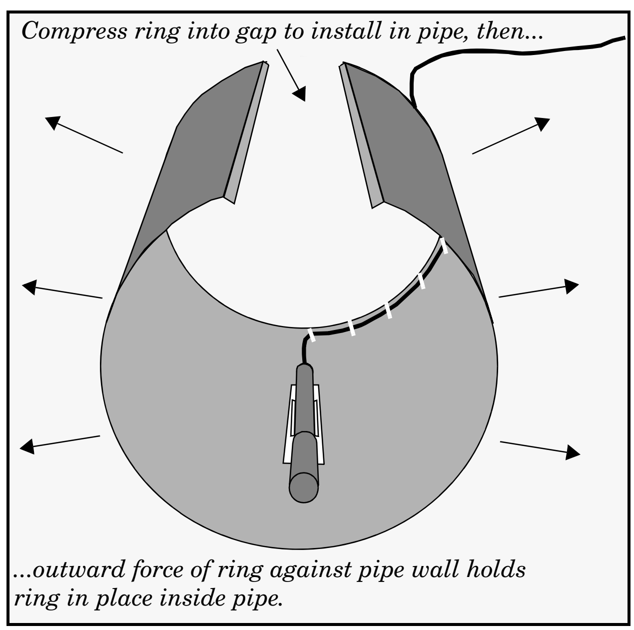


Figure 3-5 Sensor Installed on a Spring Ring

Attaching the Sensor to the Ring

Attach the AV sensor to the ring either by using two 4-40 countersink screws or by snapping the optional probe carrier to the ring. This second method of attaching the sensor allows for easy removal in case service is needed later.

⚠ CAUTION

Make sure the slots on the AV sensor carrier are completely pressed into the tabs on the ring. This is particularly important where there is any possibility of reverse flows, or where flows are of high velocity. If the AV sensor is not fully pressed into the mounting ring tabs, it might come loose in the stream, and could possibly be damaged or lost.

Make sure the sensor cable is securely fastened along the back (downstream) edge of the ring. Otherwise, the sensor may provide **inaccurate level readings** under conditions of high velocity.

To complete the sensor-spring ring assembly procedure, attach the sensor cable to the downstream edge of the ring. Follow the cable routing shown in Figure 3-5. Other routing directions may affect measurement accuracy. The cable can actually create a stilling well downstream from the sensor, causing the level to read low. Use the self-locking plastic ties supplied with the ring. Install the ring in the pipe by compressing it. Press inward on both sides and slide the ring into the pipe.

Route the sensor cable out of the stream and secure it in position by placing the ties through the holes in the mounting ring and then locking them around the cable, as shown in figure 3-5.

⚠ CAUTION

Do not overtighten the plastic cable ties; they should be tightened just enough to secure the cable in place, without greatly indenting the cable. Overtightening the plastic ties may collapse the reference tube in the cable, blocking it.

The spring ring may need anchoring. Under conditions of high velocity (greater than 1.5 meters per second or 5 feet per second), the ring may not have sufficient outward spring force to maintain a tight fit inside the pipe. The ring may start to lift off the bottom of the pipe, or may even be carried downstream.

This problem is more prevalent in the larger diameter pipes and in pipes with smooth inside surfaces, such as plastic pipes. If any of these conditions are present, or if movement of the mounting ring is detected or suspected, you must anchor the ring in place. You can do this by setting screws through the ring into the pipe, or by other appropriate means. If there is a problem with the smaller diameter rings, it may be sufficient to simply increase the outward spring force of the ring by bending it into a less round configuration.

3.5.2 Scissors Mounting Ring

For pipes larger than 15" in diameter, Teledyne Isco offers the adjustable Scissors Ring (also known as the Universal Mounting Ring). This device consists of two or more metal strips that lock together with tabs to form a single assembly. There is a base section where the sensors are mounted, two or more extension sections (usually), and a scissors section at the top that expands the entire assembly and tightens it inside the pipe. The scissors section contains a long bolt that increases the length of the section as it is tightened.

The assembled scissors rings fit pipe diameters from 16" to 80". Secure the unit in place by tightening the scissors mechanism with a $^5/_8$" socket wrench or other suitable tool. Ring sections are .040" thick half-hard 301 stainless steel sheet. All other parts are also stainless steel, except for the plastic cable ties in the hardware kit.

Each extension, 1, 2, 3, and 4, adds 9.0", 21.5", 31.5", or 41.5", respectively, to the circumference of the ring. Used alone, the base section fits a pipe that is approximately 16" to 19" in diameter. The 9.0" (smallest) extensions can be used to take up or remove slack, to bring the scissors mechanism into a position where it can be effectively tightened.

☑ Note

The hardware kit includes flat head bolts and nuts.Teledyne Isco strongly recommends bolting the assembled scissors ring together before installation, using the holes provided for that purpose. Bolting the tongue sections together can greatly increase safety and prevent the assembly from being torn apart.

Do not overtighten the mechanism. It is designed to flex somewhat to provide a positive lock, once moderately tightened.

For installations in larger channels and/or high flow, extensions 2, 3, and 4 have slots for attaching the ring to the channel wall using appropriate anchoring hardware.

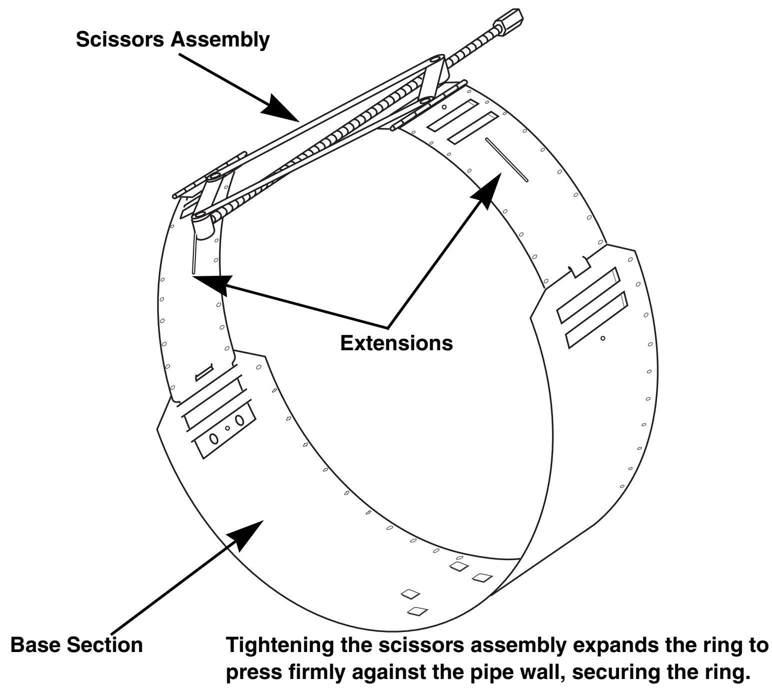


Figure 3-6 Scissors Ring adjustment

To prevent debris from catching on the probe cable, it is important to attach the cable to the mounting ring so it offers as little resistance to the flow as possible. Attach the sensor cable to the downstream edge of the ring, using the self-locking plastic ties supplied with the ring. Place the ties through the holes in the mounting ring and then lock them around the cable.

⚠ CAUTION

Do not overtighten the plastic cable ties; they should be tightened just enough to secure the cable in place, without greatly indenting the cable. Overtightening the plastic ties may collapse the reference tube in the cable, blocking it.

3.5.3 Completing the AV Sensor Installation

The AV sensor installation is finished by securing any excess sensor cable using cable clamps or other means.

The reference tube inside the cable can be restricted or blocked if the cable is kinked, sharply bent, coiled, or otherwise pinched. The sensor cable should be handled and mounted with care. Also, if there is any appreciable distance between the point where the sensor cable leaves the mounting apparatus and the location of the flow meter, *be sure* to attach the cable to the flow stream wall to prevent it from vibrating, moving around, tangling, or possibly collecting debris.

⚠ CAUTION

Under no circumstances should you leave any extra length of sensor cable dangling freely in the flow stream where it could trap debris or become tangled.

Use gloves and eye protection when assembling and installing the rings in a pipe. Though deburred, the edges of the stainless steel can cut if improperly handled. *Please read the information in the Isco Mounting Rings Manual on how best to install this device.*

Observe general safety procedures when entering any manhole. See “General Safety Procedures” in the back of this manual for more information on general hazards and necessary precautions.

2150 Area Velocity Flow Module

Section 4 Programming

4.1 Section Overview

This section describes how to set up the operation of a 2150 Module using Isco's Flowlink for Windows software.

> ☑ **Note**
>
> The 2100 System requires Flowlink 4.1 or later. Earlier versions do not support 2100 System instruments.

Flowlink Help

Detailed Flowlink instructions are beyond the scope of this manual. Flowlink's operating instructions are available in a Windows Help format. You can access the help topics for an active window by clicking on its *Help* button or by pressing F1 on your computer's keyboard. You can also access Help topics from a Contents and Index window (HELP>CONTENTS AND INDEX from the Flowlink menu).

4.2 Flowlink Connections

Make the necessary wiring connections to allow your computer to communicate with the site. Figure 4-1 shows a connection using Isco's *RS232 Communication Cable*, P/N 60-2004-046.

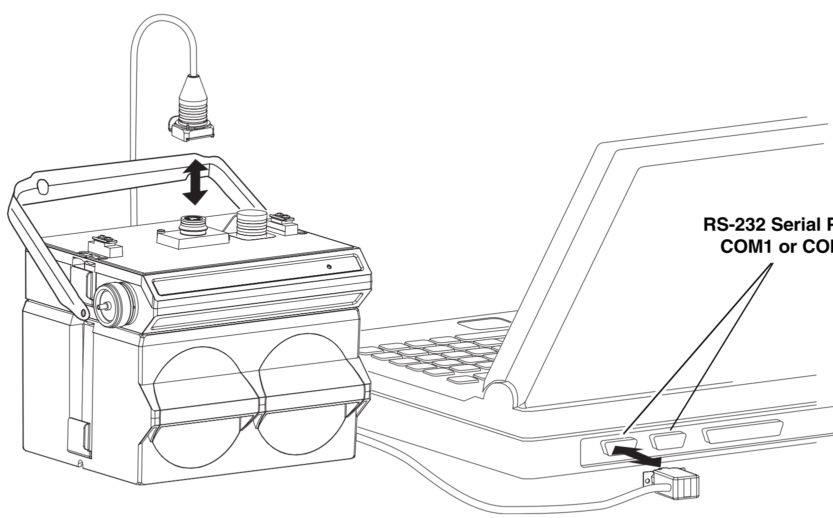


Figure 4-1 Flowlink connections

An easy way to begin Flowlink communications with the site is to *Quick Connect*. As a default Flowlink setting, the Quick Connect dialog box opens when you start Flowlink. Click on the large *2100 Instruments* button to connect. Flowlink will read the 2100 system information and try to match it with an existing site in the open database. If Flowlink cannot find a match for the connected site, it creates a new site in the database.

4.2.1 Communication Resolution

During the connection process, Flowlink checks the stability of the site's communications. If communication is found to be unstable, Flowlink presents the *Communication Resolution* window.

There are two common causes of unstable communications. One cause is a Module Name conflict, which may occur when two or more modules at a site use the same module name. The second cause is a Site Name conflict, which occurs when a module added to the site indicates that it belongs to a different site.

The Communications Resolution window lets you choose how the modules should be reconfigured and which Site Name should be retained. To resolve the communications, select the sites and modules that should be reconfigured and click the OK button. Be aware that reconfiguring a module removes the Site Name, Module Name, program settings, *and any stored data*. The module is then restarted with the stable Site's Name, a default Module Name, and default program settings, and the data storage is ready to accept new data.

4.3 Program Settings

While connected, Flowlink displays the *Site View* window. This window contains all of the program settings that control the site's operation. The settings are grouped, or categorized, using five tabs: Measurements, Site Info, Modules, Data Storage, and a variable tab used to set up the various measurement types.

Essential Settings

Some program settings are essential to the operation of an AV Module and its attached AV Sensor. Five program settings should always be verified when you are setting up a new site:

- **Level** – Enter a liquid level measurement to calibrate the level readings from the AV Sensor (4.3.1).
- **Zero Level Offset** – If the AV Sensor is not installed in the bottom-center of the channel, the distance the AV Sensor is offset must be entered (4.3.2).
- **Set Flow Rate to zero if no velocity data checkbox** - Determines how the AV Module reports flow rates if stream velocity data is not available (4.3.3).
- **Flow Conversion** – The AV Module can calculate flow rate readings. To correctly convert the measured level and velocity readings to a flow rate, the flow conversion method and channel properties should be defined (4.3.5).
- **Silt Level** – The AV Module can compensate for a build up of silt around the sensor (4.3.6).

These five program settings directly affect the data collection. Incorrect settings may introduce errors in the measured data, many of which may prove to be difficult to correct afterwards.

Data Storage Settings

You should also check the Data Storage Rates while you are reviewing the program settings. You can view the storage rates on the Data Storage tab to ensure that pertinent types of data are being stored, and that the rates will provide a sufficient amount of data for your application. Refer to section 4.3.7 for instructions on how to modify the data storage rates.

General Settings

Once the site's communication has been resolved, the Site and Module Names may be changed to help you better manage the sites and data collection. Giving sites descriptive names such as "12th and Main Streets" can help you easily recognize the measurement locations, instead of generic terms such as "Site 1." Site and Module Names are discussed in sections 4.3.8 and 4.3.9.

Changing a Setting

After modifying a setting as described in sections 4.3.1 through 4.3.9, click on the APPLY button (or press F9 on your keyboard). Flowlink sends the change to the module and updates the site's settings in its Flowlink database.

4.3.1 Level

A measurement of the actual liquid depth should be taken to calibrate the level readings. The value of this measured depth should be entered on the *Level* measurement tab in Flowlink.

> ☑ **Note**
>
> Before calibrating the level, allow a newly installed AV Sensor to stabilize under the stream conditions. If the sensor undergoes wide temperature variations between its storage and operating environments, it may take several minutes to stabilize.

Measurement Location

The location of your measurements can affect the flow conversion results. An understanding of how the AV Sensor measures level and velocity will help you determine where the measurements should be taken.

The AV Sensor transmits an ultrasonic sound wave. It propagates from the front of the sensor in a cone-shaped pattern. From within this cone, the AV Sensor measures the stream velocity. Therefore, your level measurement should be taken from a point inside the cone. Since this cone cannot be seen, a general rule is to measure in front of the sensor along the channel centerline at a distance equal to the liquid depth. For example, if the stream is one foot deep, take the level and channel dimension measurements one foot upstream from the sensor. If the flow at this point is turbulent, consider relocating the sensor.

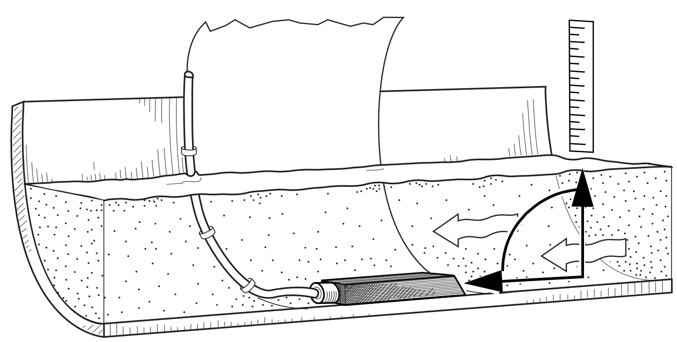
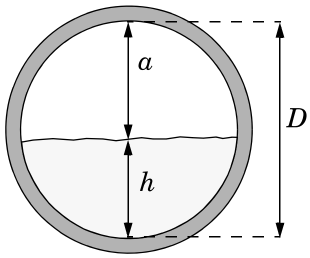


Figure 4-2 Preferred Measurement Location

Do not measure the level and channel dimensions right at the sensor, as the sensor and the mounting ring may cause a slight "jump" or localized rise in the level. At very low levels and high velocities, this jump in the liquid surface may become quite significant.



Level (h) = D – a

In round pipes you can measure the level without disturbing the stream surface. This method is preferred. Refer to the diagram to the left. First measure the inside diameter of the pipe (*D*). Then measure the airspace (*a*) from the liquid surface to the peak of the inside diameter. Average this measurement if the surface is not calm. The level measurement you enter (*h*) is calculated by subtracting the distance above the liquid (*d*) from the diameter (*D*).

If difficult channel conditions keep you from making the measurements as described above, another site should be considered. If this is impossible, you may opt for an alternative level calibration method. The method described below will often yield better results than entering a "best estimate" of the liquid level, but results within the listed performance specifications *may be compromised*.

Alternative Level Calibration

1. Fill a bucket with 6 to 12 inches (15 to 30 cm) of water.
2. Place the AV Sensor upside-down in the bucket of water to allow any air bubbles trapped under the sensor to escape.
3. After a few minutes, place the AV Sensor right-side up at the bottom of the bucket.
4. With the AV Sensor flat against the bottom of the bucket, measure the distance from the bottom surface of the bucket to the liquid surface. Enter the distance on the *Level* measurement tab in Flowlink.

4.3.2 Zero Level Offset

AV Sensors are sometimes offset in the channel to avoid heavy concentrations of silt, or to maximize the level resolution over a specific range. When the AV Sensor is offset, an offset distance must be entered on the *Velocity* measurement tab in Flowlink.

Refer to Figure **4-3**. Enter a value for the vertical distance the sensor is installed above the true zero level of the stream. For example, if the sensor is mounted on the side of the pipe two inches higher than the true zero level (the bottom center of the pipe), the Zero Level Offset is two inches. If the sensor is mounted at the bottom of the channel, enter zero.

☑ Note

Do not confuse the circumferential distance between true zero and the location of the AV Sensor with the vertical distance (height). If you install the AV Sensor at the true zero level of the pipe or channel, you would enter "0" for the offset (ignoring the thickness of the mounting ring).

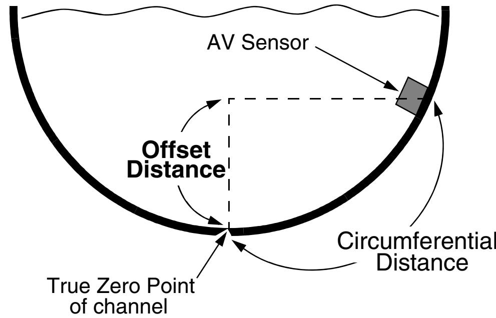


Figure 4-3 Zero Level Offset Measurement

4.3.3 No Velocity Data and Flow Rates

Occasionally velocity readings are lost because either a flow stream does not contain enough reflective particles, or the sensor is covered with silt. These lost velocity readings are logged as a "No Data Code." If the AV Module is set up to use area velocity flow conversion, it is then unable to calculate the flow rate. You can control how the Flow Rate readings will be reported during these conditions with the "Set flow rate to zero if no velocity data" checkbox, found on Flowlink's *Velocity* measurement tab.

- Checked, the AV Module stores the flow rate as 0.0 when velocity data is not available.
- Unchecked, the AV Module will use last valid velocity measurement in the flow rate calculation.

☑ Note

Measuring velocity becomes extremely difficult at low liquid levels. When the level falls below one inch, the module no longer measures the velocity. Instead, velocity is interpolated based on measurements that occurred between one and seven inches of liquid.

4.3.4 Prevent Velocity Signal Interference

If the AV Sensors of a multiple module site are placed near each other it is important that each sensor receives its own transmitted signal. To prevent this sort of interference, you can synchronize the modules so that only one module may take a velocity measurement at any given moment.

To synchronize the velocity measurements of a multiple module site, check the *Prevent interference* box found on the *Velocity* measurement tab. You may leave this box unchecked for single module sites or multiple module sites measuring velocities of separate channels.

4.3.5 Flow Conversion

The AV Module is capable of determining flow rates using either area velocity conversion or level-to-flow rate conversion. Table **4-1** lists the available flow conversion methods.

The AV Module is capable of calculating and storing any two conversion methods simultaneously. Flow conversions are defined on the *Flow Rate* and *Flow Rate 2* measurement tabs in Flowlink.

To do this, select the *Conversion Type* that matches your application, then enter the required parameters in the fields to the right of the selected conversion type.

Table 4-1 Flow Conversion Methods

Conversion Type		Device, Formula, or Table	Size or Parameters
Area Velocity	**Channel Shape**	Area × Velocity	Round Pipe, U-Channel, Rectangular, Trapezoidal, Elliptical
	Level-to-area Data Points	User-developed Table	3 to 50 data points
Level to Flow	**Weir**	V-Notch Weir	22.5, 30, 45, 60, 90, 120 degrees
		Rectangular Weir with end contractions	Crest Length
		Rectangular Weir without end contractions	Crest Length
		Thel-Mar	6, 8, 10, 12-14, 15-16 inches
		Cipoletti Weir	Crest Length
	Flume	Parshall Flume	1, 2, 3, 6, 9 inches 1, 1.5, 2, 3, 4, 5, 6, 8, 10, 12 feet
		Palmer-Bowlus Flume	4, 6, 8, 10, 12, 15, 18, 21, 24, 27, 30, 48 inches
		Leopold-Lagco	4, 6, 8, 10, 12, 15, 18, 21, 24, 30 inches
		"HS" Flume	0.4, 0.6, 0.8, 1.0 feet
		"H" Flume	0.5, 0.75, 1, 1.5, 2, 2.5, 3, 4.5 feet
		"HL" Flume	4.0 feet
		Trapezoidal Flume	Large 60-degree V Extra Large 60-degree V 2-inch, 45-degree WSC 12-inch, 45-degree SRCRC
	Flow Metering Insert	V-notch	6, 8, 10, 12 inches
		Round Orifice	6, 8, 10, 12 inches
	Manning Formula	Round Pipe	Slope, Roughness, Diameter
		U-Channel Pipe	Slope, Roughness, Width
		Rectangular Pipe	Slope, Roughness, Width
		Trapezoidal	Slope, Roughness, Bottom Width, Top Width
	Equation	Flow = 0.00*(Head^0.00) + 0.00*(Head^0.00)	
	Level-to-Flow Rate Data Points	User-developed tables for level-to-flow rate	3 to 50 data points

If the selected flow conversion requires channel dimensions, actual channel measurements should be taken. Channel measurements are preferred over nominal values. Significant errors may be introduced if your measurements are inaccurate. The example below illustrates the importance of accurate measurements.

Example:

Nominal Pipe Diameter:	10 inches
Actual Pipe Diameter:	10.25 inches
Level Measured Near Outfall:	2.75 inches
Correct Level Measurement:	3 inches

During programming, you enter 10 inches for the round pipe diameter - from the pipe manufacturer's specification. You also enter the 2.75 inch level measurement taken behind the sensor near an outfall. Although each setting has only a 0.25 inch error, the cumulative flow measurement error may exceed 14%!

Refer to the discussion on *measurement location* in section 4.3.1, and Figure 4-2 to determine where to measure the channel dimensions.

4.3.6 Silt Level

Silting in the flow stream will alter your channel dimensions, affecting the flow rate conversion. To compensate for a buildup of silt, a *Silt Level* value can be entered on the *Flow Rate* measurement tab in Flowlink. Silt level compensation is only available when using Area Velocity flow conversion.

4.3.7 Data Storage Rates

The data storage function of an AV Module can record level, velocity, flow rate, total flow, and input voltage readings. The interval at which the AV Module stores the readings is called the *Data Storage Rate*. The AV Module is shipped with default storage rates of 15 minutes for the level, velocity, and flow rate, and 1 hour for total flow and input voltage readings.

You can modify the data storage rates to log readings at a faster or slower rate. Keep in mind that although the AV Module can store data as fast as 1 reading every 15 seconds, faster storage rates will shorten battery life, increase memory usage, and lengthen *Retrieve Data* (interrogation) times.

You can also create conditional data storage rates. The AV Module can log data at a secondary rate when user-defined conditions have been met. For example, an AV Module can store level readings at a primary rate of 15 minutes, and a secondary rate of 1 minute when the level reading is greater than or equal to 1 foot. Secondary rates allow you to collect detailed data when defined events of interest occur, while reducing power and memory consumption when detailed readings are not needed.

To modify the Data Storage Rates, first click on the *Set Up Data Storage…* button on a measurement tab. Then enter the Primary and Secondary Rate settings on the *Data Storage Setup* window. Repeat this for each measurement type.

4.3.8 Site Name

The modules are shipped with default names so that they can immediately begin to communicate with Flowlink. You can change the site name to a more descriptive name on the *Site Info* tab in Flowlink. Keep in mind that the name must be unique among the other site names in the open Flowlink database.

Site names can be up to 20 characters long. Any character may be used in the name except:

/	forward slash	\	back slash
:	colon	*	asterisk
?	question mark	“	double-quote
<	left angle bracket	>	right angle bracket
l	bar	&	ampersand

4.3.9 Module Name

The modules are shipped with default names so that they can immediately begin to communicate with Flowlink. You can change a Module Name to a more descriptive name on the *Modules* tab in Flowlink. Keep in mind that the name must be unique among the other module names connected at that site.

To help you match up a single module in a stack with its module name in Flowlink, the Modules tab includes an *Identify* button. Highlighting a module name and clicking the Identify button will turn on the module’s Communication Indicator.

Module names can be up to 20 characters long. Any character may be used in the name, except for those noted in *Site Name*, section 4.3.8.

2150 Area Velocity Flow Module

Section 5 Modbus Protocol

Sections 5.1 through 5.5 give an overview of the basic capabilities and operation of Modbus protocol as it applies to Isco 2100 Series flow modules.

For a Glossary of Terms and Common Acronyms, see sections 5.4 and 5.5.

For Modbus technical specifications, turn to section 5.6.

5.1 Introduction

Modbus is a simple command/response mechanism to read from and write to specific memory locations called *registers*. A register is a holding place for a piece of digital information within the equipment. There are three standard protocols for Modbus: Modbus RTU, Modbus TCP/IP, and Modbus ASCII. The Isco 2100 Series devices use Modbus ASCII protocol, the method discussed in this manual. Modbus ASCII has more liberal communication timing requirements. Modbus communication for the Isco 2100 Series provides a standard protocol that can be used to retrieve real-time data from a single module or stack of modules at a site, or multiple sites, over a wide area. The data can be sent to a central computer for display, data collection, or process control.

Modbus implementation is independent of Flowlink and cannot alter the Flowlink-programmed configuration of the module. Modbus cannot be used to retrieve historical data from a module's memory.

Due to the wide variety of configurations that can be made with Modbus, it is impossible to cover every usable application. This section will discuss the overall capabilities and operation of Modbus.

5.2 Operation

There are many standard, third party Modbus drivers and OPC servers that may be used to link a remote Modbus device, such as a 2100 Series module, to SCADA or process control software, such as Wonderware™ or Intellution™. The OPC server communicates with the remote instrumentation and accesses registers. The definition of what information is contained and where (the register number, or address) is decided by the manufacturer (Teledyne Isco).

In a 2100 module, the registers hold, but are not limited to, the current real-time value of the meter's level, velocity, flow, input voltage, temperature, and total flow readings, stored in specified register locations. A list of the 2100 register addresses, and what parameters are held where, is available in section 5.6.

By accessing these registers you can obtain the current value of whatever parameter you desire. The reading(s) can then be displayed or stored wherever you designate as a destination; for example, a process control computer.

> **☑ Note**
> Level, flow, velocity, and temperature data is stored in metric units only.

Not all registers are limited to read-only data storage. You can also use some registers for control purposes. For example, by writing a “1” value to register 24 (“Identify Module” register), you will tell a 2100 module to light the LED on the front of the module.

5.2.1 Establishing Communication

There are several different communications protocols supported in the 2100 series that require auto-baud rate detection. Because of this, each time a modbus connection is made, the module uses a polling mechanism to repeatedly send a command until a response is received. It may take up to 20 command retries before the module has identified the baud rate and a response is received.

5.2.2 Module Addressing

When connecting to a site via a Modbus OPC server, you use a dedicated line of communication to that module or stack from the OPC server, which can be a dedicated communications cable (direct connection) or a dedicated phone number (modem).

When you are using a direct connection, you are dedicating a specified COM port on the computer, and that COM port determines the site to which you are connecting.

When you are using a modem, the dedicated line is defined by the site's phone number.

If you connect more than one 2100 Series module at a site, the Modbus OPC server, while using the shared communication line for all of the modules within the network, must have some way to differentiate between the modules. When sending a command to a specific module, the command has an address field. This allows the server software to talk to, as well as control, the specified module, while ignoring other modules in the same stack or site.

Each module capable of Modbus Protocol communication will automatically create its own specific ASCII address within the site, using:

- The model numbers of the modules
- The user-defined module names

5.3 Configurations

A variety of configurations can be made with Modbus, either through direct connection or through a modem.

In the example shown in Figure 5-1, you are direct-connecting a server PC to two individual 2100 sites through Modbus, using the COM ports on the OPC Server, which are directly connected to the remote sites.

Connection to the module is made through the RS-232 communication port on the top of the module.

☑ Note

For low power operation, we recommend connecting the module(s) to the computer using the straight-through cable (Isco part number 60-5314-529), which consumes less power, instead of our standard interrogation cable.

In Figure 5-1, the OPC Server PC must have two COM ports. Modbus requires one COM port each, for direct connection of each 2150.

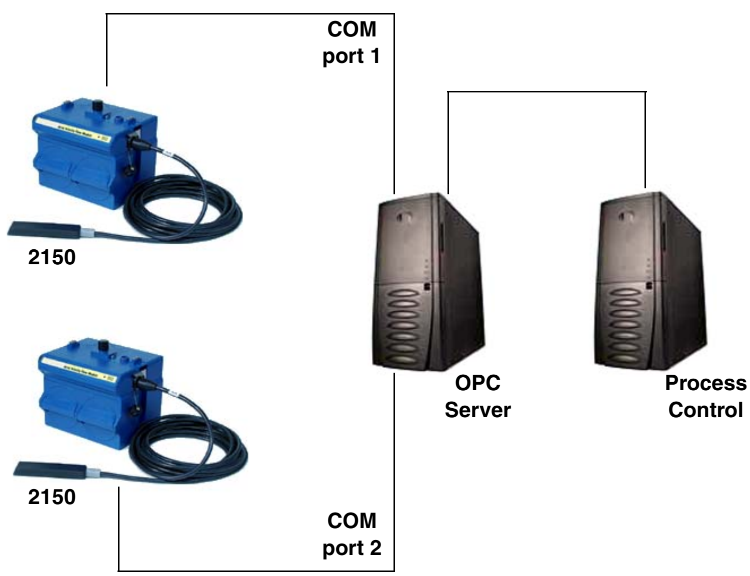


Figure 5-1 Configuration example

The operation sequence for the example above can be summarized in the following steps:

2150:

1. 2150s take readings from probes.
2. 2150s store readings (level, velocity, flow rate, etc.) in their specified registers.

Process Control:

3. The user requests data through Process Control.
4. Process Control asks the OPC server to gather information.

5. OPC connects to the 2150 stack through the cable (direct connection), takes register data from the specified 2150, and populates the OPC server's holding index.
6. Process Control takes data from the OPC server's holding index and gives data to the user.

Note that Process Control can be either manual or automated in this example, and that the OPC server and Process Control may be located physically on the same computer.

5.4 Glossary of Terms

ASCII – Short for American Standard Code for Information Interchange, ASCII is a code that represents English characters with numbers. Most computers represent text with ASCII code, making it possible for one computer or device to share data with another.

2100 modules support Modbus ASCII protocol.

Dedicated Line – A telecommunications path reserved for communication between two specified points and not shared among multiple points.

Modbus Protocol – Modbus Protocol is a messaging structure used to establish master-slave/client server communications between intelligent devices. Modbus is a simple command/response mechanism to read from and write to registers.

OPC – OPC (OLE for Process Control) means open connectivity via open (free for use) standards. It is a series of software standards specifications that fill a need in automation (like printer drivers did for Windows), acting as a translator for data transmission and process control.

The specification defines a standard set of objects, interfaces, and methods for use in process control and manufacturing automation applications to facilitate interoperability. There are hundreds of OPC Data Access servers and clients.

Registers – Registers are locations in memory that have specific data stored for retrieval or are used for control functions. A register is a holding place for a piece of digital information within the equipment. The definition of what is contained and where (the registry number, or address) is decided by the manufacturer (in this case Teledyne Isco).

SCADA – SCADA (Supervisory Control And Data Acquisition) is a computer system for gathering and analyzing real-time data. SCADA systems are used to monitor and control plant operation, or equipment in industries such as telecommunications, water and waste control, energy, oil and gas refining, and transportation.

The SCADA system transfers the information (for example, where a leak has occurred in a pipeline), back to a central site, alerting the home station of the leak, performing necessary analysis and control (such as determining if the leak is critical), and displaying the information in a logical and organized manner.

SCADA systems can be relatively simple, such as one that monitors the environmental conditions of a small office building, or very complex, such as a system that monitors all the activity in a nuclear power plant or a municipal water system.

5.5 Common Acronyms

ASCII – American Standard Code for Information Interchange

DCS – Distributed Control Systems

MTU – Master Terminal Unit

OPC – Object Linking and Embedding (OLE) for Process Control

PLC – Programmable Logic Controller

RTU – Remote Terminal Unit

SCADA – Supervisory Control And Data Acquisition

TCP/IP – Transmission Control Protocol/Internet Protocol

5.6 Register Specifications

All numbers in the Modbus registers are stored most significant byte first. If the polling device has a byte ordering of least significant byte first (an Intel-based PC, for example), the bytes will need to be reversed after they are received.

The Modbus ASCII address is used to index the data by modules.

Modbus ASCII address 1 contains information related to the site. The first register contains a 16-bit integer count of the number of modules that have data to report. The maximum number of modules that can be supported is 4.

Modbus ASCII addresses 2 through the number of modules plus 1 contain data from the individual modules.

The Modbus ASCII addresses will be sorted by the model number, and then by module name, which is entered by the user through Flowlink. This allows the user to control the ordering of the addresses and easily predict what data will be in specific registers.

Every measured parameter has a corresponding status and measurement time that are updated with each measurement.

The maximum number of supported measurements from all modules in the system is 28.

The Modbus registers are assigned within 30 seconds after the 2100 module is powered up. To conserve power for the users who do not use Modbus communications, no Modbus registers will be updated with sensor readings until a Modbus master communicates with the 2100 module.

The register definitions for the Site Information device (Modbus ASCII address 1) are in Table 5-1 below:

Table 5-1 Modbus ASCII Address 1 Register Definitions

Register Number(s)	Name	Data type	Units	Read/Write
1	Number of modules (N) (1-4)	16 bit integer	None	Read
2-20	Site name	38-byte string	None	Read

The register definitions for the individual modules (Modbus ASCII addresses 2-(N+1)) are in Table 5-1 below:

Table 5-2 Modbus ASCII Address 2-(N+1) Register Definitions

Register Number(s)	Name	Data Type	Units	Read/Write
1-4	Model number	8-byte string	None	Read
5-23	Module name	38-byte string	None	Read
24[a]	Identify module	16 bit integer	None	Read/Write
25[b]	Take reading flag	16 bit integer	None	Read/Write
26[c]	Update interval	16 bit integer	Seconds	Read/Write
27[d]	Active flag 1	16 bit field	None	Read
28	Active flag 2	16 bit field	None	Read
29	Active flag 3	16 bit field	None	Read
30	Active flag 4	16 bit field	None	Read
40,41	Level	4-byte float	Meters	Read
42	Level status code[e]	16-bit integer		Read
43-52	Level time record	Time[f]		Read
55,56	Velocity	4-byte float	Meters/second	Read
57	Velocity status code	16-bit integer		Read
58-63	Velocity time record	Time		Read
70,71	Flow	4-byte float	Cubic Meters/sec	Read
72	Flow status code	16-bit integer		Read
73-78	Flow time record	Time		Read
85,86	Flow 1	4-byte float	Cubic Meters/sec	Read
87	Flow 1 status code	16-bit integer		Read
88-93	Flow 1 time record	Time		Read
100,101	Volume	4-byte float	Cubic Meters	Read
102	Volume status code	16-bit integer		Read
103-108	Volume time record	Time		Read
115,116	Volume 1	4-byte float	Cubic Meters	Read

Table 5-2 Modbus ASCII Address 2-(N+1) Register Definitions (Continued)				
Register Number(s)	**Name**	**Data Type**	**Units**	**Read/Write**
117	Volume 1 status code	16-bit integer		Read
118-123	Volume 1 time record	Time		Read
130,131	Voltage	4-byte float	Volts	Read
132	Voltage status code	16-bit integer		Read
133-138	Voltage time record	Time		Read
145,146	Temperature	4-byte float	Degrees Celsius	Read
147	Temperature status code	16-bit integer		Read
148-153	Temperature time record	Time		Read
160,161	Internal Temp	4-byte float	Degrees Celsius	Read
162	Internal Temp status code	16-bit integer		Read
163-168	Internal Temp time record	Time		Read
175,176	Analog channel 1	4-byte float	0-100 percent	Read
177	Analog channel 1 status code	16-bit integer		Read
178-183	Analog channel 1 time record	Time		Read
190,191	Analog channel 2	4-byte float	0-100 percent	Read
192	Analog channel 2 status code	16-bit integer		Read
193-198	Analog channel 2 time Record	Time		Read
205,206	Analog channel 3	4-byte float	0-100 percent	Read
207	Analog channel 3 status code	16-bit integer		Read
208-213	Analog channel 3 time record	Time		Read
220,221	Analog channel 4	4-byte float	0-100 percent	Read
222	Analog channel 4 status code	16-bit integer		Read
223-228	Analog channel 4 time record	Time		Read
235,236	Analog channel 5	4-byte float	0-100 percent	Read
237	Analog channel 5 status code	16-bit integer		Read
238-243	Analog channel 5 time record	Time		Read
250,251	Analog channel 6	4-byte float	0-100 percent	Read
252	Analog channel 6 status code	16-bit integer		Read
253-258	Analog channel 6 time record	Time		Read
265,266	Analog channel 7	4-byte float	0-100 percent	Read
267	Analog channel 7 status code	16-bit integer		Read
268-273	Analog channel 7 time record	Time		Read
280,281	Analog channel 8	4-byte float	0-100 percent	Read
282	Analog channel 8 status code	16-bit integer		Read
283-288	Analog channel 8 time record	Time		Read
1765, 1766	Signal strength[g]	4-byte float	0-100 percent	Read

Table 5-2 Modbus ASCII Address 2-(N+1) Register Definitions (Continued)				
Register Number(s)	Name	Data Type	Units	Read/Write
1767	Signal strength status code	16-bit integer		Read
1768-1779	Signal strength time record	Time		Read
1780, 1781	Spectrum strength[g]	4-byte float	0-100 percent	Read
1782	Spectrum strength status code	16-bit integer		Read
1783-1794	Spectrum strength time record	Time		Read
1795, 1796	Spectrum ratio[g]	4-byte float	0-100 percent	Read
1797	Spectrum ratio status code	16-bit integer		Read
1798-1809	Spectrum ratio time record	Time		Read

a. A write to the Identify module register will cause the module to perform the identify operation which may be a steady LED for a few seconds or a beep in the Field Wizard.

b. Setting the Take Reading flag to 1 will cause the module to update the registers with current data readings. It will be set to zero when the readings have all been updated. This may be used to initiate readings and poll for when they are ready to be read. It may take up to 50 seconds to update all the readings, depending upon the flow conditions. Setting the Take Reading flag to 2 causes an automatic, 15 second update of readings when a Modbus master is polling the 2100.

c. The Update Interval specifies an interval in seconds that the registers are automatically updated. It defaults to zero, which indicates that no automatic updating will occur.

d. The Active Flag (1-4) bit fields specify what fields/registers are active in the list. This provides support for a maximum of 64 fields. For example, if bit 0 of register 27 is set, the Level (registers 40,41) is active. If bit 1 of register 27 is set, then the Velocity (registers 55,56) is active. If bit 0 of register 28 is set, the Analog channel 7 (registers 265,266) is active.

e. A non-zero status code indicates a measurement problem.

f. Time is represented in a series of registers: Order is from lowest address to highest - Seconds (0-59), Minutes (0-59), Hours (0-23), Days (1-31), Month (1-12) and Year (1977-2099).

g. Optional software feature. Contact Teledyne Isco to order enable code for the module used for communication.

Table 5-3 2100 Measurement Parameters by Model Number*			
2103, 2103c/g, 2105, 2105c/g	2108	2110	2150, 2151, 2151P
Voltage	Analog channel 1	Level	Level
	Analog channel 2	Flow	Velocity
	Analog channel 3	Volume	Flow
		Voltage	Flow 1
		Temperature	Volume
			Volume 1
			Voltage
			Temperature
			Signal strength
			Spectrum strength
			Spectrum ratio
*Single module only; does not include any additional connected devices. Subject to change.			

2150 Area Velocity Flow Module

Section 6 Maintenance

6.1 Maintenance Overview

This section explains the maintenance requirements of the 2150 Module and its AV Sensor.

The 2100 Series system is designed to perform reliably in adverse conditions with a minimal amount of routine service requirements. To keep your system working properly, the following should be checked at regular intervals:

- Battery power (section 6.3)
- Desiccant (section 6.4)
- Channel conditions (section 6.5)

Maintenance intervals are affected by many variables. The number of modules powered by a Battery Module and the Data Storage Rate will affect the battery life. Humidity levels obviously affect the service life of the desiccant, and the amount of debris in the stream can drastically alter the channel conditions.

As a guide, a basic system installed in an environment with moderate humidity levels and an AV Sensor installed in a channel relatively free from debris and silt, the maintenance interval should not exceed three months. A basic system is defined as:

- a single AV Module and AV Sensor,
- powered by a fresh pair of alkaline lantern batteries,
- recording readings at the default intervals of 15 minutes.

Experience is often the best tool to use when establishing minimum maintenance intervals for your system. Until you have gained an understanding of the AV Module's operation under differing environmental conditions, a weekly maintenance interval is recommended.

6.2 Maintenance Kits

Teledyne Isco, Inc.
Customer Service Dept.
P.O. Box 82531
Lincoln, NE 68501 USA

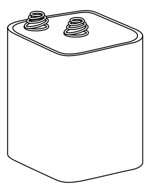
Phone: (800) 228-4373
(402) 464-0231
FAX: (402) 465-3022

E-mail:
IscoInfo@teledyne.com

Many of the parts called out in the *Installation* and *Maintenance* sections of this manual are available in maintenance kits. Kit number 60-2059-001, which supports the AV Module, contains O-rings for the connectors and desiccant cartridge, a hydrophobic filter, and a one-pound container of indicating silica gel desiccant. Kit number 60-2099-001, which supports the Battery Module, contains O-rings for the connectors, gaskets for the battery doors, humidity indicators, and bags of desiccant. You can order the kits by calling Teledyne Isco's Customer Service Department.

6.3 Batteries

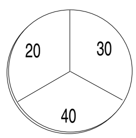
Input voltage can be monitored while you are connected to the AV Module with Flowlink. The AV Module also can record Input Voltage readings to closely track the power consumption. Keep in mind that battery discharge rates vary widely depending on the configuration of your system and its operating environment. Batteries should be replaced according to the instructions in section 3.3.1.


Lantern Battery

The batteries should be replaced with:

- new 6V alkaline lantern batteries (Isco P/N 340-2006-02), *or*
- fully-charged lead-acid batteries (Isco P/N 60-2004-041).

6.4 Desiccant



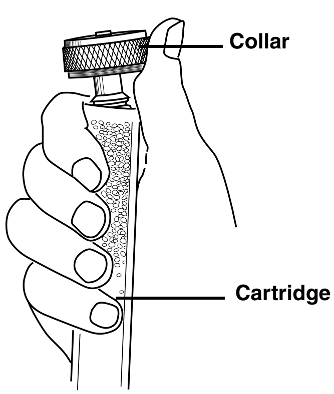
Battery Module Humidity Indicator

The 2100 System devices use desiccant to protect the internal components from moisture damage. In the AV Module, a desiccant cartridge is used to dry the reference air for the sensor. This prevents moisture from plugging the reference line, which would cause the sensor to report erroneous level readings. The cartridge is filled with indicating silica gel that is yellow or blue when dry. As the desiccant becomes saturated, the color changes from blue to pink, or from yellow to green. Replace the desiccant before the entire length of the cartridge turns pink or green.

The Battery Module uses desiccant bags to keep the interior of the case dry. The bags are located inside the battery caps. Attached to the inside face of each cap is a humidity indicator. Humidity indicators have regions that display 20, 30, and 40 percent humidity levels. Ideally, each region should be completely blue. As the desiccant becomes saturated, the humidity levels will increase and the regions turn pink. When the 40 percent region begins to turn pink, the components are no longer adequately protected and the desiccant must be replaced.

6.4.1 Replacing the Desiccant: AV Module

The desiccant is contained in a cartridge located on the left side of the AV Module. To remove the cartridge, unscrew the collar and slide the cartridge out of the AV Module. The clear tube reveals the silica gel desiccant inside.



To replace the silica gel desiccant:

1. Hold the cartridge upright with the collar at the top.
2. As shown in the margin, push the collar off the cartridge.
3. Empty the saturated silica gel beads or granules.
4. Fill the tube with new (Isco P/N 099-0011-03) or reactivated (see section 6.4.3) silica gel desiccant.
5. Press the collar onto the tube.
6. Slide the cartridge into the AV Module. Tighten the collar to seal the cartridge in place.

6.4.2 Replacing the Desiccant: Battery Module

A bag of desiccant is located inside each of the battery caps behind a retaining plate. To replace the desiccant:

1. Loosen the two mounting screws that secure the metal retaining plate.
2. Rotate the retaining plate until it is free from the mounting screws.
3. Remove the spent desiccant bag from the cap and replace it with a new (Isco P/N 099-0002-33) or reactivated (see section 6.4.3) bag.
4. Replace the retaining plate and secure it with the screws.

6.4.3 Reactivating the Desiccant

Silica gel beads/granules and bags of desiccant can be reactivated.

⚠ CAUTION

Desiccant may produce irritating fumes when heated. Observe the following precautions:

- Use a vented oven in a well-ventilated room.
- Do not remain in the room while the regeneration is taking place.
- Use the recommended temperature. Avoid heating the desiccant at higher than recommended temperatures.

There have been reports of irritating fumes coming from the desiccant during reactivation. While our attempts to duplicate the problem have been unsuccessful, we still urge you to use caution. Material Safety Data Sheets are in the back of this manual.

The desiccant's ability to remove moisture may lessen with each saturation/reactivation cycle, resulting in a need for more frequent service. After several cycles, the desiccant may no longer be effective as it saturates too quickly. At this point, replace the desiccant.

Silica gel

To reactivate the silica gel desiccant, pour the spent desiccant into a heat resistant container. Never heat the cartridge assembly; it will melt. Heat the silica gel in a *vented convection oven* at 212° to 350°F (100° to 175°C) for two to three hours, or until the blue or yellow color returns. Allow the desiccant to cool and store it in an airtight container until ready for use.

Desiccant bags

Bagged desiccant will often include reactivation or recharging instructions on the bag's labeling. Always follow the instructions printed on the bag. If the instructions are not available, the bags may be heated in a *vented convection oven* at 245°F (120°C) for sixteen hours.

6.5 Channel Conditions

Because the sensor body offers a streamlined profile to the flow, solid materials rarely collect on the sensor. However, clean the channel upstream and downstream from the sensor periodically. This maintains the hydrostatic conditions on which the level-to-area conversion is based.

6.6 Other Maintenance

Other maintenance may be performed on the AV Module and sensor "as-needed." Sections 6.6.1 through 6.6.3 describe these activities.

6.6.1 Hydrophobic Filter

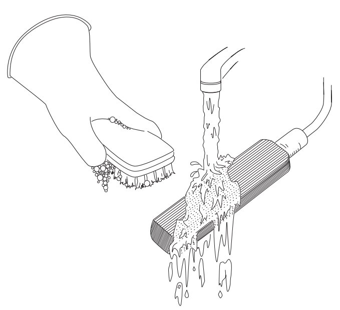
209-0093-93

If the AV Module is in a humid location or submerged, a hydrophobic filter prevents water from entering the desiccant cartridge and reference line. Any amount of water will plug the filter and it must be rinsed with clean water and allowed to dry, or replaced so that the reference line can be reliably ventilated. *Drifting level readings are often an indication that the hydrophobic filter may be plugged*.

Remove the hydrophobic filter with a 5/8" or 16mm socket. Gently screw in the replacement filter (Isco part #209-0093-93).

If the hydrophobic filter frequently requires replacement, consider relocating the modules so that they are better protected.

6.6.2 Cleaning



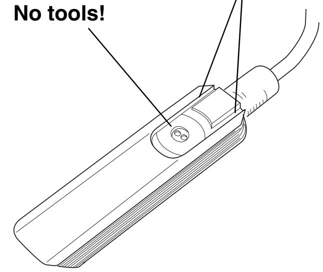
The AV Module case may be cleaned with mild detergent and warm water. Before cleaning the module, ensure that all protective connector caps are in place.

The cable and outer surfaces of the AV Sensor may also be cleaned with mild detergent and warm water.

If the flow stream carries a great deal of debris, beware of organic materials that may collect beneath the AV Sensor. This material swells as it becomes saturated with water and may exert pressure on the outer diaphragm. This can damage the transducer and permanently disable the AV Sensor. Keeping the ports clean not only prevents damage, but assures you that the AV Sensor will respond to the hydrostatic pressure above instead of the pressure created by swollen material.

If the ports become blocked:

1. Remove the sensor from its mounting ring, plate, or carrier.
2. Scrape any accumulated solids off the exterior of the sensor. Use a brush and flowing water.
3. Remove debris that has accumulated in the ports.
4. The outer diaphragm is behind the small round cover on the bottom of the sensor. It should be visible through the two small openings at the center of the cover. Gently flush the cover and holes with water to remove debris.



⚠ CAUTION

Avoid using tools near the cover openings. The transducer is extremely sensitive to pressure applied to its exposed surface. Direct or indirect contact with the outer diaphragm may permanently damage the AV Sensor.

6.6.3 Sensor Cable Inspection

Erroneous level or velocity readings may not always indicate a fault inside the AV Sensor body. A damaged cable can affect the operation of the sensor, particularly if the reference air tube inside the cable is collapsed or blocked. Damaged cables cannot be spliced or repaired.

If the AV Sensor cable is damaged, you must replace the entire assembly, as the sensor body and cable are a factory-sealed unit. Keep the connector clean and dry and install the cable so that it is not at risk of damage resulting from other activity taking place in the area. The connector can be replaced in some instances, depending on the condition of the cable.

In temporary installations, do not leave cables lying around where they may be stepped on or run over by heavy equipment. Do not leave extra cable loose in the flow stream where it can trap debris.

In permanent installations, cables repeatedly subjected to abuse will fail and should be installed in conduit for protection. The conduit must be large enough to pass the connector through, as you cannot remove or replace it.

6.7 How to Obtain Service

The internal components of the AV Module are not user-serviceable. The case is completely sealed to protect the internal components. To repair the unit, the case must be broken open and replaced. If you think your module requires repair, contact Teledyne Isco's Technical Service Department.

__Teledyne Isco, Inc.__
Technical Service Dept.
P.O. Box 82531
Lincoln, NE 68501 USA

Phone: (800) 228-4373
(402) 464-0231
FAX: (402) 465-3085

E-mail:
IscoService@teledyne.com

The pressure transducer, the ultrasonic transducers, cable connections, and the electronic components of the AV Sensor are encapsulated in plastic resin and are not user-serviceable. If any part of the AV Sensor fails, it must be replaced.

Corresponding with a Teledyne Isco Technical Service Representative can often resolve the problem without the need to return the item. If the difficulty cannot be resolved you will be issued a Return Authorization Number (RAN) and information on returning it to the factory.

6.7.1 Diagnostics

As a troubleshooting aid, many module functions can generate a diagnostic file. With the assistance of a Teledyne Isco Technical Service Representative, the diagnostic files can often be used to isolate a problem.

To view a diagnostic file, connect to the site with Flowlink. View the measurement tab of the suspect function and click on the *Diagnostics...* button. The module then generates the file and sends it to Flowlink where it is displayed as a text report.

Flowlink can also collect all of the diagnostic files while retrieving data. The last available diagnostic files are always kept in Flowlink's database where they can be viewed "off-line" at a later time. To enable Flowlink to automatically collect all diagnostic files while retrieving the data, open the *Utilities>Options* from the menu and check the *Retrieve data gets text reports* box on the 2100 tab.

2150 Area Velocity Flow Module

Appendix A Replacement Parts

A.1 Replacement Parts Diagrams and Listings

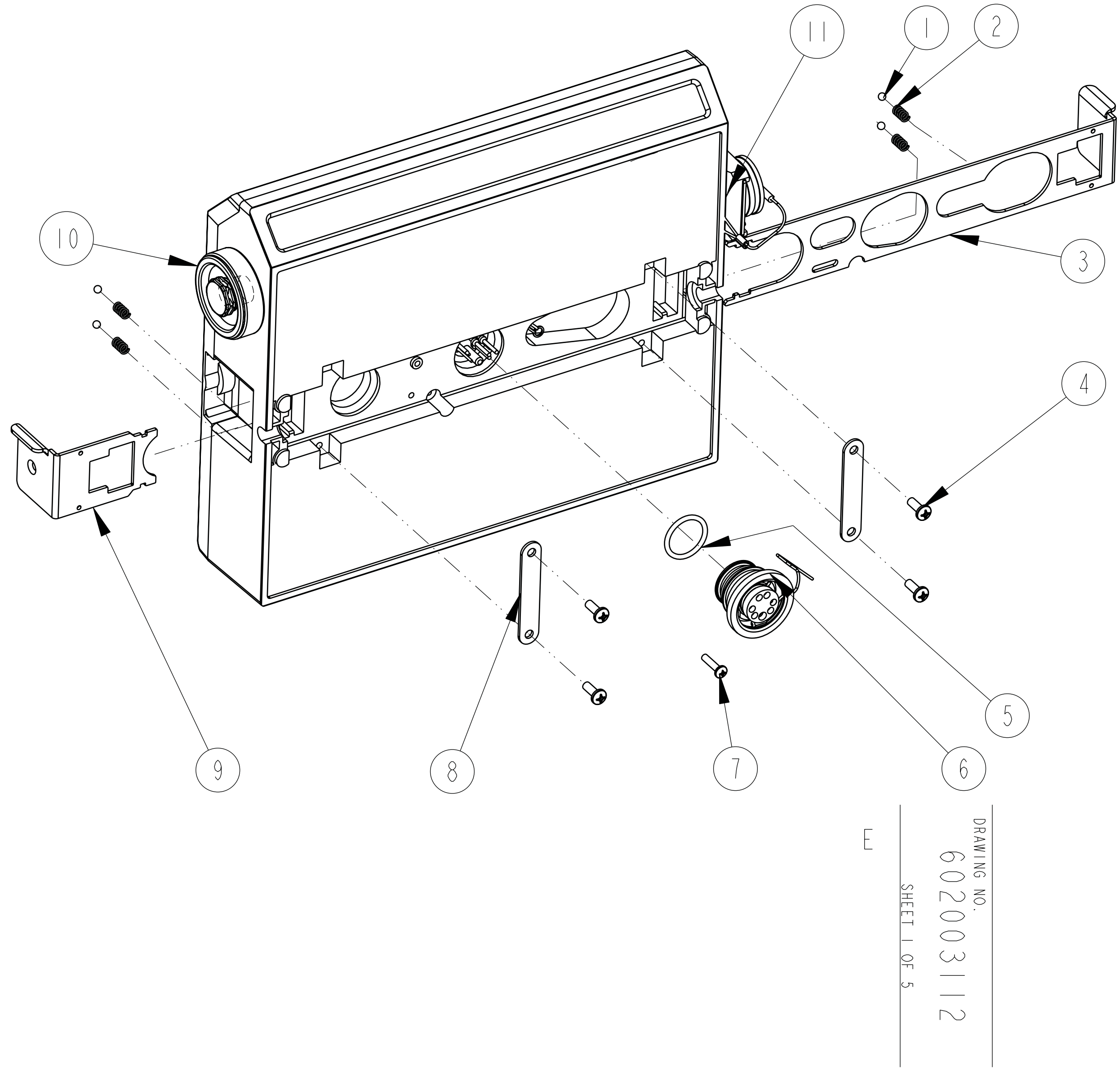
Replacement parts are called out in illustrations in this section. Reference the call-outs in the accompanying tables to determine the part number for the item.

Replacement parts can be purchased by contacting Teledyne Isco's Customer Service Department.

Teledyne Isco, Inc.
Customer Service Department
P.O. Box 82531
Lincoln, NE 68501 USA

Phone: (800) 228-4373
        (402) 464-0231
FAX: (402) 465-3022

E-mail: IscoInfo@teledyne.com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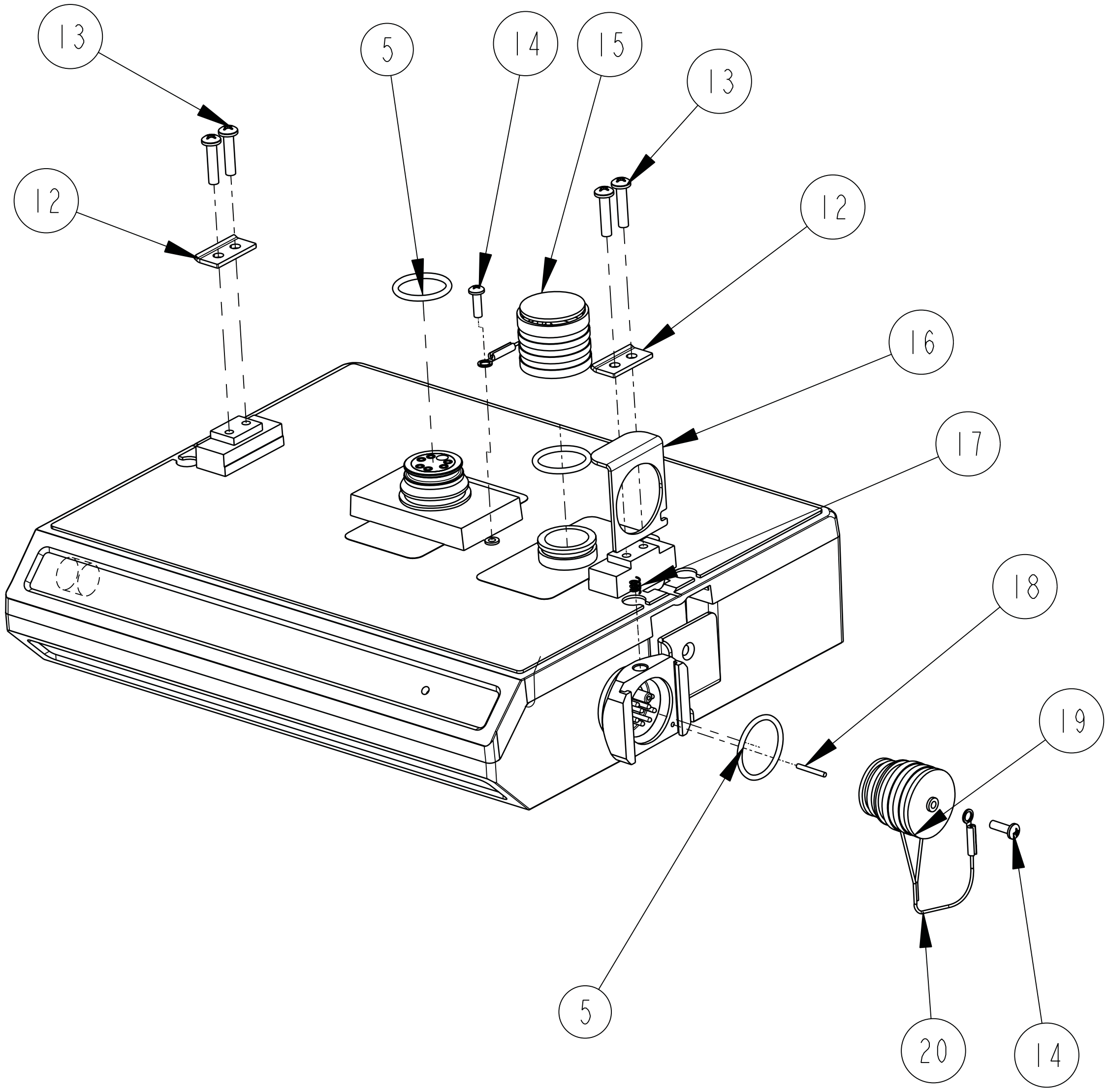
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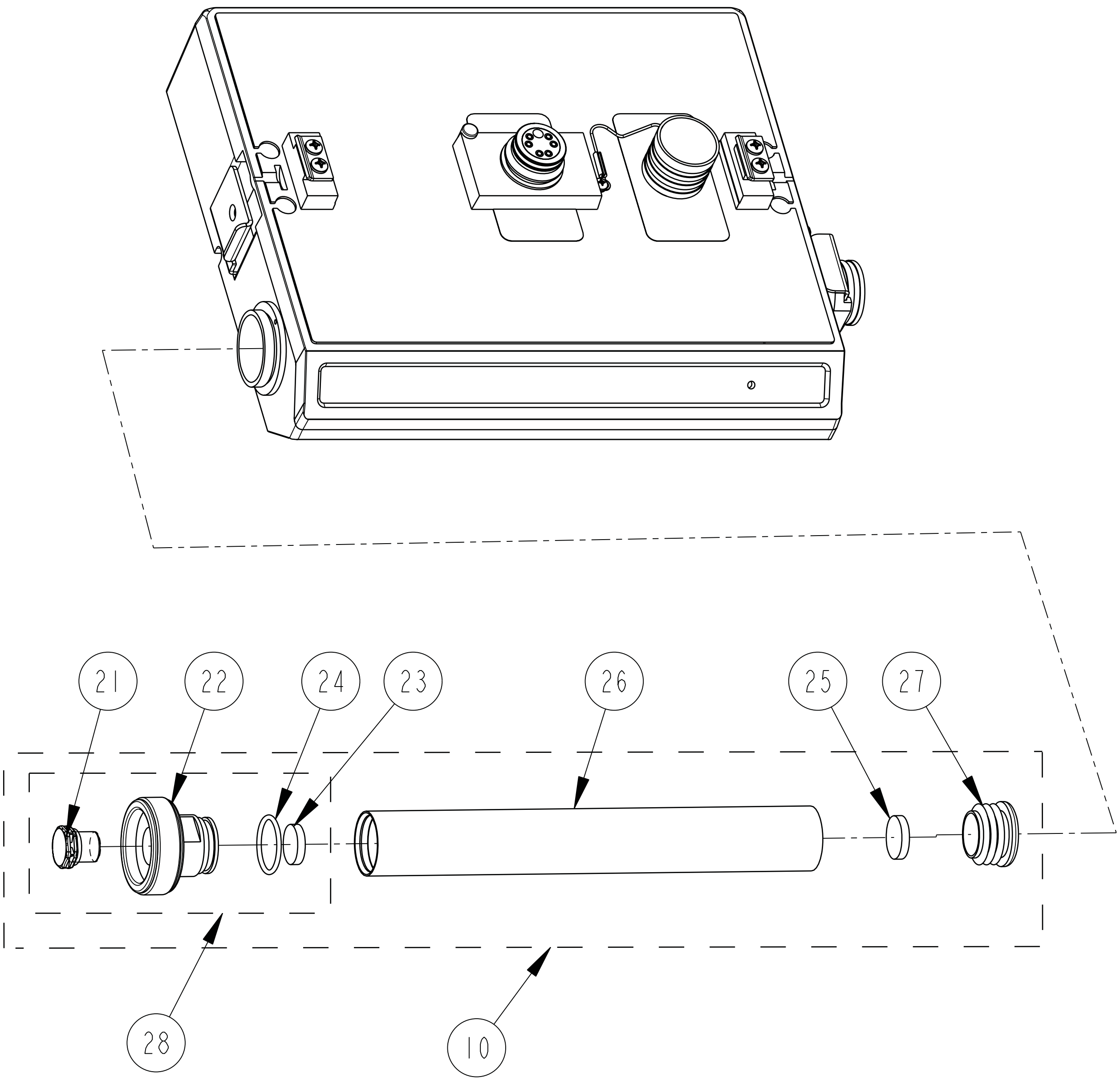
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602003112

REPLACEMENT PARTS LIST

SHEET: 4 OF 5

TELEDYNE ISCO, INC.

REV: E | DATE: 022008

ITEM NO.	PART NUMBER	DESCRIPTION
1	201900102	BALL .125 DIAMETER 316 SST
2	203011602	COMPRESSION SPRING, .022 DIAMETER WIRE, .31 FREE LENGTH
3	692003190	LARGE LATCH
4	231311206	SCREW, SELF TAP #6 X 3/8, PAN HEAD, PHILLIPS, SST
5	202100669	O RING,.669 ID,.079 CROSS SECTION, BUNA-N RUBBER
6	602004013	PLUG ASSEMBLY FEMALE CONNECTOR (includes item 5)
7	231611108	SCREW, SELF TAP, #4 X 1/2, PAN HEAD PHILLIPS, SST
8	602003022	LATCH HOLD
9	692003189	SMALL LATCH
10	602004016	DESICCANT ASSEMBLY (includes items 21 thru 27)
11	602004033	PLUG ASSEMBLY, FEMALE PROBE (includes items 5, 14, 19, and 20)
12	602003019	NODE CLIP
13	231514920	SCREW, SELF TAP, 6-19 X 5/8 TORX, PAN HEAD, SST
14	231310140	SCREW, SELF TAP, #4 X 3/8, PAN HEAD PHILLIPS, SST
15	602004012	CAP ASSEMBLY, MALE CONNECTOR
16	602003018	CONNECTOR CLIP
17	203011105	COMPRESSION SPRING, .026 DIAMETER WIRE, .31 FREE LENGTH
18	236410408	PIN, SPRING, 1/16 X 1/2 LONG SST
19	602003076	PLUG, FEMALE PROBE
20	692003172	CABLE, FEMALE PROBE PLUG
21	209009393	SCREW IN FILTER
22	602004265	DESICCANT CAP ASSEMBLY
23	692203300	FRIT, .620 DIA.
24	202500017	O-RING, .676 ID, .070 CROSS SECTION, BUNA-N RUBBER
25	692203301	FRIT, .670 DIA.
26	602003046	DESICCANT TUBE

NOTE: 1. For current prices and quotations on parts, contact Isco Service Department.
2. This list is subject to change without notice.

602003112

REPLACEMENT PARTS LIST

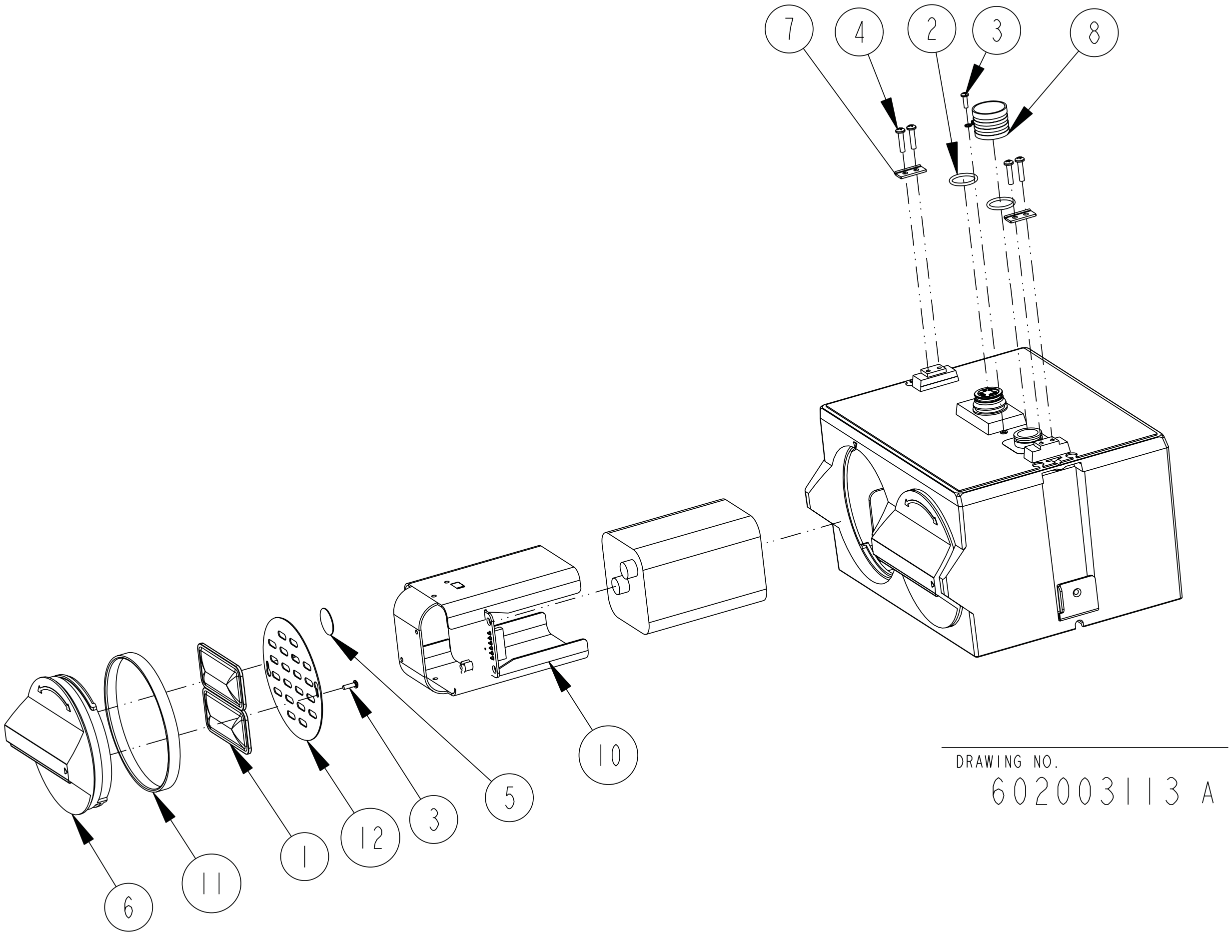
SHEET: 5 OF 5

TELEDYNE ISCO, INC.

REV: E | DATE: 022008

ITEM NO.	PART NUMBER	DESCRIPTION
27	602003074	CAP PLUG MODIFICATION, DESICCANT
28	602004270	GORE DESICCANT CAP

NOTE: 1. For current prices and quotations on parts, contact Isco Service Department.
2. This list is subject to change without notice.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DRAWING NO.
602003113 A

602003113

REPLACEMENT PARTS LIST

SHEET: 2 OF 2

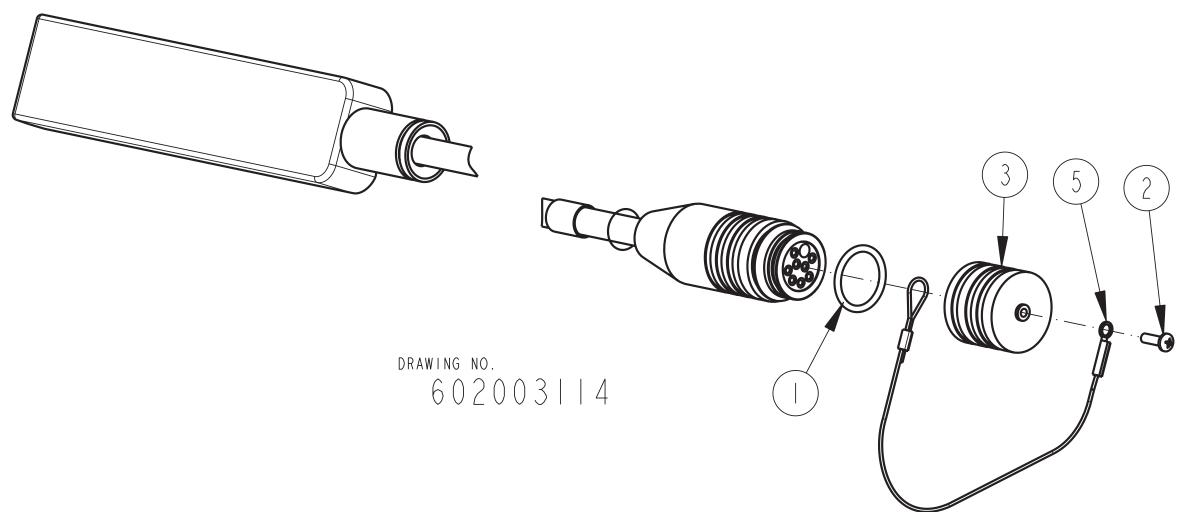
TELEDYNE ISCO, INC.

REV: A | DATE: 06200

ITEM NO.	PART NUMBER	DESCRIPTION
1	099000201	DESICCANT BAG 16.5 GRAM
2	202100669	O RING, .669 ID, .079 CROSS SECTION, BUNA-N RUBBER
3	231310140	SCREW, SELF TAP, #4 X 3/8, PAN HEAD, PHILLIPS, SST
4	231514920	SCREW, SELF TAP 6-19 X 5/8, TORX, PAN HEAD, SST
5	490001300	HUMIDITY INDICATOR CARD
6	602003014	CAP BATTERY NODE
7	602003019	NODE CLIP
8	602004012	CAP ASSEMBLY, MALE CONNECTOR
9	602004017	BATTERY CAP ASSEMBLY (Includes 1, 3, 5, 6, 11, & 12)
10	602004030	BATTERY HOLDER ASSEMBLY
11	692003017	BATTERY CAP GASKET
12	692003067	BATTERY CAP PLATE

3 — Refer to 2150/2110 module for a listing of parts associated with latch and lower communication port cap.

NOTE: 1. For current prices and quotations on parts, contact Isco Service Department.
2. This list is subject to change without notice.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DRAWING NO.
602003114

602003114

REPLACEMENT PARTS LIST

SHEET: 2 OF 2

Isco, Inc.

REV: | DATE: 03294

ITEM NO.	PART NUMBER	DESCRIPTION
1	202100669	O RING, .669 ID, .079 CROSS SECTION, BUNA-N RUBBER
2	231310140	SCREW, SELF TAP, #4 X 3/8, PAN HEAD, PHILLIPS, SST
3	602003075	CAP, MALE PROBE
4	602004034	CAP ASSEMBLY, MALE PROBE (Includes items 2, 3, & 5)
5	692003174	CABLE, MALE PROBE CAP

NOTE: 1. For current prices and quotations on parts, contact Isco Service Department.
2. This list is subject to change without notice.

2150 Area Velocity Flow Module

Appendix B Accessories

B.1 How to Order

Accessories can be purchased by contacting Teledyne Isco's Customer Service Department.

Teledyne Isco, Inc.
Customer Service Dept.
P.O. Box 82531
Lincoln, NE 68501 USA

Phone: (800) 228-4373
(402) 464-0231
FAX: (402) 465-3022

E-mail: IscoInfo@teledyne.com

B.2 General Accessories

2150 A/V Sensor	60-2004-135
Tubing, Reference Air Extension, 10 ft.	60-2003-104
Alkaline Lantern Battery	340-2006-02
Rechargeable 6V Lead-acid Lantern Battery	60-2004-041
Charging Adapter for 6V Lead-acid Lantern Battery	60-2004-040
Power adaptor cable for Isco batteries and power packs, 2 ft standard, CE-rated	69-2004-451
RS232 Communication Cable	60-2004-046
2100 Module to Module Extension Cable	60-2004-056
Sampler Interface Cable	60-2004-260
2108 Analog Output Module	68-2000-010
Flowlink for Windows Software	CALL
ProHanger *bracket for 18–20 inch (45–50 cm) manhole*	209-9006-01
ProHanger *bracket for 20–22 inch (50–56 cm) manhole*	209-9006-02
Spreader Bar *adjusts from 22.5 to 48 inches (57 to 122 cm)*	60-3004-110
Instruction Manual	60-2004-038
Isco Open Channel Flow Measurement Handbook	60-3003-041

B.3 Maintenance Kits

AV Module Maintenance Kit	60-2059-001
Battery Module Maintenance Kit	60-2099-001

B.4 AV Sensor Mounting Accessories

The 2150 Area Velocity Sensor can be installed using Isco's installation systems listed below. A Low Profile Carrier is optional when attaching the AV Sensor to any system listed below.

Low Profile Carrier *(attaches the 2150 AV sensor to a standard-size ring or plate)* 60-3204-029

Standard Spring Rings *(Each ring includes plastic ties to fasten the cable and a manual)*

6" Dia 68-3200-007
8" Dia 68-3200-008
10" Dia 68-3200-009
12" Dia 68-3200-010
15" Dia 68-3200-011

Standard Scissors Rings *(Each scissors ring includes a base section, scissors mechanism, extensions, plastic ties, and a manual)*

16-24" Pipe. 68-3000-042
26-38" Pipe. 68-3000-043
38-44" Pipe. 68-3000-044
44-48" Pipe. 68-3000-045
60" Pipe 68-3000-046
72" Pipe 68-3000-047
16-60" Pipe. 68-3000-048

Base Section *(with plastic ties and manual)* 60-3004-169

Street Level Installation System

Multi-section Pole *(Includes manual. To complete your system, you must also order a Street Level Mounting Ring)* 60-3204-012
Street Level Mounting Ring for 6" dia. pipe 60-3204-014
Street Level Mounting Ring for 8" dia. pipe 60-3204-015
Street Level Mounting Ring for 10" dia. pipe 60-3204-016
Street Level Mounting Ring for 12" dia. pipe 60-3204-017
Street Level Mounting Ring for 15" dia. pipe 60-3204-018

Sensor Mounting Plate *(With plastic ties & instructions)* . . 68-3000-051

2150 Area Velocity Flow Module

Appendix C Material Safety Data Sheets

C.1 Overview

This appendix to the manual provides Material Safety Data Sheets for the desiccant used by the 2150 Area Velocity Module and 2191 Battery Module.

Teledyne Isco cannot guarantee the accuracy of the data. Specific questions regarding the use and handling of the products should be directed to the manufacturer listed on the MSDS.

101 Christine Drive
Belen, New Mexico 87002
Phone: (505) 864-6691
Fax: (505) 861-2355

SÜD-CHEMIE
Performance Packaging

ISO 9002

MATERIAL SAFETY DATA SHEET -- September 28, 1998
SORB-IT®
Packaged Desiccant

SECTION I -- PRODUCT IDENTIFICATION

Trade Name and Synonyms:	Silica Gel, Synthetic Amorphous Silica, Silicon, Dioxide
Chemical Family:	Synthetic Amorphous Silica
Formula:	$SiO_2.x\ H_2O$

SECTION II -- HAZARDOUS INGREDIENTS

Components in the Solid Mixture

COMPONENT	CAS No	%	ACGIH/TLV (PPM)	OSHA-(PEL)
Amorphous Silica	63231-67-4	>99	PEL - 20 (RESPIRABLE), TLV – 5	LIMIT – NONE, HAZARD - IRRITANT ″

Synthetic amorphous silica is not to be confused with crystalline silica such as quartz, cristobalite or tridymite or with diatomaceous earth or other naturally occurring forms of amorphous silica that frequently contain crystalline forms.

This product is in granular form and packed in bags for use as a desiccant. Therefore, no exposure to the product is anticipated under normal use of this product. Avoid inhaling desiccant dust.

SECTION III -- PHYSICAL DATA

Appearance and Odor:	White granules; odorless.
Melting Point:	>1600 Deg C; >2900 Deg F
Solubility in Water:	Insoluble.
Bulk Density:	>40 lbs./cu. ft.
Percent Volatile by Weight @ 1750 Deg F:	<10%.

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Belen, New Mexico 87002
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Fax: (505) 861-2355

SÜD-CHEMIE
Performance Packaging

ISO 9002

MATERIAL SAFETY DATA SHEET -- September 28, 1998
SORB-IT®
Packaged Desiccant

SECTION IV -- FIRE EXPLOSION DATA

Fire and Explosion Hazard - Negligible fire and explosion hazard when exposed to heat or flame by reaction with incompatible substances.

Flash Point - Nonflammable.

Firefighting Media - Dry chemical, water spray, or foam. For larger fires, use water spray fog or foam.

Firefighting - Nonflammable solids, liquids, or gases: Cool containers that are exposed to flames with water from the side until well after fire is out. For massive fire in enclosed area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn. Withdraw immediately in case of rising sound from venting safety device or any discoloration of the tank due to fire.

SECTION V -- HEALTH HAZARD DATA

Health hazards may arise from inhalation, ingestion, and/or contact with the skin and/or eyes. Ingestion may result in damage to throat and esophagus and/or gastrointestinal disorders. Inhalation may cause burning to the upper respiratory tract and/or temporary or permanent lung damage. Prolonged or repeated contact with the skin, in absence of proper hygiene, may cause dryness, irritation, and/or dermatitis. Contact with eye tissue may result in irritation, burns, or conjunctivitis.

First Aid (Inhalation) - Remove to fresh air immediately. If breathing has stopped, give artificial respiration. Keep affected person warm and at rest. Get medical attention immediately.

First Aid (Ingestion) - If large amounts have been ingested, give emetics to cause vomiting. Stomach siphon may be applied as well. Milk and fatty acids should be avoided. Get medical attention immediately.

First Aid (Eyes) - Wash eyes immediately and carefully for 30 minutes with running water.

101 Christine Drive
Belen, New Mexico 87002
Phone: (505) 864-6691
Fax: (505) 861-2355

SÜD-CHEMIE
Performance Packaging

ISO 9002

MATERIAL SAFETY DATA SHEET -- September 28, 1998
SORB-IT®
Packaged Desiccant

NOTE TO PHYSICIAN: This product is a desiccant and generates heat as it adsorbs water. The used product can contain material of hazardous nature. Identify that material and treat accordingly.

SECTION VI -- REACTIVITY DATA

Reactivity - Silica gel is stable under normal temperatures and pressures in sealed containers. Moisture can cause a rise in temperature which may result in a burn.

SECTION VII --SPILL OR LEAK PROCEDURES

Notify safety personnel of spills or leaks. Clean-up personnel need protection against inhalation of dusts or fumes. Eye protection is required. Vacuuming and/or wet methods of cleanup are preferred. Place in appropriate containers for disposal, keeping airborne particulates at a minimum.

SECTION VIII -- SPECIAL PROTECTION INFORMATION

Respiratory Protection - Provide a NIOSH/MSHA jointly approved respirator in the absence of proper environmental control. Contact your safety equipment supplier for proper mask type.

Ventilation - Provide general and/or local exhaust ventilation to keep exposures below the TLV. Ventilation used must be designed to prevent spots of dust accumulation or recycling of dusts.

Protective Clothing - Wear protective clothing, including long sleeves and gloves, to prevent repeated or prolonged skin contact.

Eye Protection - Chemical splash goggles designed in compliance with OSHA regulations are recommended. Consult your safety equipment supplier.

101 Christine Drive
Belen, New Mexico 87002
Phone: (505) 864-6691
Fax: (505) 861-2355

SÜD-CHEMIE
Performance Packaging

ISO 9002

MATERIAL SAFETY DATA SHEET -- September 28, 1998
SORB-IT®
Packaged Desiccant

SECTION IX -- SPECIAL PRECAUTIONS

Avoid breathing dust and prolonged contact with skin. Silica gel dust causes eye irritation and breathing dust may be harmful.

* No Information Available

HMIS (Hazardous Materials Identification System) for this product is as follows:

Health Hazard	0
Flammability	0
Reactivity	0
Personal Protection	HMIS assigns choice of personal protective equipment to the customer, as the raw material supplier is unfamiliar with the condition of use.

The information contained herein is based upon data considered true and accurate. However, United Desiccants makes no warranties expressed or implied, as to the accuracy or adequacy of the information contained herein or the results to be obtained from the use thereof. This information is offered solely for the user's consideration, investigation and verification. Since the use and conditions of use of this information and the material described herein are not within the control of United Desiccants, United Desiccants assumes no responsibility for injury to the user or third persons. The material described herein is sold only pursuant to United Desiccants' Terms and Conditions of Sale, including those limiting warranties and remedies contained therein. It is the responsibility of the user to determine whether any use of the data and information is in accordance with applicable federal, state or local laws and regulations.

Material Safety Data Sheet

Indicating Silica Gel
Identity (Trade Name as Used on Label)

Manufacturer :	MULTISORB TECHNOLOGIES, INC. (formerly Multiform Desiccants, Inc.)	MSDS Number* :	M75
Address:	325 Harlem Road Buffalo, NY 14224	CAS Number* :	
Phone Number (For Information):	716/824-8900	Date Prepared:	July 6, 2000
Emergency Phone Number:	716/824-8900	Prepared By* :	G.E. McKedy

Section 1 - Material Identification and Information

Components - Chemical Name & Common Names (Hazardous Components 1% or greater; Carcinogens 0.1% or greater)	%*	OSHA PEL	ACGIH TLV	OTHER LIMITS RECOMMENDED
Silica Gel SiO_2	98.0	6mg/m^3 (total dust)	10mg/m^3 (total dust)	
Cobalt Chloride	>2.0	0.05mg/m^3 (TWA cobalt metal dust & fume)	.05mg/m^3 (Cobalt, TWA)	
Non-Hazardous Ingredients				
TOTAL	100			

Section 2 - Physical/Chemical Characteristics

Boiling Point	N/A	Specific Gravity (H_20 = 1)	2.1
Vapor Pressure (mm Hg and Temperature	N/A	Melting Point	N/A
Vapor Density (Air =1)	N/A	Evaporation Rate (__________=1)	N/A
Solubility in Water	Insoluble, but will adsorb moisture.	Water Reactive	Not reactive, but will adsorb moisture.
Appearance and Odor	Purple crystals, no odor.		

Section 3 - Fire and Explosion Hazard Data

Flash Point and Methods Used	N/A	Auto-Ignition Temperature	N/A	Flammability Limits in Air % by Volume	N/A	LEL	UEL
Extinguisher Media	Dry chemical, carbon dioxide and foam can be used.						
Special Fire Fighting Procedures	Water will generate heat due to the silica gel which will adsorb water and liberate heat.						
Unusual Fire and Explosion Hazards	When exposed to water, the silica gel can get hot enough to reach the boiling point of water. Flooding with water will reduce the temperature to safe limits.						

Section 4 - Reactivity Hazard Data

STABILITY ☐**Stable** ☐**Unstable**	Conditions To Avoid	Moisture and high humidity environments.
Incompatibility (Materials to Avoid)	Water.	
Hazardous Decomposition Products	Carbon dioxide, carbon monoxide, water	
HAZARDOUS POLYMERIZATION ☐May Occur	Conditions To Avoid	None.

*Optional

Indicating Silica Gel

Page 2

Section 5 - Health Hazard Data

PRIMARY ROUTES OF ENTRY	☐Inhalation ☐Skin Absorption	☐Ingestion ☐Not Hazardous	**CARCINOGEN LISTED IN**	☐NTP ☐IARC Monograph	☐OSHA ☐Not Listed
HEALTH HAZARDS	Acute	May cause eye, skin and mucous membrane irritation.			
	Chronic	Prolonged inhalation may cause lung damage.			
Signs and Symptoms of Exposure	Drying and irritation.				
Medical Conditions Generally Aggravated by Exposure	Asthma.				
EMERGENCY FIRST AID PROCEDURES - Seek medical assistance for further treatment, observation and support if necessary.					
Eye Contact	Flush with water for at least 15 minutes.				
Skin Contact	Wash affected area with soap and water.				
Inhalation	Remove affected person to fresh air.				
Ingestion	Drink at least 2 glasses of water.				

Section 6 - Control and Protective Measures

Respiratory Protection (Specify Type)	Use NIOSH approved dust mask or respirator.		
Protective Gloves	Light cotton gloves.	Eye Protection	Safety glasses.
VENTILATION TO BE USED	☐ Local Exhaust	☐Mechanical (General)	☐Special
	☐Other (Specify)		
Other Protective Clothing and Equipment	None.		
Hygienic Work Practices	Avoid raising dust. Avoid contact with skin, eyes and clothing.		

Section 7 - Precautions for Safe Handling and Use/Leak Procedures

Steps to be Taken if Material Is Spilled Or Released	Sweep or vacuum up and place the spilled material in a waste disposal container. Avoid raising dust.
Waste Disposal Methods	Dispose in an approved landfill according to federal, state and local regulations.
Precautions to be Taken In Handling and Storage	Cover promptly to avoid blowing dust. Wash after handling.
Other Precautions and/or Special Hazards	Keep in sealed containers away from moisture. The silica gel will readily adsorb moisture.

*Optional

Indicating Silica Gel

MATERIAL SAFETY DATA SHEET

Effective Date	March 8, 2005
MSDS Number	M163

Section 1 – Product and Company Information

Product Name: **Silica gel, indicating, yellow**

Product Use: Desiccant, absorbent
Grades: Silica gel, indicating
Synonyms: Amorphous silica gel, SiO_2, silicon dioxide (amorphous)

Company; Multisorb Technologies, Inc.
Street Address: 325 Harlem Road
City, State, Zip, Country: Buffalo, NY 14224-1893 USA

Telephone Number: (716) 824 8900 [USA] Monday - Friday (8:00 - 5:00 EDT)
Fax Number: (716) 824 4091 [USA]
Website / E-Mail : multisorb.com

Section 2 – Composition / Information on Ingredients

Component Name	CAS Number	% by Weight
Synthetic amorphous silica gel (SiO_2)	112926-00-8	100
Phenolphthalein	77-09-08	100 ppm

While this material is not classified, this MSDS contains valuable information critical to the safe handling and proper use of this product. This MSDS should be retained and available for employees and other users of this product.

Section 3 – Hazard Identification

Emergency Overview: A yellow bead or granular material that poses little or no immediate hazard. This material is not combustible.

Potential Health Effects:
Eyes: Dust and or product may cause eye discomfort and irritation seen as tearing and reddening.

Skin: The product dust may cause drying of the skin. Silica gel may get hot enough to burn skin when it adsorbs moisture rapidly. Use an excess of water to cool the silica gel.

Ingestion: Material is not toxic and will pass through the body normally.

Inhalation: Slight irritation is possible but none is expected.

Medical Effects Generally Aggravated by Exposure: Respiratory ailments.

Chronic Effects/Carcinogenity: May cause eye, skin and mucous membrane irritation and drying.

Section 8 – Exposure Controls/Personal Protection

Engineering Controls: Use exhaust ventilation to keep the airborne concentrations below the exposure limits.

Respiratory Protection: Use NIOSH approved respirator when the air quality levels exceed the TLV's.

Skin Protection: Light gloves will protect against abrasion and drying of the skin.

Eye Protection: Safety glasses.

Component Name	Exposure Limits		
	OSHA PEL	**ACGIH TLV**	**Other Recommended Limits**
Silica gel	TWA 20 mppcf (80 mg / m^3 % SiO_2)	TWA 10 mg / m^3	NIOSH REL TWA 6 mg / m^3 IDLH 3000 mg / m^3
Phenolphthalein	Not Applicable	Not Applicable	Not Applicable

Section 9 – Physical and Chemical Properties

Appearance: Yellow beads or granules

Odor: None

Physical State: Solid bead

PH: Not applicable

Vapor Pressure: Not applicable

Vapor Density: Not applicable

Boiling Point: 4046° F (2230° C)

Melting Point: 3110° F (1710° C)

Solubility: Insoluble in water

Specific Gravity: 2.1

Section 10 – Stability and Reactivity

Stability: Stable

Conditions to avoid: Moisture and high humidity environments.

Incompatibility: Water, fluorine, oxygen difluoride, chlorine trifluoride

Hazardous Decomposition Products: None

Hazardous Polymerization: Will not occur

Section 8 – Exposure Controls/Personal Protection

Engineering Controls: Use exhaust ventilation to keep the airborne concentrations below the exposure limits.

Respiratory Protection: Use NIOSH approved respirator when the air quality levels exceed the TLV's.

Skin Protection: Light gloves will protect against abrasion and drying of the skin.

Eye Protection: Safety glasses.

Component Name	Exposure Limits		
	OSHA PEL	**ACGIH TLV**	**Other Recommended Limits**
Silica gel	TWA 20 mppcf (80 mg / m^3 % SiO_2)	TWA 10 mg / m^3	NIOSH REL TWA 6 mg / m^3 IDLH 3000 mg / m^3
Phenolphthalein	Not Applicable	Not Applicable	Not Applicable

Section 9 – Physical and Chemical Properties

Appearance: Yellow beads or granules

Odor: None

Physical State: Solid bead

PH: Not applicable

Vapor Pressure: Not applicable

Vapor Density: Not applicable

Boiling Point: 4046° F (2230° C)

Melting Point: 3110° F (1710° C)

Solubility: Insoluble in water

Specific Gravity: 2.1

Section 10 – Stability and Reactivity

Stability: Stable

Conditions to avoid: Moisture and high humidity environments.

Incompatibility: Water, fluorine, oxygen difluoride, chlorine trifluoride

Hazardous Decomposition Products: None

Hazardous Polymerization: Will not occur

Section 11 – Toxicological Information

This product and its components are not listed on the NTP or OSHA Carcinogen lists.

Animal Toxicology Tests for DOT Hazard classification
(Tests Conducted on finely ground silica gel)

1 - hour LC_{50} (rat) > 2 mg / l
48 - hour oral LD_{50} (rat) est. > 31,600 mg / kg
48 - hour dermal LD_{50} (rabbit) est. > 2,000 mg / kg
Considered an ocular irritant

Human Toxicology Silica gel is a synthetic amorphous silica not to be confused with crystalline silica. Epidemiological studies indicate low potential for adverse health effects. In the activated form, silica gel acts as a desiccant and can cause a drying irritation of the mucous membranes and skin in cases of severe exposure. Multisorb Technologies Inc. knows of no medical conditions that are abnormally aggravated by exposure to silica gel. The primary route of entry is inhalation of dust.

Section 12 – Ecological Information

Not known to have any adverse effect on the aquatic environment. Silica gel is insoluble and non-toxic.

Section 13 – Disposal Information

Disposal Information If this product as supplied becomes a waste, it does not meet the criteria of a hazardous waste as defined under the Resource Conservation and Recovery Act (RCRA) 40 CFR 261. Materials of a hazardous nature that contact the product during normal use may be retained on the product. The user of the product must identify the hazards associated with the retained material in order to assess the waste disposal options. Dispose according to federal, state and local regulations.

Section 14 – Transportation Information

U.S. Department of Transportation Shipping Name: Not classified as a hazardous material. Not regulated.

Section 15 – Regulatory Information (Not meant to be all inclusive - selected regulations represented)

TSCA Listed: Yes

DSL/NDSL (Canadian) Listed: Yes

OSHA: TWA 20 mppcf (80 mg / m^3 % SiO_2) for Silica gel

NIOSH: REL TWA 6 mg / m^3 IDLH 3,000 mg / m^3 for silica gel
Animal tests conducted in 1976 - 1978. 18 month exposure at 15 mg / m^3 showed silica deposition in respiratory macrophages and lymph nodes, minimum lung impairment, no silicosis.

ACGIH: TLV - 10 mg / m^3 for Silica gel

DOT: Not classified as a hazardous material.

Section 16 – Other Information

HMIS – Hazardous Materials Identification System

HMIS Rating	
Health	0
Flammability	0
Reactivity	0

0 - minimal hazard, 1 - slight hazard, 2 - moderate hazard, 3 - serious hazard, 4 - severe hazard

This MSDS was prepared by: George E. Mckedy
Senior Applications Development Specialist
Multisorb Technologies, Inc.

This data and recommendations presented in this data sheet concerning the use of our product and the materials contained therein are believed to be correct but does not purport to be all inclusive and shall be used only as a guide. However, the customer should determine the suitability of such materials for his purpose before adopting them on a commercial scale. Since the use of our products is beyond our control, no guarantee, expressed or implied, is made and no responsibility assumed for the use of this material or the results to be obtained therefrom. Information on this form is furnished for the purpose of compliance with Government Health and Safety Regulations and shall not be used for any other purposes. Moreover, the recommendations contained in this data sheet are not to be construed as a license to operate under, or a recommendation to infringe, any existing patents, nor should they be confused with state, municipal or insurance requirements, or with national safety codes.

2150 Area Velocity Flow Module

Appendix D Safety Information

D.1 Safety Considerations

In field installations of Teledyne Isco wastewater samplers and associated equipment, the safety of the personnel involved should be the foremost consideration. The following sections provide safety procedures for working in and around manholes and sewers. the first section offers general safety advice. The second section deals with the special problem of hazardous gases found in sewers.

The 2150 has not been approved for use in hazardous locations as defined by the National Electrical Code.

D.2 Practical Safety Precautions

The following procedures are those used by Black & Veatch, a respected consulting firm, and are published here by permission.

Field personnel must keep safety uppermost in their minds at all times. When working above ground, rules of common sense and safety prevail. However, when entering manholes, strict safety procedures must be observed. Failure to do so could jeopardize not only your own life, but also the lives of other crew members.

D.2.1 Hazards

There are many hazards connected with entering manholes. Some of the most common hazards are:

Adverse Atmosphere – The manhole may contain flammable or poisonous gases or the atmosphere may be deficient in oxygen. orced ventilation may be necessary.

Deteriorated Rungs – Manhole steps may be corroded and not strong enough to support a man. It may be difficult to inspect the rungs because of poor lighting.

Traffic – Whenever manholes are located in the traveled way, barricades and warning devices are essential to direct traffic away from an open manhole.

Falling Objects – Items placed near the manhole opening may fall and injure a worker in the manhole.

Sharp Edges – Sharp edges of items in or near a manhole may cause cuts or bruises.

Lifting Injuries – Unless proper tools are used to remove manhole covers, back injuries or injuries to hands or feet may result.

D.2.2 Planning

Advance planning should include arrangements for test equipment, tools, ventilating equipment, protective clothing, traffic warning devices, ladders, safety harness, and adequate number of personnel. Hasty actions may result in serious injuries. Time spent in the manhole should be kept to a minimum.

D.2.3 Adverse Atmospheres

[Refer to Table D-1, Hazardous Gases, at the end of this appendix.] Before workers enter a manhole, tests should be made for explosive atmosphere, presence of hydrogen sulfide, and oxygen deficiency. Combustible or toxic vapors may be heavier than air, so the tests on the atmosphere must be run at least 3/4 of the way down the manhole.

Whenever adverse atmosphere is encountered, forced ventilation must be used to create safe conditions. After the ventilating equipment has been operated for a few minutes, the atmosphere in the manhole should be retested before anyone enters the manhole.

When explosive conditions are encountered, the ventilating blower should be placed upwind to prevent igniting any gas that is emerging from the opening. When a gasoline engine blower is used, it must be located so that exhaust fumes cannot enter the manhole.

If testing equipment is not available, the manhole should be assumed to contain an unsafe atmosphere and forced ventilation must be provided. It should never be assumed that a manhole is safe just because there is no odor or the manhole has been entered previously.

D.2.4 Entering Manholes

Since the top of the manhole is usually flush with the surrounding surface, there may not be anything for the person who is entering the manhole to grab on to steady himself. Persons who are entering manholes should not be permitted to carry anything in their hands as they enter the manhole, to ensure that their hands will be free to hold on or grab if they slip. A good method for entering a manhole is to sit on the surface facing the manhole steps or ladder, with the feet in the hole and the arms straddling the opening for support. As the body slides forward and downward, the feet can engage a rung, and the back can rest against the opposite side of the opening. If there is any doubt about the soundness of the manhole steps, a portable ladder should be used.

A person should never enter a manhole unless he is wearing personal safety equipment, including a safety harness and a hard hat. Two persons should be stationed at the surface continuously while anyone is working inside a manhole, to lift him out if he is overcome or injured. One man cannot lift an unconscious man out of a manhole. The persons stationed at the surface should also function as guards to keep people and vehicles away from the manhole opening. To avoid a serious injury, a person should not be lifted out of a manhole by his arm unless it is a dire emergency.

When more than one person must enter a manhole, the first person should reach the bottom and step off the ladder before the next one starts down. When two men climb at the same time, the upper one can cause the lower one to fall by slipping or stepping on his fingers.

D.2.5 Traffic Protection

In addition to traffic cones, markers, warning signs, and barricades, a vehicle or a heavy piece of equipment should be placed between the working area and oncoming traffic. Flashing warning signals should be used to alert drivers and pedestrians. Orange safety vests should be worn by personnel stationed at the surface when the manhole is located in a vehicular traffic area.

D.2.6 Falling Objects

All loose items should be kept away from the manhole opening. This applies to hand tools as well as stones, gravel and other objects.

D.2.7 Removing the Covers

Manhole covers should be removed with a properly designed hook. Use of a pick ax, screwdriver, or small pry bar may result in injury. A suitable tool can be made from $^3/_4$-inch round or hex stock. Two inches of one end should be bent at a right angle and the other end should be formed into a D-handle wide enough to accommodate both hands. Even with this tool, care must be exercised to prevent the cover from being dropped on the toes. The 2-inch projection should be inserted into one of the holes in the cover, the handle grasped with both hands, and the cover lifted by straightening the legs which have been slightly bent at the knees.

D.2.8 Other Precautions

Other precautions which should be taken when entering a manhole are:

- Wear a hard hat.
- Wear coveralls or removable outer garment that can be readily removed when the work is completed.
- Wear boots or nonsparking safety shoes.
- Wear rubberized or waterproof gloves.
- Wear a safety harness with a stout rope attached.
- Do not smoke.
- Avoid touching yourself above the collar until you have cleaned your hands.

D.2.9 Emergencies

Every member of the crew should be instructed on procedures to be followed in cases of an emergency. It is the duty of each crew chief to have a list of emergency phone numbers, including the nearest hospital and ambulance service, police precinct, fire station, and rescue or general emergency number.

D.2.10 Field Equipment

The following equipment will be available for use:

Blowers	Gloves	Traffic cones
Breathing apparatus	Hard Hats	Coveralls
Harnesses	First aid kits	Manhole irons
Emergency flashers	Pick axes	Flashlights
Rain slickers	Mirrors	Ropes

Gas detectors Safety vests Gas masks
Waders"

D.3 Lethal Atmospheres in Sewers

The following is an article written by Dr. Richard D. Pomeroy, and published in the October 1980 issue of ***Deeds & Data*** of the WPCF. Dr. Pomeroy is particularly well known for his studies, over a period of nearly 50 years, in the field of the control of hydrogen sulfide and other odors in sewers and treatment plants. He has personally worked in a great many functioning sewers. In the earlier years he did so, he admits, with little knowledge of the grave hazards to which he exposed himself.

It is gratifying that the subject of hazards to people working in sewers is receiving much more attention than in past years, and good safety procedures are prescribed in various publications on this subject. It is essential that people know and use correct procedures.

It is less important to know just what the hazardous components of sewer atmospheres are, as safety precautions should in general be broadly applicable, but there should be a reasonable understanding of this subject. It is disturbing to see statements in print that do not reflect true conditions.

One of the most common errors is the assumption that people have died from a lack of oxygen. The human body is able to function very well with substantially reduced oxygen concentrations. No one worries about going to Santa Fe, New Mexico, (elev. 2,100 meters), where the partial pressure of oxygen is equal to 16.2% (a normal atmosphere is about 21%) oxygen. When first going there, a person may experience a little 'shortness of breath' following exercise. People in good health are not afraid to drive over the high passes in the Rocky Mountains. At Loveland Pass, oxygen pressure is 13.2% of a normal atmosphere. At the top of Mt. Whitney, oxygen is equal to 12.2%t. Many hikers go there, and to higher peaks as well. After adequate acclimation, they may climb to the top of Mt. Everest, where oxygen is equal to only 6.7%.

The lowest oxygen concentrations that I have observed in a sewer atmosphere was 13 percent. It was in a sealed chamber, near sea level, upstream from an inverted siphon on a metropolitan trunk. A man would be foolish to enter the chamber. Without ventilation, he might die, but not from lack of oxygen.

It seems unlikely that anyone has ever died in a sewer from suffocation, that is, a lack of oxygen. Deaths have often been attributed to 'asphyxiation.' This is a word which, according to the dictionary, is used to mean death from an atmosphere that does not support life. The word has sometimes been misinterpreted as meaning suffocation, which is only one kind of asphyxiation.

In nearly all cases of death in sewers, the real killer is hydrogen sulfide. It is important that this fact be recognized. Many cities diligently test for explosive gases, which is very important, and they may measure the oxygen concentration which usually is unimportant, but they rarely measure H_2S. Death has occurred where it is unlikely that there was any measurable reduction in the oxygen concentration. Waste water containing 2 mg per liter of dissolved sulfide, and at a pH of 7.0, can produce, in a chamber with high turbulence, a concentration of 300 PPM H_2S, in the air. This is considered to be a lethal concentration. Many people have died from H_2S, not only in sewers and industries, but also from swamps and from hot springs. In one resort area, at least five persons died from H_2S poisoning before the people were ready to admit that H_2S is not a therapeutic agent. Hardly a year passes in the U.S. without a sewer fatality from H_2S as well as deaths elsewhere in the world.

The presence of H_2S in a sewer atmosphere is easily determined. A bellows-and-ampoule type of tester is very satisfactory for the purpose, even though it is only crudely quantitative. When using a tester of this type, do not bring the air to the ampoule by way of a tube, as this may change the H_2S concentration. Hang the ampoule in the air to be tested, with a suction tube to the bulb or bellows.

Lead acetate paper is very useful as a qualitative indicator. It cannot be used to estimate the amount of sulfide, but it will quickly turn black in an atmosphere containing only a tenth of a lethal concentration.

Electrodes or other similar electrical indicating devices for H_2S in air have been marketed. Some of them are known to be unreliable, and we know of none that have proved dependable. Do not use one unless you check it at frequent intervals against air containing known H_2S concentrations. A supposed safety device that is unreliable is worse than none at all.

Remember that the nose fails, too, when it comes to sensing dangerous concentrations of H_2S.

Various other toxic gases have been mentioned in some publications. It is unlikely that any person has been asphyxiated in a sewer by any of those other gases, except possibly chlorine. The vapor of gasoline and other hydrocarbons is sometimes present in amounts that could cause dTeledyne Iscomfort and illness, but under that condition, the explosion hazard would be far more serious. The explosimeter tests, as well as the sense of smell, would warn of the danger. Pipelines in chemical plants might contain any number of harmful vapors. They, too, are sensed by smell and explosimeter tests if they get into the public sewer. Such occurrences are rare.

The attempt to instill a sense of urgency about real hazards is diluted if a man is told to give attention to a long list of things that in fact are irrelevant.

Be very careful to avoid high H_2S concentrations, flammable atmospheres, and hazards of physical injuries. Remember that much H_2S may be released by the stirring up of sludge in the bottom of a structure. Obey your senses in respect to irritating gases, such as chlorine (unconsciousness comes suddenly from breathing too much). Be cautious about strange odors. Do not determine percent oxygen in the air. There is a danger that the result will influence a man's thinking about the seriousness of the real hazards. Most important, use ample ventilation, and do not enter a potentially hazardous structure except in a good safety harness with two men at the top who can lift you out."

D.4 Hazardous Gases

The following table contains information on the properties of hazardous gases.

Table D-1 Hazardous Gases

Gas	Chemical Formula	Common Properties	Specific Gravity or Vapor Density Air =1	Physiological Effect	Max Safe 60 Min. Exposure ppm	Max. Safe 8 Hour Exposure ppm	Explosive Range (% by vol. in air) Limits lower/upper	Likely Location of Highest Concentration	Most Common Sources	Simplest and Cheapest Safe Method of Testing
Ammonia	NH_3	Irritant and poisonous. Colorless with characteristic odor.	0.60	Causes throat and eye irritation at 0.05%, coughing at 0.17%. Short exposure at 0.5% to 1% fatal.	300 to 500	85	16 25	Near top. Concentrates in closed upper spaces	Sewers, chemical feed rooms.	Detectable odor at low concentrations
Benzene	C_6H_6	Irritant, colorless anesthetic	2.77	Slight symptoms after several hours exposure at 0.16% to 0.32%. 2% rapidly fatal.	3,000 to 5,000	25	1.3 7.1	At bottom.	Industrial wastes, varnish, solvents.	Combustible gas indicator
Carbon Bisulfide	CS_2	Nearly odorless when pure, colorless, anesthetic. Poisonous.	2.64	Very poisonous, irritating, vomiting, convulsions, psychic disturbance.	—	15	1.3 44.0	At bottom	An insecticide	Combustible gas indicator
Carbon Dioxide	CO_2	Asphyxiant, Colorless, odorless. When breathed in large quantities, may cause acid taste. Non-flammable. Not generally present in dangerous amounts unless an oxygen deficiency exists.	1.53	Cannot be endured at 10% more than a few minutes, even if subject is at rest and oxygen content is normal. Acts on respiratory nerves.	40,000 to 60,000	5,000	— —	At bottom; when heated may stratify at points above bottom.	Products of combustion, sewer gas, sludge. Also issues from carbonaceous strata.	Oxygen deficiency indicator
Carbon Monoxide	CO	Chemical asphyxiant. Colorless, odorless, tasteless. Flammable. Poisonous.	0.97	Combines with hemoglobin of blood. Unconsciousness in 30 min. at 0.2% to 0.25%. Fatal in 4 hours at 0.1%. Headache in few hours at 0.02%.	400	50	12.5 74.0	Near top, especially if present with illuminating gas.	Manufactured gas, flue gas, products of combustion, motor exhausts. Fires of almost any kind.	CO ampoules.
Carbon Tetra-Chloride	CCl_4	Heavy, ethereal odor.	5.3	Intestinal upset, loss of consciousness, possible renal damage, respiratory failure.	1,000 to 1,500	100	— —	At bottom.	Industrial wastes, solvent, cleaning	Detectable odor at low concentrations.

Table D-1 Hazardous Gases (Continued)

Gas	Chemical Formula	Common Properties	Specific Gravity or Vapor Density Air =1	Physiological Effect	Max Safe 60 Min. Exposure ppm	Max. Safe 8 Hour Exposure ppm	Explosive Range (% by vol. in air) Limits lower/upper	Likely Location of Highest Concentration	Most Common Sources	Simplest and Cheapest Safe Method of Testing
Chlorine	Cl_2	Irritant. Yellow-green color. Choking odor detectable in very low concentrations. Non-flammable.	2.49	Irritates respiratory tract. Kills most animals in a very short time at 0.1%.	4	1	— —	At bottom.	Chlorine cylinder and feed line leaks.	Detectable odor at low concentrations.
Formaldehyde	CH_2O	Colorless, pungent suffocating odor.	1.07	Irritating to the nose.	—	10	7.0 73.0	Near bottom.	Incomplete combustion of organics. Common air pollutant, fungicide.	Detectable odor.
Gasoline	C_5H_{12} to C_9H_{20}	Volatile solvent. Colorless. Odor noticeable at 0.03%. Flammable.	3.0 to 4.0	Anesthetic effects when inhaled. Rapidly fatal at 2.4%. Dangerous for short exposure at 1.1 to 2.2%.	4,000 to 7,000	1,000	1.3 6.0	At bottom.	Service stations, garages, storage tanks, houses.	1. Combustible gas indicator. 2. Oxygen deficiency indicator.**
Hydrogen	H_2	Simple asphyxiant. Colorless, odorless, tasteless. Flammable	0.07	Acts mechanically to deprive tissues of oxygen. Does not support life.	—	—	4.0 74.0	At top.	Manufactured gas, sludge digestion tank gas, electrolysis of water. Rarely from rock strata.	Combustible gas indicator.
Hydrogen Cyanide	HCN	Faint odor of bitter almonds. Colorless gas	0.93	Slight symptoms appear upon exposure to 0.002% to 0.004%. 0.3% rapidly fatal.	—	10	6.0 40.0	Near top.	Insecticide and rodenticide.	Detector tube
Gas	Chemical Formula	Common Properties	Specific Gravity or Vapor Density Air = 1	Physiological Effect*	Max Safe 60 Min. Exposure ppm	Max. Safe 8 Hour Exposure ppm	Explosive Range (% by vol. in air.) Limits lower/upper	Likely Location of Highest Concentration	Most Common Sources	Simplest and Cheapest Safe Method of Testing
Hydrogen Sulfide	H_2S	Irritant and poisonous volatile compound. Rotten egg odor in small concentrations. Exposure for 2 to 15 min. at 0.01% impairs sense of smell. Odor not evident at high concentrations. Colorless. Flammable.	1.19	Impairs sense of smell, rapidly as concentration increases. Death in few minutes at 0.2%. Exposure to 0.07 to 0.1% rapidly causes acute poisoning. Paralyzes respiratory center.	200 to 300	20	4.3 45.0	Near bottom, but may be above bottom if air is heated and highly humid.	Coal gas, petroleum, sewer gas. Fumes from blasting under some conditions. Sludge gas.	1. H_2S Ampoule. 2. 5% by weight lead acetate solution.
Methane	CH_4	Simple asphyxiant. Colorless, odorless, tasteless, flammable.	0.55	Acts mechanically to deprive tissues of oxygen. Does not support life.	Probably no limit, provided oxygen percent-age is sufficient for life.	—	5.0 15.0	At top, increasing to certain depth.	Natural gas, sludge gas, manufactured gas, sewer gas. Strata of sedimentary origin. In swamps or marshes.	1. Combustible gas indicator 2. Oxygen deficiency indicator.

Table D-1 Hazardous Gases (Continued)

Gas	Chemical Formula	Common Properties	Specific Gravity or Vapor Density Air =1	Physiological Effect	Max Safe 60 Min. Exposure ppm	Max. Safe 8 Hour Exposure ppm	Explosive Range (% by vol. in air) Limits lower/upper	Likely Location of Highest Concentration	Most Common Sources	Simplest and Cheapest Safe Method of Testing
Nitrogen	N_2	Simple asphyxiant. Colorless, tasteless. Non-flammable. Principal constituent of air. (about 79%).	0.97	Physiologically inert.	—	—	— —	Near top, but may be found near bottom.	Sewer gas. sludge gas. Also issues from some rock strata.	Oxygen deficiency indicator.
Nitrogen Oxides	NO N_2O NO_2	Colorless Colorless, sweet odor. Reddish-brown. Irritating odor. Deadly poison	1.04 1.53 1.58	60 to 150 ppm cause irritation and coughing. Asphyxiant. 100 ppm dangerous. 200 ppm fatal.	50	10	— —	Near bottom.	Industrial wastes. Common air pollutant.	NO_2 detector tube.
Oxygen	O_2	Colorless, odorless, tasteless. Supports combustion.	1.11	Normal air contains 20.8% of O_2. Man can tolerate down to 12%. Minimum safe 8 hour exposure, 14 to 16%. Below 10%, dangerous to life. Below 5 to 7% probably fatal.	—	—	— —	Variable at different levels.	Oxygen depletion from poor ventilation and absorption, or chemical consumption of oxygen.	Oxygen deficiency indicator.
Ozone	O_3	Irritant and poisonous. Strong electrical odor. Strong oxidizer. Colorless. At 1 ppm, strong sulfur-like odor.	1.66	Max. naturally occurring level is 0.04 ppm. 0.05 ppm causes irritation of eyes and nose. 1 to 10 ppm causes headache, nausea; can cause coma. Symptoms similar to radiation damage.	0.08	0.04	— —	Near bottom.	Where ozone is used for disinfection.	Detectable odor at 0.015 ppm.
Sludge Gas	—***	Mostly a simple asphyxiant. May be practically odorless, tasteless.	Variable	Will not support life.	No data. Would vary widely with composition.		5.3 19.3	Near top of structure.	From digestion of sludge.	See components.
Sulfur Dioxide	SO_2	Colorless, pungent odor. Suffocating, corrosive, poisonous, non-flammable.	2.26	Inflammation of the eyes. 400 to 500 ppm immediately fatal.	50 to 100	10	— —	At bottom, can combine with water to form sulfurous acid.	Industrial waste, combustion, common air pollutant.	Detectable taste and odor at low concentration.
Toluene	C_5H_{12} to C_9H_{20}	Colorless, benzene-like odor.	3.14	At 200-500 ppm, headache, nausea, bad taste, lassitude.	200	100	1.27 7.0	At bottom.	Solvent.	Combustible gas indicator.
Turpentine	$C_{10}H_{16}$	Colorless, Characteristic odor.	4.84	Eye irritation. Headache, dizziness, nausea, irritation of the kidneys.	—	100		At bottom.	Solvent, used in paint.	1. Detectable odor at low concentrations. 2.Combustible gas indicator.
Xylene	C_8H_{10}	Colorless, flammable	3.66	Narcotic in high concentrations. less toxic than benzene.	—	100	1.1 7.0	At bottom.	Solvent	Combustible gas indicator.

Table D-1 Hazardous Gases (Continued)

Gas	Chemical Formula	Common Properties	Specific Gravity or Vapor Density Air =1	Physiological Effect	Max Safe 60 Min. Exposure ppm	Max. Safe 8 Hour Exposure ppm	Explosive Range (% by vol. in air) Limits lower/upper	Likely Location of Highest Concentration	Most Common Sources	Simplest and Cheapest Safe Method of Testing
* Percentages shown represent volume of gas in air.										
** For concentration over 0.3%.										
***Mostly methane and carbon dioxide with small amounts of hydrogen, nitrogen, hydrogen sulfide, and oxygen; occasionally traces of carbon monoxide.										

DECLARATION OF CONFORMITY

ISM1-A

Application of Council Directive:	89/336/EEC – The EMC Directive 73/23/EEC – The Low Voltage Directive
Manufacturer's Name:	Teledyne Isco, Inc.
Manufacturer's Address:	4700 Superior, Lincoln, Nebraska 68504 USA Mailing Address: P.O. Box 82531, Lincoln, NE 68501
Equipment Type/Environment:	Laboratory Equipment for Light Industrial/Commercial Environments
Trade Name/Model No:	2150 Area Velocity Flow Module and Sensor
Year of Issue:	2001
Standards to which Conformity is Declared:	EN 61326-1998 EMC Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use EN 61010-1 Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use

Standard	Description	Severity Applied	Performance Criteria
EN61000-4-2	Electrostatic Discharge	Level 2 - 4kV contact discharge Level 3 - 8kV air discharge	B B
EN61000-4-3	Radiated RF Immunity	80 MHz to 1000MHz 80% AM at 1kHz Level 1 – 10V/m	*B
EN61000-4-4	Electrical Fast Transient	Level 1 – 1kV on I/O lines	B
EN61000-4-5	Surge on I/O Lines	1kV common mode, 0.5KV differential mode	B
EN61000-4-6	Conducted RF on I/O lines	150 kHz to 80 MHz, 3V rms, 80% modulated	B
CISPR11/ EN 55011	RF Emissions	Group 1, Class A Industrial, Scientific, and Medical Equipment	

* Standard requires performance criteria A, however, tests show some degradation of performance due to RF at 10V/m, in that flow rates are affected beyond the tolerances published in the instrument's specifications.

We, the undersigned, hereby declare that the design of the equipment specified above conforms to the above Directive(s) and Standards as of July 1, 2001.

William Foster

William Foster
USA Representative

TELEDYNE ISCO
A Teledyne Technologies Company

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Director of Engineering
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60-2002-155
Rev A

DECLARATION OF CONFORMITY

CE
ISM1-A

Application of Council Directive:	89/336/EEC – The EMC Directive 73/23/EEC – The Low Voltage Directive
Manufacturer's Name:	Teledyne Isco, Inc.
Manufacturer's Address:	4700 Superior, Lincoln, Nebraska 68504 USA Mailing Address: P.O. Box 82531, Lincoln, NE 68501
Equipment Type/Environment:	Laboratory Equipment for Light Industrial/Commercial Environments
Trade Name/Model No:	2191 Battery Module
Year of Issue:	2001
Standards to which Conformity is Declared:	EN 61326-1998 EMC Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use EN 61010-1 Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory use.

Standard	Description	Severity Applied	Performance Criteria
EN61000-4-2	Electrostatic Discharge	Level 2 - 4kV contact discharge Level 3 - 8kV air discharge	B B
EN61000-4-3	Radiated RF Immunity	80 MHz to 1000MHz 80% AM at 1kHz Level 1 – 10V/m	B
EN61000-4-4	Electrical Fast Transient	Level 1 – 1kV on I/O lines	B
EN61000-4-5	Surge on I/O Lines	1kV common mode, 0.5KV differential mode	B
EN61000-4-6	Conducted RF on I/O lines	150 kHz to 80 MHz, 3V rms, 80% modulated	B
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Teledyne Isco One Year Limited Factory Service Warranty *

Teledyne Isco warrants covered products against failure due to faulty parts or workmanship for a period of one year (365 days) from their shipping date, or from the date of installation by an authorized Teledyne Isco Service Engineer, as may be appropriate.

During the warranty period, repairs, replacements, and labor shall be provided at no charge. Teledyne Isco's liability is strictly limited to repair and/or replacement, at Teledyne Isco's sole discretion.

Failure of expendable items (e.g., charts, ribbon, tubing, lamps, glassware, seals, filters, fittings, and wetted parts of valves), or from normal wear, accident, misuse, corrosion, or lack of proper maintenance, is not covered. Teledyne Isco assumes no liability for any consequential damages.

This warranty does not cover loss, damage, or defects resulting from transportation between the customer's facility and the repair facility.

Teledyne Isco specifically disclaims any warranty of merchantability or fitness for a particular purpose.

This warranty applies only to products sold under the Teledyne Isco trademark and is made in lieu of any other warranty, written or expressed.

No items may be returned for warranty service without a return authorization number issued from Teledyne Isco.

The warrantor is Teledyne Isco, Inc.
4700 Superior, Lincoln, NE 68504, U.S.A.

*** This warranty applies to the USA and countries where Teledyne Isco Inc. does not have an authorized dealer. Customers in countries outside the USA, where Teledyne Isco has an authorized dealer, should contact their Teledyne Isco dealer for warranty service.**

In the event of instrument problems, always contact the Teledyne Isco Service Department, as problems can often be diagnosed and corrected without requiring an on-site visit. In the U.S.A., contact Teledyne Isco Service at the numbers listed below. International customers should contact their local Teledyne Isco agent or Teledyne Isco International Customer Service.

Return Authorization

A return authorization number must be issued prior to shipping. Following authorization, Teledyne Isco will pay for surface transportation (excluding packing/crating) both ways for 30 days from the beginning of the warranty period. After 30 days, expense for warranty shipments will be the responsibility of the customer.

Shipping Address: Teledyne Isco, Inc. - Attention Repair Service
4700 Superior Street
Lincoln NE 68504 USA

Mailing address: Teledyne Isco, Inc.
PO Box 82531
Lincoln NE 68501 USA

Phone: Repair service: (800)775-2965 (lab instruments)
(800)228-4373 (samplers & flow meters)
Sales & General Information (800)228-4373 (USA & Canada)

Fax: (402) 465-3001

Email: iscoservice@teledyne.com **Web site:** www.isco.com

TELEDYNE ISCO
A Teledyne Technologies Company

FLO-DAR™ with Flo-Logger™ Area/Velocity Radar Flow Meter

MARSH McBIRNEY
A Hach Company Brand

The Flo-Dar Flow Meter with Flo-Logger provides an ideal solution for non-contact, maintenance-free portable sewer flow monitoring.

Features and Benefits

The Flo-Dar Area/Velocity Radar Flow Meter provides a revolutionary approach to open channel flow monitoring. Flo-Dar combines advanced Digital Doppler Radar velocity sensing technology with ultrasonic pulse echo depth sensing to remotely measure open channel flow. Combined with the Flo-Logger, users have a portable solution for flow measurement needs.

Accurate Flow Measurement

Flo-Dar provides the user with highly accurate flow measurements under a wide range of flows and site conditions. By measuring the velocity of the fluid from above, Flo-Dar eliminates accuracy problems inherent with submerged sensors including sensor disturbances, high solids content and distribution of reflectors.

Non-Contact Sensor Eliminates Lost Data

No lost data with non-contact, above the flow sensor that is unaffected by fouling due to debris and grease.

Easy Installation and Maintenance

As the sensor is mounted above the flow, personnel have little or no contact with the flow during installation. Future sensor removal can be done without the need for confined space entry.

Perfect Solution for Difficult Flow Conditions

Operates in the most difficult conditions including flows with high solids content, high temperature, shallow and caustic flows, large man-made channels, and high velocities up to 20 ft/s.

Optional Surcharge Velocity Sensor

During surcharge events Flo-Dar's optional electromagnetic sensor will continue to provide uninterrupted and accurate flow monitoring through dry and wet weather flows without the need for routine sensor cleaning or maintenance.

Applications

Industrial

- *Process Waste*
- *Plant Influent*
- *Plant Effluent*
- *Non-contact Cooling Water*
- *Stormwater Monitoring and Compliance*

Municipal

- *Sanitary Sewer Evaluation Studies*
- *Collection Systems*
- *Capacity Studies*
- *Combined Sewer Overflows*
- *Inflow and Infiltration (I&I) Studies*
- *Billing / Custody Transfer*
- *Plant Influent and Effluent*

Specifications*

FLO-DAR SENSOR

Enclosure Material
Polystyrene

Enclosure Rating
IP68 Waterproof rating, polystyrene

Dimensions
17.5 x 42.3 x 29.7 cm
(6.9 W x 16.65 L x 11.7 D in.)

Weight
4.8 kg (10.5 lbs.)

Operating Temperature
-10° to 50° C (14° to 122° F)

Storage Temperature
-40° to 60° C (-40° to 140° F)

Power Requirements
Supplied by Flo-Logger

Interconnecting Cable
Polyurethane, 0.400 (+/-0.015) in. diameter
IP68
Operating temperature: -20 to 105 degrees C (-4 to 221° F)

Certification
Complies with FCC Part 15C, Subpart 245-TCB ID
BEJPDA-L05C-WL

Complies with Industry Canada Spec RSS210 Issue 5.0
Cert # 466Q-L05CBT(user licensing not required)

VELOCITY MEASUREMENT

Method
Radar

Range:
0.23 to 6.10 m/s (0.75 to 20 ft/s)

Frequency Range
24.075 to 24.175 G-Hz, 15.2mW (max.)

Accuracy
± 0.5%; ± 0.03 m/s (± 0.1 ft/s)

DEPTH MEASUREMENT

Method
Ultrasonic

Standard Operating Range from sensor to liquid
0 to 152.4 cm (0 to 60 in.)

Optional Extended Operating Range
0 to 6.1 m (0 to 20 ft.) with 40.64 cm (16 in.) dead band, temperature compensated.

Accuracy
±1%; ± 0.25 cm (± 0.1 in.)

FLOW MEASUREMENT

Method
Based on Continuity Equation

Accuracy
± 5% of reading typical where flow is in a channel with uniform flow conditions and is not surcharged, ±1% full scale max.

SURCHARGE CONDITIONS DEPTH/VELOCITY

DEPTH (Std with Flo-Dar Sensor)

Method
Piezo-resistive pressure transducer

Maximum Range
3.5 m (138 in.)

VELOCITY (Optional Surcharge Velocity Sensor)

Method
Electromagnetic

Range
± 6.1 m/s (± 20 ft/s)

Power Requirements
Power supplied by Flo-Logger

FLO-LOGGER PORTABLE DC POWERED ELECTRONICS

Data Storage
64K (16K cycles of velocity/depth data)

Local Terminal
RS232C at 19.2K baud

Power Requirements
Two 6-volt lantern batteries (Alkaline Energizer 529 recommended)

Housing
Sealed watertight Polystyrene – meets IP68 rating
Length: 37.03 cm (14.625")
Diameter: 19.69 cm (7.75")
Weight: 3.4 kg (7.5 lbs.) (including alkaline batteries)

Temperature
Operating Range: -10° to 51° C (14° to 125° F)
Storage Range: -20° to 51° C (-4° to 125° F)

Sensor/Logger Disconnect
Both the sensor and the logger have waterproof (IP68) connectors for easy separation from the interconnecting cable.

Set-up/Data Retrieval
Flo-Ware for Windows software (sold separately) is the user on-site set-up, data management, and report generation software. It is compatible with desktop/portable computers utilizing Windows 95/98/2000/Me/NT/XP. Flo-Ware FX for PocketPC has all the same functionality as Flo-Ware for Windows with the exception of report generation.

Timebase Accuracy
One second per day

Battery Life
60 days (typical) at intervals of 1 sample every 15 minutes (with recommeded batteries)

CE Both Flo-Dar sensor and Flo-Station meet CE requirements.

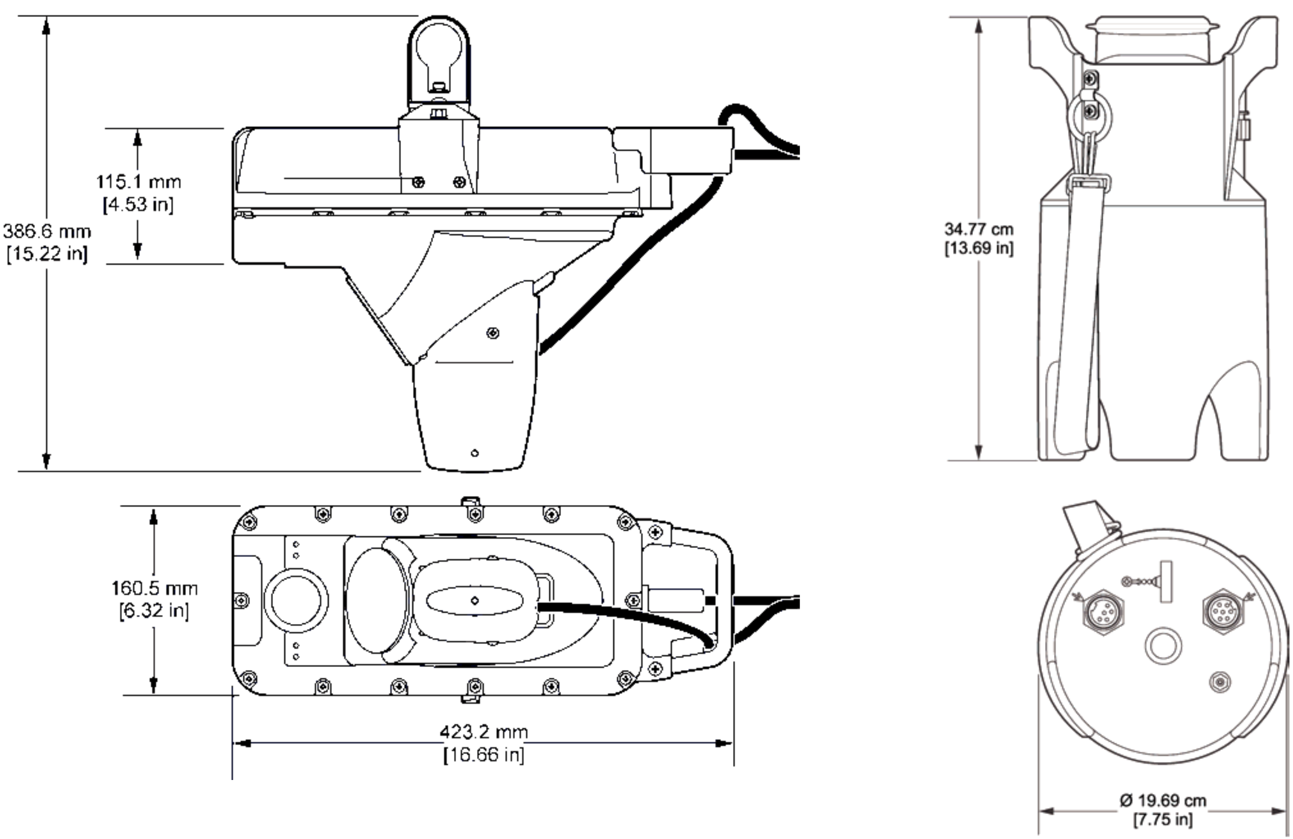
*Specifications subject to change without notice.

Engineering Specifications

FLO-DAR SENSOR WITH FLO-LOGGER

1. The flow meter shall be capable of measuring level, average velocity and surcharge depth.
2. The method of velocity measurement shall be Doppler radar.
3. The sensor shall combine advanced Doppler Radar velocity sensing technology with ultrasonic pulse echo level sensing to remotely measure open channel flow.
4. Flow shall be calculated based on the Continuity Equation (Q=V x A), where Q=Flow, V=Average Velocity and A=Area.
5. The range of velocity measurement shall be 0.23 to 6.10 m/s (0.75 to 20 ft/s).
6. The method of depth measurement shall be ultrasonic.
7. The standard operating range for depth measurement shall be 0 to 152.4 cm (0 to 60 in.) with an optional operating range of 0 to 6.1 m (0 to 20 ft.) (with 16 in. dead band).
8. The flow meter shall have a surcharge condition velocity sensor option.
9. Exterior dimensions of the sensor shall not exceed 17.53 x 42.32 x 29.72 cm (6.9 W x 16.66 L x 11.7 in. D) or 17.53 x 42.32 x 38.65 cm (6.9 W x 16.66 L x 15.22 in. D) with Surcharge Velocity option. Extended Range Level option adds 11.43 cm (4.5 in.) to L.
10. The flow meter shall be the Marsh McBirney Flo-Dar with Flo-Logger Open Channel Flow Meter.

Dimensions



Ordering Information

			Surcharge Option	Extended Range	
Flo-Dar Sensors	**Model 4000-**	___	___	___	
30 ft.		1			
60 ft.		2			
100 ft.		3			
As needed (Max 1000 feet		4			
No			0		
Yes			3		
Standard				0	
Extended Range Option				1	
Extended Range Option w/Remote Depth Sensor				2	
		SVS Connector	Flo-Ware Software	Options	
Flo-Dar Electronics (Flo-Logger)	**Model 1004-**	___	___	___	
No		1			
Yes		2			
Current license holder			0		
New license holder			1		
External Power Connector				**P**	**May order both P & E 1004-1XPE**
Relay Output- drives sampler				**E**	

Mounting Hardware

800016701	Permanent Mount - Includes sensor frame and all mounting hardware
800016401	Portable Sensor Mount - 34-52 inch manhole diameters, Includes jack bar assembly, frame, and all hardware.
800016402	Portable Sensor Mount - 52-70 inch manhole diameters, Includes jack bar assembly, frame, and all hardware assembly, frame, and all hardware
800016403	Portable Sensor Mount - 70-88 inch manhole diameters, Includes jack bar assembly, frame, and all hardware
800016404	Portable Sensor Mount - 89-107 inch manhole diameters, Includes jack bar assembly, frame, and all hardware
800012402	Laser Alignment Tool

Accessories & Spares

110000701	Replacement Battery Pack - for use in Long Life Battery Pack P/N 800017701
110000501	Lithium Battery Pack, 12 month life at 15 minute measurement cycle 7.2 VDC
115000101	Rechargeable Battery - 6V Lantern (requires 2)
800004001	Battery Charger - used for recharging 6V batteries 110 VAC
55032	Desiccant Replacement Cartridge
151000201	Moisture Block Replacement Cartridge for air tube (APR)
800007201	Suspension Cable - Stainless Steel to hang Flo-Logger to manhole step
420001001	Suspension Strap - Fabric to hang Flo-Logger to manhole step (spare)
Odd Shape SPC	Odd Shaped Table - Configures software for user's specified conduit.
245000501	Sensor Retrieval Pole - Used to place and retrieve sensor from mounting bracket. Pole extends to 7.3 m (21 ft.)
510012701	Sensor Retrieval Hook - Used with Sensor Retrieval Pole
131013101	Flo-Logger to Laptop Interface Cable - Spare for Logger only.

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U.S.A.
Telephone: 800-368-2723
Fax: 301-874-8459
E-mail: orders@marsh-mcbirney.com
www.marsh-mcbirney.com

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Understanding the Flo-Dar™ Flow Measuring System

MARSH McBIRNEY
A Higher Level of Flow Measurement

Independent tests verify non-contact flowmeter is highly accurate under both open channel and surcharge conditions

Flo-Dar is the only non-contact open channel velocity/area type flow meter available for measurement of flows in municipal wastewater and storm water sewers. Flo-Dar consists of a radar-based velocity measurement system and an ultrasonic-based pulse echo depth measurement system.

Flo-Dar has an optional surcharge velocity sensor (electromagnetic type) and depth sensor (pressure transducer) that provides the continuation of accurate flow data where intermittent, surcharged flow conditions are experienced.

Flo-Dar combines the information from the velocity and depth systems along with site specific data (pipe size, pipe shape, velocity profile) and provides the user with highly accurate, reliable flow data under a wide range of flow velocities and depths. Since the radar velocity sensor and the ultrasonic depth sensor cease to provide useful data when submerged, Flo-Dar has an optional surcharge velocity sensor (electromagnetic type) and depth sensor (pressure transducer) that provides for the continuous measurement of accurate flow data where intermittent, surcharged flow conditions are experienced.

The data system merges the data from these two independent flow systems and provides the user with a single flow signal that accurately represents flow over a range from a dry pipe to extreme surcharge conditions. Accuracy tests performed at Alden Research Labs have shown that the Flo-Dar is highly accurate under both open channel and surcharge (submerged) conditions.

Accuracy tests performed at Alden Research Labs have shown that the Flo-Dar is highly accurate under both open channel and surcharge (submerged) conditions.

Measurement of Flow Under Free Flow, Non-submerged Conditions

Open Channel Velocity

Open channel flow is any flow in a channel that has a free surface. Flo-Dar measures open channel flow as depicted in Figure 1. The radar velocity sensor measures flow in a manner similar to how radar guns measure the velocity of a baseball or an automobile.

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Marsh-McBirney has developed and patented a process that yields an accurate determination of the average velocity from the measurement of the surface velocity at a known point on the flow surface.

Factors that influence the accuracy and stability of the measured surface velocity signal:
1. *Transmitted Frequency*
2. *Speed of Microwaves in Air*
3. *Angle of Microwave Beam*
4. *Calculation of Mean Velocity*

A radar "horn" contained inside of the watertight housing transmits a microwave beam through the housing at a defined angle to the flow surface. Disturbances on the surface reflect some of the microwaves back to the horn. The frequency of these returning microwave signals have been shifted (the Doppler effect) by an amount directly proportional to the speed of the moving surface. This frequency shift is detected and measured by the Flo-Dar flow meter and the data is stored as a measure of the surface velocity.

Since the accurate measurement of open channel flow requires the accurate determination of the average velocity of the flow stream, the measured surface velocity must be dynamically modified to obtain an accurate average velocity for use in the Continuity Equation, Q= Vav x A). Marsh-McBirney has developed and patented a process that yields an accurate determination of the average velocity from the measurement of the surface velocity at a known point on the flow surface.

If one analyzes each of the four factors that influence the accuracy and stability of the measured surface velocity signal, it becomes obvious that a Doppler Radar based velocity sensor is very accurate and stable:

1. Transmitted Frequency - The transmitted frequency of 24.175 GHz is controlled to an accuracy of +/- 0.065%
2. Speed of Microwaves in Air - Essentially constant at the speed of light
3. Angle of Microwave Beam - The sensor is placed in a rigid mount that is positioned parallel to the water surface (i.e. nearly level). The sensor can be removed from the mount and reinstalled while easily maintaining its original mounting location.
4. Calculation of Average Velocity—The relationship between the sensed (surface) velocity and the average velocity varies with pipe size and water depth.

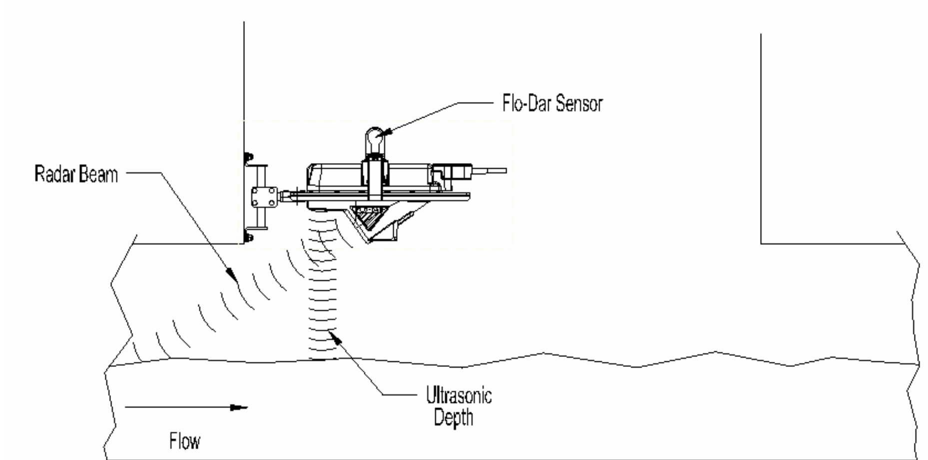

Figure 1

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By applying algorithms developed through basic hydraulic principles and from actual flow data taken at Alden Labs and at various customer sites, the surface velocity is transformed into an accurate representation of the mean velocity.

Since the location of the sensing region on the flow surface is known, the repeatability of the surface velocity measurement is excellent and its relationship to the mean velocity is very predictable.

Since the location of the sensing region on the flow surface is known, the repeatability of the surface velocity measurement is excellent and its relationship to the mean velocity is predictable.

Figures 2a, 2b, 2c and 2d depict the relationship that exists between various velocity contours and the mean velocity at different **d**epth/**D**iameter ratios. Note that the velocity gradients that exist throughout the flow cross section are generally represented at the flow's surface - essentially creating a "finger-print" of the velocity contours that exist beneath the surface.

As one might expect, the velocities near the wall are less than the mean velocity and those near the surface are greater than the mean velocity. Since a) the radar sensor measures surface velocity at a know location on the flow surface, and b) these various surface velocities have known relationships to the mean velocity, then the mean velocity can be reliably and accurately calculated.

The accuracy of the calculated average velocity, after correction, is typically between 2% to 5%.

Note that the velocities present on the surface are typically within 10% of the average velocity. The accuracy of the calculated mean velocity, after correction, is typically between 2% to 5%. (See Note 1.)

Ultrasonic Pulse Echo Depth Measurement

Ultrasonic pulse echo depth sensors operate by energizing a piezoelectric transducer with an electronic pulse. This pulse creates an ultrasonic pulse of energy that travels to the flow surface where a portion of the energy returns to the transducer.

The transit time to the flow surface and back is recorded and the distance calculated by knowing the speed of sound at the site which has been corrected by an embedded temperature sensor. The accuracy of the depth measurement is 1%, +/- 0.1 inch .

Measurement of Flow Under Submerged Conditions

Electromagnetic (EM) Surcharge Velocity Sensor

As stated previously, the radar based velocity sensor measures the surface velocity of the flowing stream by detecting the average speed of the surface irregularities. When the radar sensor becomes totally submerged, it becomes "blind" and is no longer capable of measuring the fluid velocity.

*Figures 2a, 2b, 2c and 2d depict the relationship that exists between various velocity contours and the mean velocity at different **d**epth/**D**iameter ratios. Note that the velocity gradients that exist throughout the flow cross section are generally represented at the flow's surface—essentially creating a "finger-print" of the velocity contours that exist beneath the surface.*

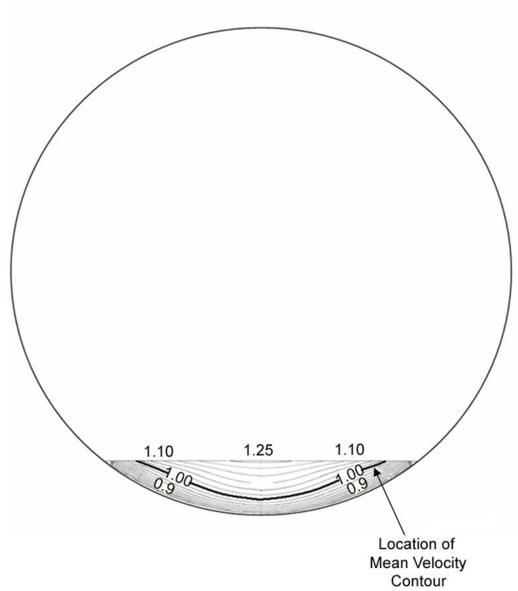


Figure 2a:
d/D= 0.10

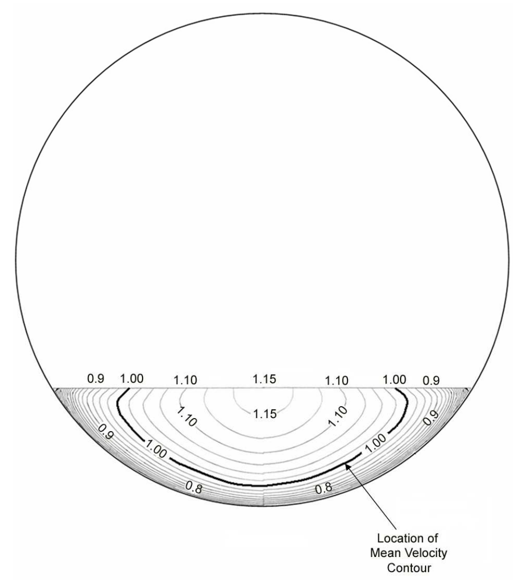


Figure 2b:
d/D= 0.25

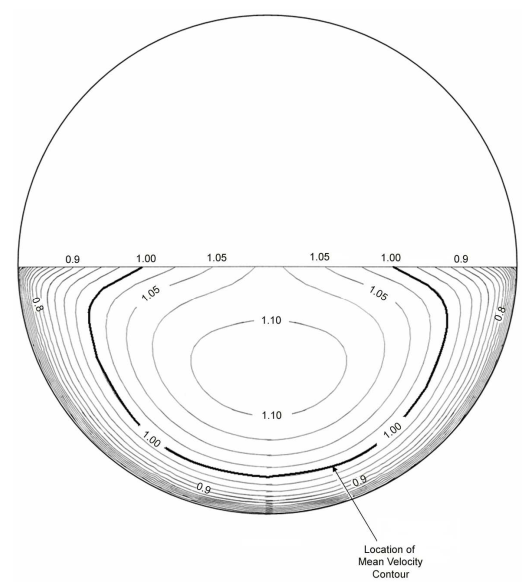


Figure 2c:
d/D= 0.50

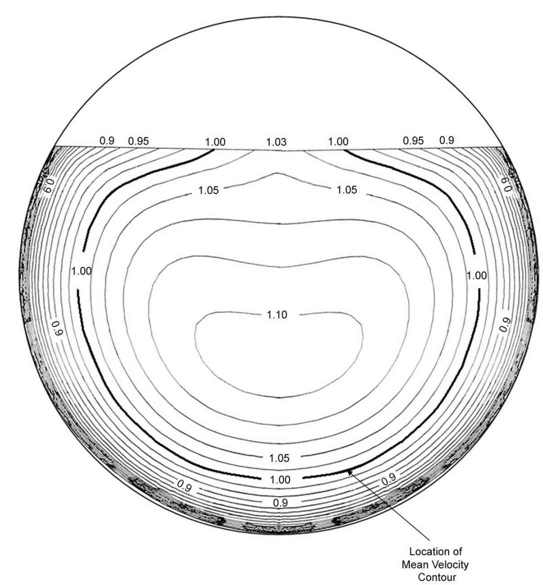


Figure 2d:
d/D= 0.75

To allow for the uninterrupted measurement of flow under conditions that change from open channel flow to submerged flow as experienced in sewers that surcharge, Marsh-McBirney has added an additional surcharge velocity sensor.

Placed on the underside of the standard Flo-Dar sensor, this electromagnetic sensor becomes active when the flow level rises to within 4 inches of the Radar horn and remains activated until the flow once again falls beneath that depth.

To allow for the uninterrupted measurement of flow under conditions that change from open channel flow to submerged flow as experienced in sewers that surcharge, Marsh-McBirney has added an additional surcharge velocity sensor. Placed on the underside of the standard Flo-Dar sensor, this electromagnetic sensor becomes active when the flow level rises to within four inches of the Radar horn and remains activated until the flow once again falls beneath that depth.

The optional surcharge velocity sensor is based on the Faraday Principle of Electromagnetic Induction. This is the same well-proven principle that “full bore” or “spool-piece” magmeters utilize, the most widely used method of measuring wastewater flow in full pipes.

In the Marsh-McBirney design, an electromagnet embedded within the streamlined sensor generates a magnetic field in the flowing stream. The flow of the water passing through this magnetic field generates voltages in the water that are directly proportional to the speed of the water passing the sensor. Marsh-McBirney uses an in-house 120 foot long towing basin for calibration of electromagnetic sensors. Tow carriage accuracy is better than +/- 0.5%.

Surcharge Depth Sensor

Once submerged conditions exist, the ultrasonic depth sensor ceases to provide useful depth information. To measure depth of the flow during surcharge conditions, a pressure transducer embedded in the Flo-Dar sensor is used in the system.

The location of the surcharge velocity sensor relative to the crown of the pipe is shown in Figure 3. This location provides sensing of the velocity stream just below the crown of the pipe where the flow exits the upstream piping. Empirical data, verified by independent tests at Alden Labs in Holden, Massachusetts indicate that the velocity measured at this location, when multiplied by 0.9, is typically equal to the average velocity.

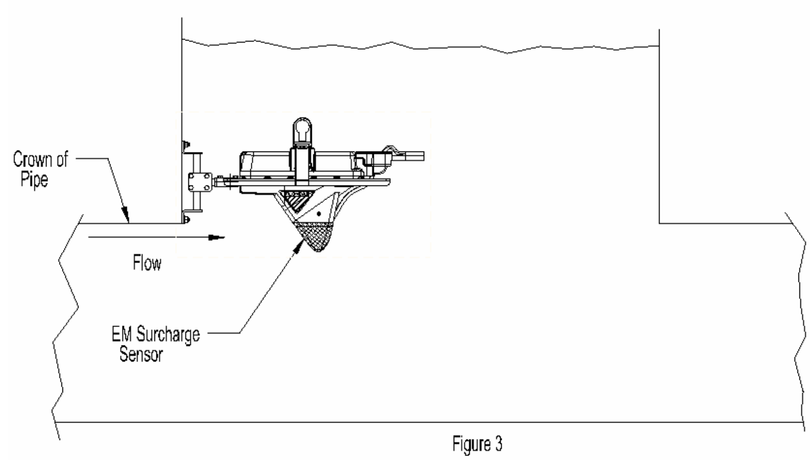


Figure 3

The flow tests showed that the Flo-Dar compared very favorably with the Alden flow standard (weigh tank) over a wide range of flows where the open channel flow ranged from 400 gpm to 6000 gpm, and the surcharge (submerged) flow ranged from 6000 gpm to 9000 gpm.

Laboratory Tests

In September 2002 Marsh-McBirney contracted Alden Research Labs of Holden, Massachusetts to perform flow accuracy tests on the Flo-Dar sensor with an electromagnetic surcharge sensor. The Flo-Dar was subjected to a flow range of 400 gpm to over 9000 gpm in a pipe size of 23.5 inches. The pipe had a slope of approximately zero. The test results are shown in Figure 4, Figure 5, Figure 6 and Figure 7.

The flow tests showed that the Flo-Dar compared very favorably with the Alden flow standard (weigh tank) over a wide range of flows where the open channel flow ranged from 400 gpm to 6000 gpm, and the surcharge (submerged) flow ranged from 6000 gpm to 9000 gpm.

Tests were also run to depict how Flo-Dar performs under transition conditions where the flow goes from an open channel condition to a surcharge (submerged) condition.

Test results show that the data from the open channel radar sensor and surcharge electromagnetic sensor overlay each other and the Alden Standard. Tests were run under both free flow conditions as well as where the pipe outlet was partially blocked so as to create an entirely different velocity/depth relationship.

Additional flow accuracy tests were run on a 36" pipe at Alden on July 17, 2003. All of the data points were shown to be within 3.5% of the Alden Standard.

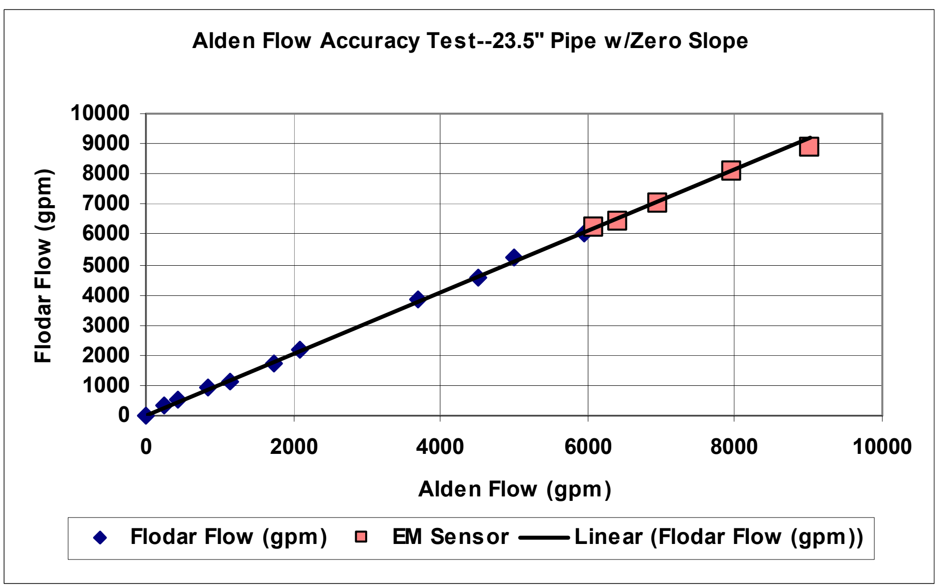
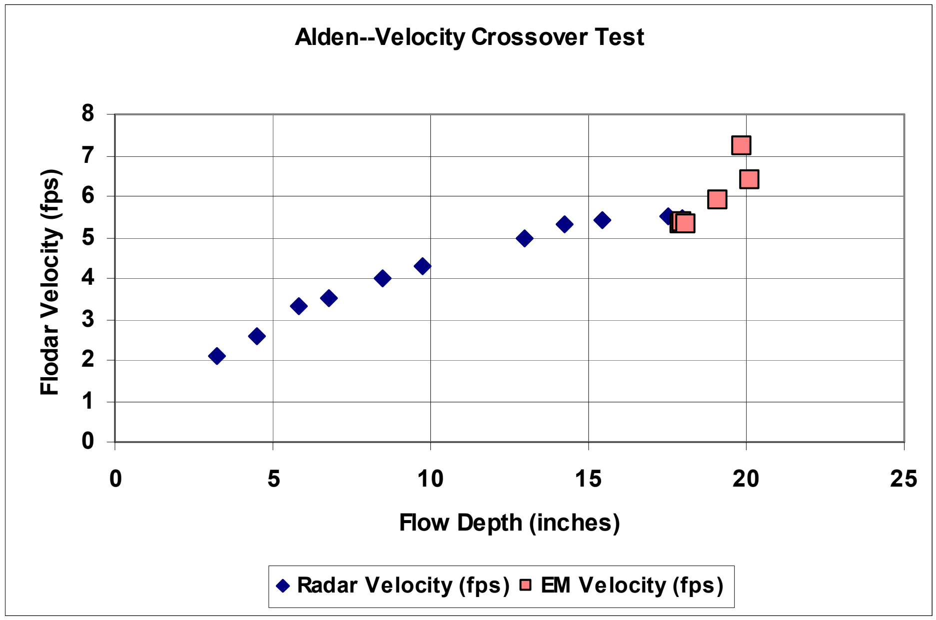


Figure 4 compares the Flo-Dar flow vs. the Alden Standard (weigh tank). The flow condition for this test was both open channel flow and surcharge (submerged) flow.



Test results show that the data from the open channel radar sensor and surcharge electromagnetic sensor overlay each other and the Alden Standard.

Figure 5 compares the velocity measured by the Radar sensor plotted against flow depth. Note that when the depth reaches approximately 18 inches the EM surcharge sensor has been activated. There is one data point where both sensors are active and then the EM surcharge sensor continues to measure after the radar sensor has become submerged and inoperative.

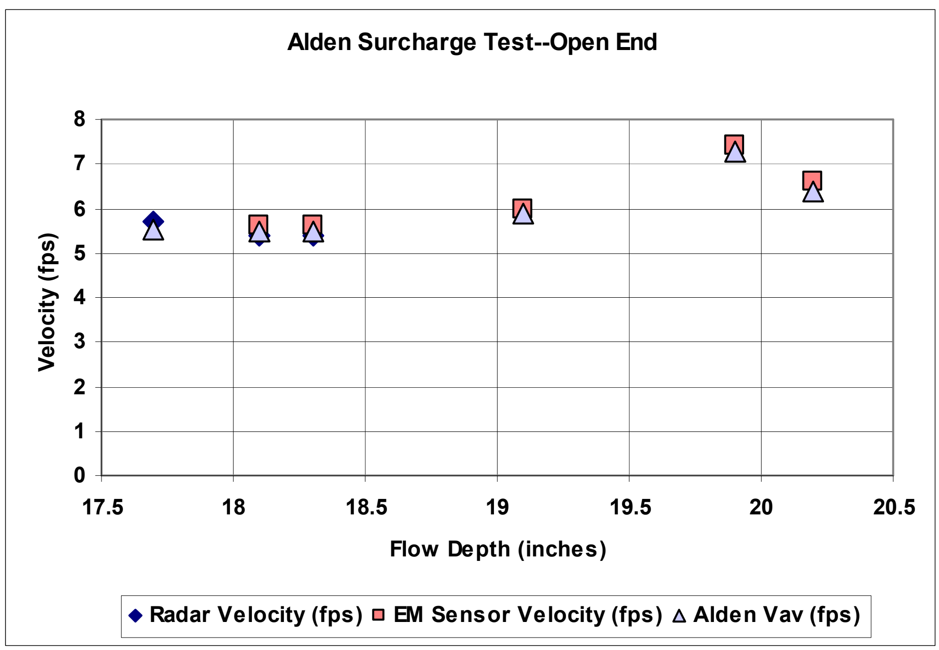


Figure 6 depicts a second surcharge test where the flow was incremented more slowly in order to achieve additional data points in the area where both the Radar sensor and the EM surcharge sensors are active simultaneously. Note that both the Radar sensor and the EM sensor are active between flow depths of 18 inches and 18.5 inches. Also, note how both the Radar and EM data points overlay each other and the Alden standard.

The accuracy of Flo-Dar under both open channel conditions as well as surcharge (submerged) conditions is more than adequate for the most demanding of metering applications including open channel billing applications.

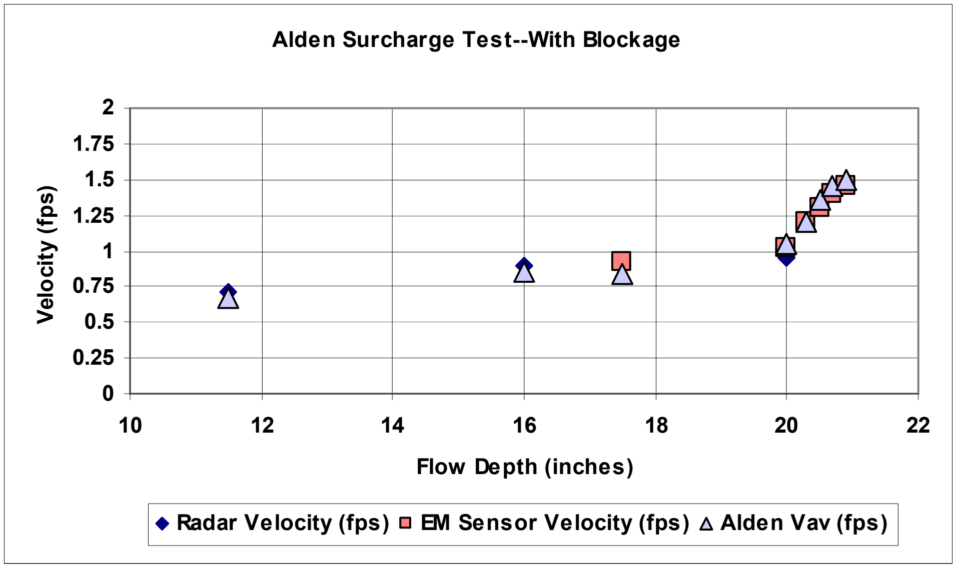


Figure 7 depicts the result of a surcharge test at a lower flow rate. In this test, a round plate with multiple holes was placed at the outlet of the test pipe so as to achieve submerged flow at a lower velocity. Note the consistency of both the Radar velocity data and the EM velocity data as compared to the Alden standard.

Additional tests performed at Alden in 2003 on a 36" pipe again validated Flo-Dar's accuracy under open channel and surcharge flow.

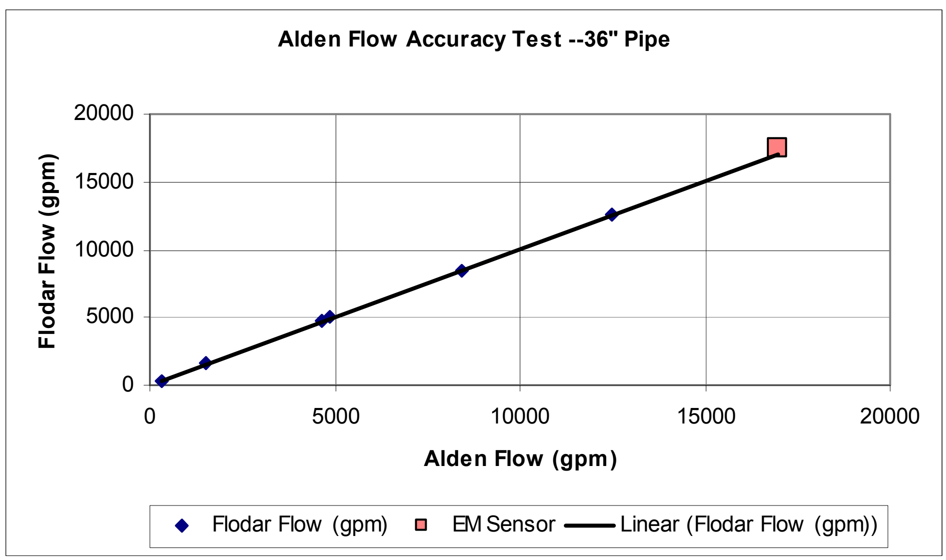


Figure 8 compares the Flo-Dar flow vs. the Alden Standard (weigh tank) for flow accuracy tests in a 36" pipe. These tests were performed on July 17, 2003. Note that at 17,000 gpm the sensor was under surcharge conditions. All of the data points were shown to be within 3.5% of the Alden Standard.

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The Flo-Dar data logger records all four of the flow parameters - open channel surface velocity and depth, and surcharged velocity and depth. When the water depth is below the bottom of the Flo-Dar sensor, only the surface velocity and the flow depth of the open channel flow are used in the flow calculation.

Flo-Dar measures open channel velocity and depth by non-contact means virtually eliminating the need to periodically clean the sensors as required by all submerged type sensors.

Once the flow depth is such that both the surcharge depth sensor is activated and a conductivity switch is activated, then flow is calculated using the full pipe dimensions for area and the surcharge velocity sensor for velocity.

Conclusions

Flo-Dar is a rugged, general purpose flow meter for use in most open channels such as sanitary sewers, storm water sewers and other man-made channels such as aqueducts as well as certain natural channels such as small streams. Flo-Dar measures open channel velocity and depth by non-contact means virtually eliminating the need to periodically clean the sensors as required by all submerged type sensors. Data recovery from Flo-Dar deployments ranges between 98% to 100% even under site conditions that render most submerged sensors inoperable.

Data recovery from Flo-Dar deployments ranges between 98% to 100% even under site conditions that render most submerged sensors inoperable.

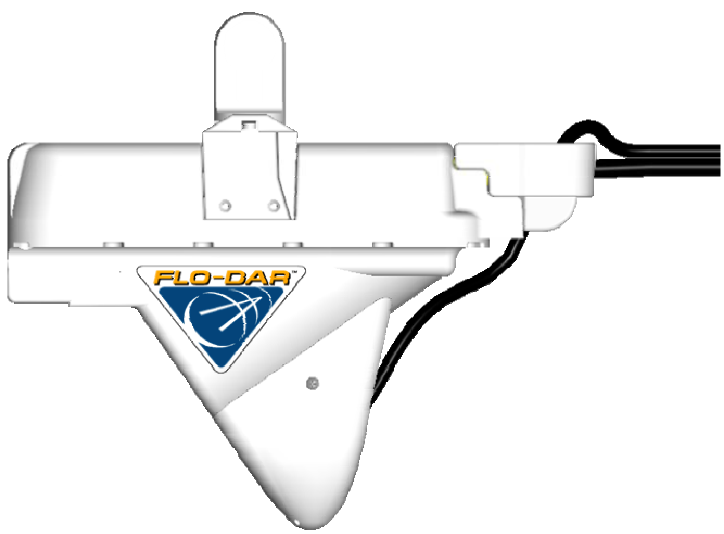
The accuracy of Flo-Dar under both open channel conditions as well as surcharge (submerged) conditions is more than adequate for the most demanding of metering applications including open channel billing applications.

Note 1. The accuracy of open channel flow meters can be affected by adverse conditions present at any metering site. The accuracy specifications of most manufacturers are generally stated under ideal conditions.

Start-Up Guide

Flo-Dar Open Channel Flowmeter
with Surcharge Velocity Sensor Option

March 2005



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Getting Started

1) Locate the following parts (See Figure 1):

1) Flo-Dar Sensor
2) Flo-Dar Logger
3) Flo-Dar Communication Cable
4) Flo-Ware Software CD
5) Sensor Mounting Frame
6) Jack-Bar Assembly
7) Extension Pipe, Tee Fitting, and Bushing
8) Clamp Set with qty. (8) ¼-20 Bolts
9) Desiccant Capsule
10) Laser-Alignment Tool
11) Installation & Operations Manual
12) Start-Up Guide (not pictured)

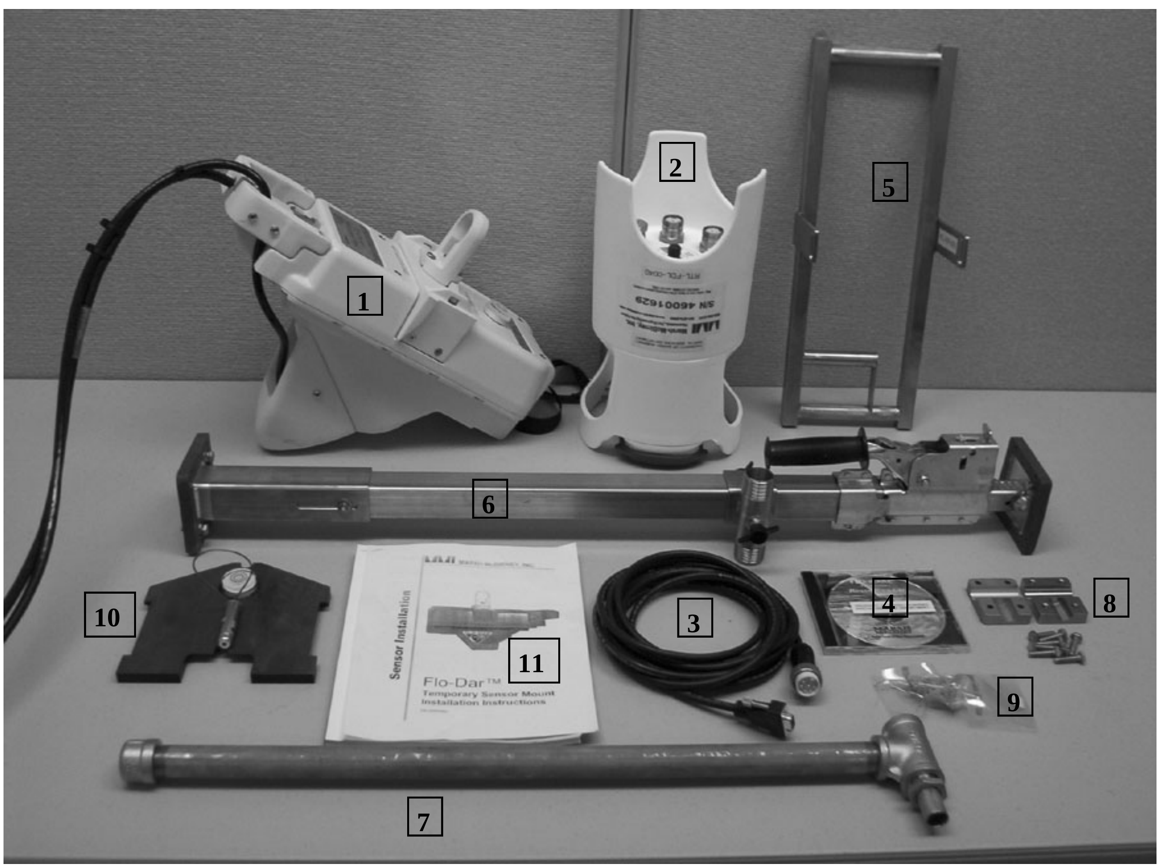


Figure 1

2) Load Flo-Ware Software onto your laptop computer.

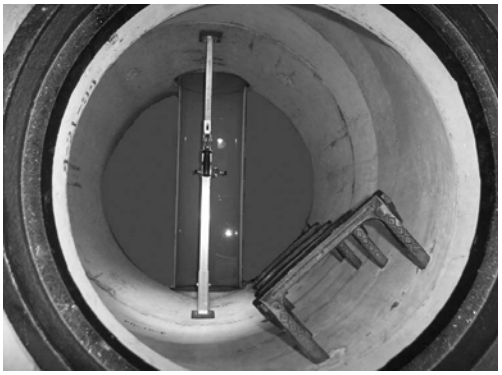
1. Insert the “Flo-Ware For Windows Resources CD” into your drive.
2. Select (single-click) “floware4.exe” from the “Software” box on your screen.
3. Select “Save” from the “File Download—Security Warning” screen.
4. Select “Save” from the “Save As” screen.
5. Select “Run” from the “Download Complete” screen.
6. Select “Run” from the “Internet Explorer—Security Warning” screen.
7. An installation wizard will initiate and load the files onto your hard drive.
8. Select the language you want to use from the “Select Language” screen.
9. Select “Next” from the “Welcome” screen.
10. Select “Next” from the “Choose Destination Location” screen.
11. Select “Next” from the “Select Components” screen.
12. Select “Next” from the “Start Installation” screen.
13. Select “Finish” from the “Installation Complete” screen.
14. Scroll down the screen and find “Flo-Dar / SVS” on the left side of the screen. Select (single-click) “flodar.exe” from that box on your screen
15. Select “Run” from the “File Download—Security Warning” screen.
16. Select “Run” from the “Internet Explorer—Security Warning” screen.
17. An installation wizard will initiate and install the files onto your hard drive.
18. Select “Finish” from the “Flo-Dar / SVS File Driver Installation” screen.

NOTE: There are ample help files on the “Flo-Ware for Windows Resources CD”

3) Set up the mounting frame and jack-bar assembly.

A) Install the jack-bar assembly in the manhole. As a general rule, the jack-bar should be approximately 20” to 24” above the crown (top) of the pipe. In order to reduce movement of the jack-bar due to the cantilever action of the sensor, the jack-bar should be located as parallel to the pipe and invert of the manhole as possible.

MOST Desirable Jack-Bar Mount



LEAST Desirable Jack-Bar Mount

NOTE: If site conditions require the jack-bar to be located oblique to the line of flow, it will still function but it will have to be checked, more carefully, for the possibility of rotating out of position when the weight of the sensor is applied to the frame.

B) Assemble the frame, clamp-set, bushing, tee, and extension as shown in figure 2. Position the frame as close as possible to the lip of the pipe by sliding the assembly along the jack-bar with the slide. Be sure to secure the set-screw.

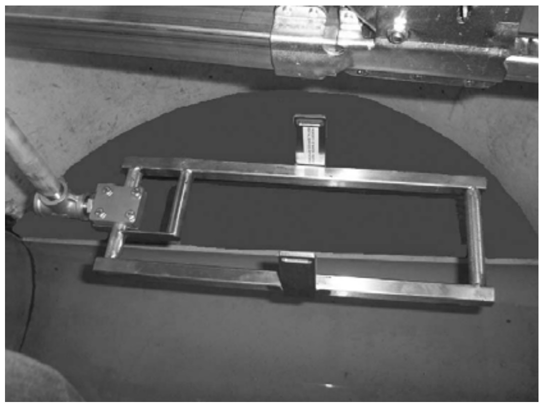


Figure 2

C) Set the elevation of the frame (measured to the top of the frame tubes) to be 6” above the inside crown of the pipe (for pipe I.D. under 25”) or 5” above the inside crown of the pipe (for pipe I.D. of 25” and greater). An easy way to set the frame elevation is to measure the distance from the bottom of the manhole invert to the top of the mounting frame tubes. (This assumes that there is no drop or hydraulic jump from the lip of the pipe to the invert) Set the dimension to equal the pipe I.D. plus 6” (for pipe I.D. under 25”) or the pipe I.D. plus 5” (for pipe I.D. of 25” or greater).

Figure 3

D) If you are not interested in measuring flow under surcharge conditions, or if you are sure the site will not surcharge, you can mount the sensor at any elevation above the surface of the water as long as the frame is within 60” of the water surface. When the sensor is mounted at higher elevations than those shown in Figure 3, it will still read normal velocity and level readings. Surcharge level will still be recorded properly, but surcharge velocity readings will not be possible. If you are mounting the sensor at higher elevations, it is still necessary to confirm the location of the velocity radar beam as described on pages 5 & 6 of this guide.

E) Align and level the frame by placing the laser alignment tool in the frame as shown in figure 4. Utilize the bubble-level on the tool to level the frame.

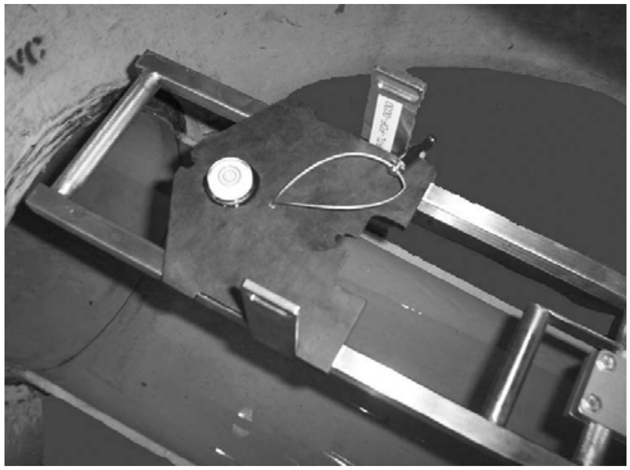


Figure 4

F) Snap the laser-pointer into the laser alignment tool as shown below in figure 5. It is a tight fit. Make sure the pointer is firmly and evenly seated in its slot as shown.

Figure 5

G) With the laser-pointer snapped into the tool, as shown, place the alignment tool back into the frame. The laser is now set up to duplicate the velocity radar beam angle. Use the laser-pointer to shine the beam onto the surface of the water. Ideally, the beam should be aligned so that it lands in the middle of the surface of the water inside the pipe.

NOTE: There are numerous adjustment points on the frame and jack-bar assembly.

H) Remove the laser-pointer from the tool and re-install it into the tool as shown below in figure 6. With the laser-pointer in the position shown, it is now set up to duplicate the ultra-sonic level transducer beam location.

I) Align the beam so that it lands in the middle of the channel you are measuring.

NOTE: You may have to check level, velocity laser alignment, and level laser alignment several times to ensure all three are correct. Adjusting one or more of the alignments will often affect one or more of the other adjustments! It is critical to remember to tighten all bolts on the jack-bar and clamp set to assure that the sensor frame does not move, once positioned correctly.

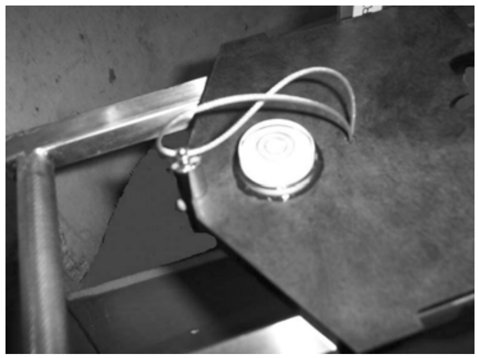


Figure 6

4) Install the Sensor.

A) Gently lower the sensor into the mounting frame and lock it in place by rotating the bail assembly (located on top of the sensor) 90 degrees. The two locking arms will extend out to engage the slots in the vertical side webs of the frame ensuring that the sensor will not dislodge from the frame, particularly if the manhole surcharges.

NOTE: Make sure the sensor is placed in the frame so that the cables are exiting the sensor on the downstream (manhole effluent) side. (see Figure 7 below)

5) Connect the Data Logger.

A) Connect the sensor cables to the data logger. Make sure the grey cable-end connects to the connector marked grey. Connect the yellow cable-end to the connector marked yellow. Tighten the threaded cable connector-ends securely to the data logger connectors.

B) Remove the desiccant capsule from the vacuum-sealed bag and plug it onto the brass A.P.R. fitting (located next to the yellow cable connector) on the data logger. See Figure 8 below.

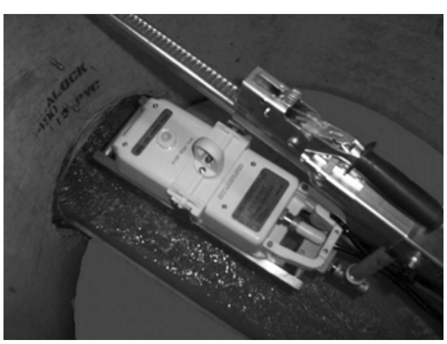


Figure 7

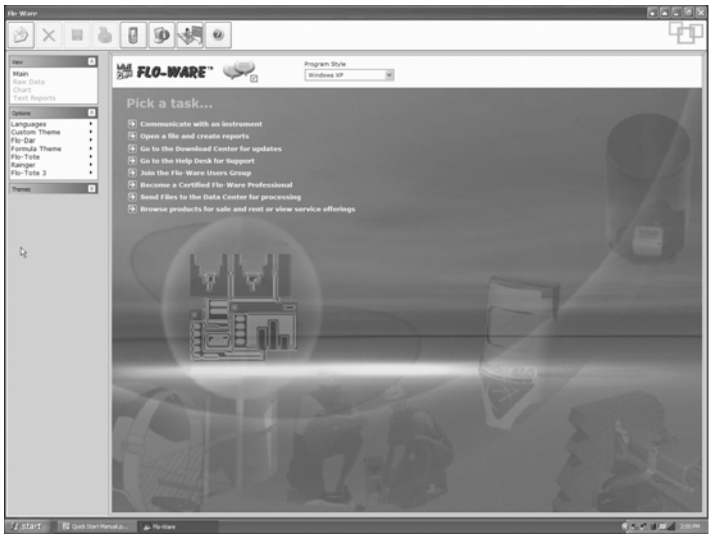
Figure 8

6) Connect your Laptop and configure the Data Logger using Flo-Ware Software.

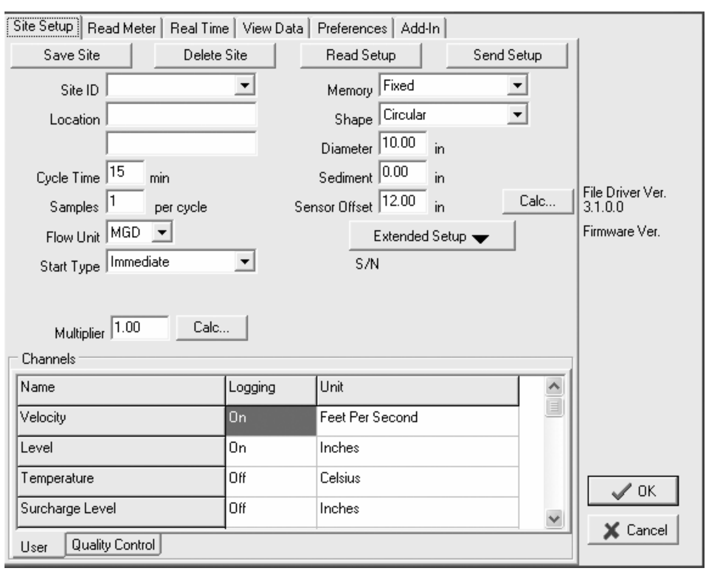
A) Connect the interface cable from the data logger to the laptop's 9-pin serial port.

NOTE: If your laptop does not have a 9-pin serial port, you will have to use a USB port with a USB-to-serial port adapter (not provided by Marsh-McBirney).

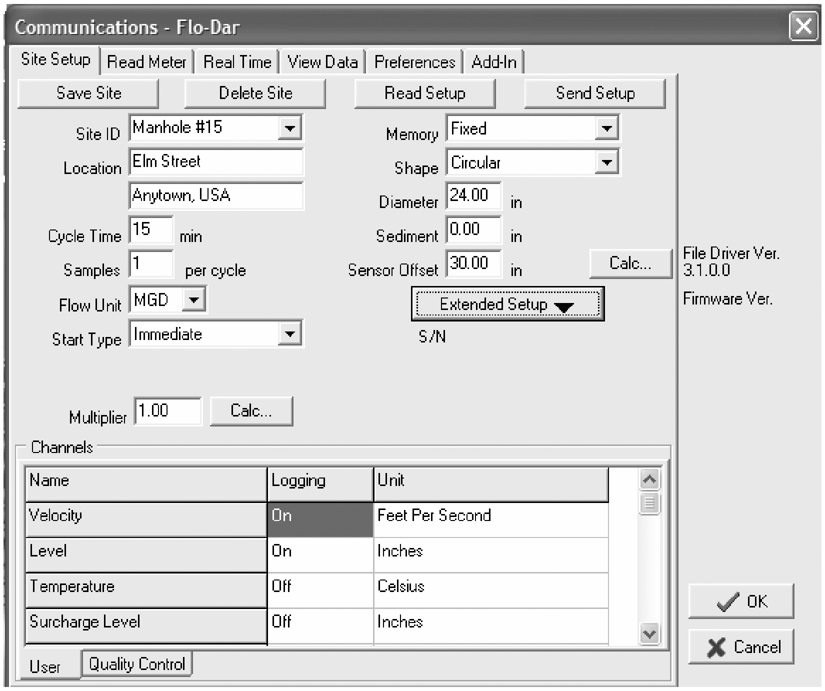
B) Double-click the "Flo-Ware" icon on your computer's desktop.
C) When Flo-Ware opens, you will see the screen shown below.



D) Place your cursor on the line that says "Communicate with an instrument" and single-click. A small pop-up window will open. Place your cursor over the "Flo-Dar" line and single-click. A second pop-up window will appear. Single-click on the word "communications". The site set-up screen will appear as shown below.

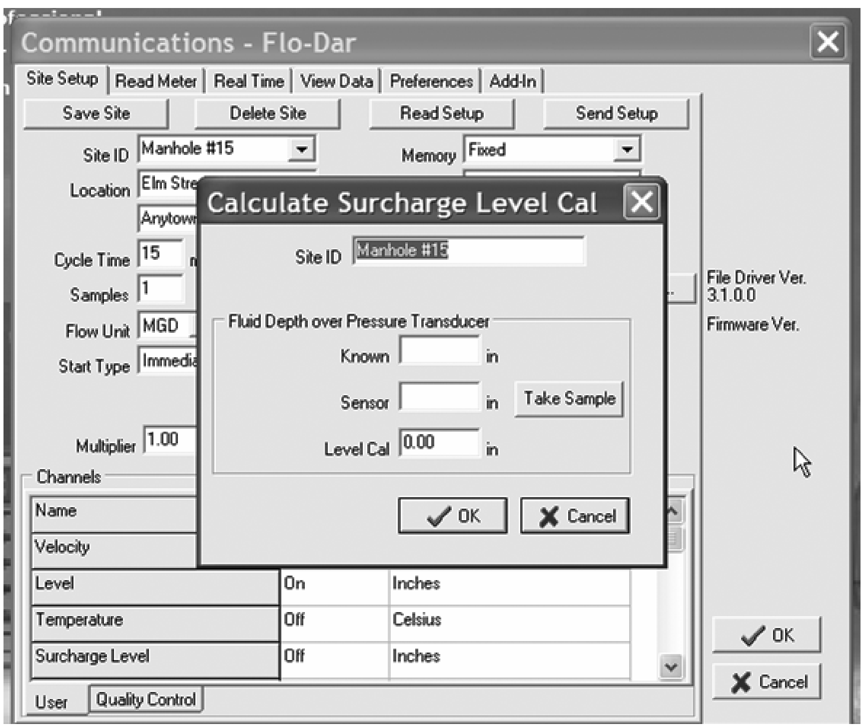


E) Proceed to enter your specific site information into the appropriate boxes in the site set-up screen. An example of a typical set-up is shown below, along with explanations-actions of the input required from the user.



- Site I.D. and Location are self-explanatory. You MUST enter something in the site I.D. box in order for the program to work.
- Cycle time is the time interval between the start of each sample.
- Number of samples is the number of 1-minute samples that the instrument will take at the beginning of each cycle.
- Flow Units can be selected by using the pull-down arrow to view the available choices.
- Start Type is either immediate or delayed. If you choose a delayed start, you can use the pull-down arrow to reveal a calendar box and time box. You can use the pull down arrow on the calendar box to view convenient calendars which allow you to click on the date you de-sire. When using a delayed start, the instrument will “sleep” until the desired start-up date and time are reached. It will then “wake up” and start sampling.
- Multiplier should be left at 1.00 for most applications in round pipes. If you have a round pipe greater than 54” in diameter, or you are using the instrument in a square/rectangular channel, or an odd-shaped channel, contact the Customer Support Department at 800-368-2723/301-874-5599 for instructions about the multiplier.
- Memory can be either “Fixed” or “Wrapped”. If you choose “Fixed”, the instrument will stop collecting data once the memory is full. In ‘Wrapped” mode, when the memory be-comes full, the instrument will continue collecting data and will over-write the first data point, then the second, etc., with new data. This will continue indefinitely until a new set-up is downloaded to the instrument.

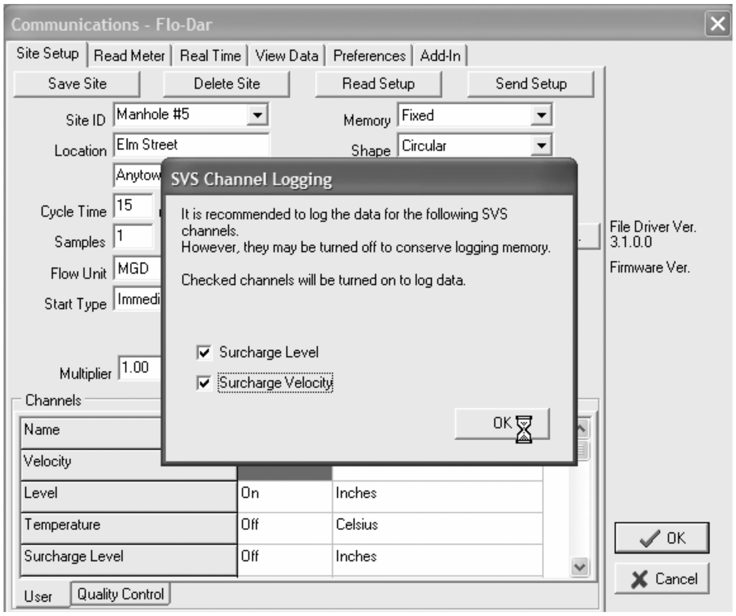
- Shape is self-explanatory. If you are measuring flow in an odd-shaped conduit, please call the factory at 1-800-368-2723 for detailed instructions.
- Diameter is the INSIDE diameter of the pipe. This dimension should be measured in the field. Often, the pipe diameter is not what one assumes from the specs on a given pipe. Always measure the inside diameter to be sure of the dimension.
- Sediment is the amount of non-flowing sediment that may be in the bottom of the pipe. The software will take sediment into account when calculating cross-sectional area for the flow calculation. If there is no sediment, leave the number at 0.00.
- Sensor offset is the dimension from the top surface of the horizontal sensor mounting frame tubing, to the bottom of the invert or cannel. (see Figure 3, page 4) If you want to measure flow in a surcharge condition, or if you want to set the instrument up to measure flow in case the manhole surcharges, then the mounting frame should be located so that the sensor offset dimension is equal to the pipe diameter plus 6 inches for pipe diameters up to 24", or equal to the pipe diameter plus 5 inches for pipe diameters greater than 24".
- Single-click on the "Extended Setup" button.
- Single-click on "Surcharge Level Cal"
- A window marked "Calculate Surcharge Level Cal will appear as shown below.



- Type 0.00 in the box marked "known".
- Single-click on the "Take Sample" box.
- Allow the unit to perform a real time sample of the surcharge pressure transducer. This will take approx. 45 seconds. The software will fill in the box marked "Sensor" and the box marked "Level Cal" with the proper values automatically.

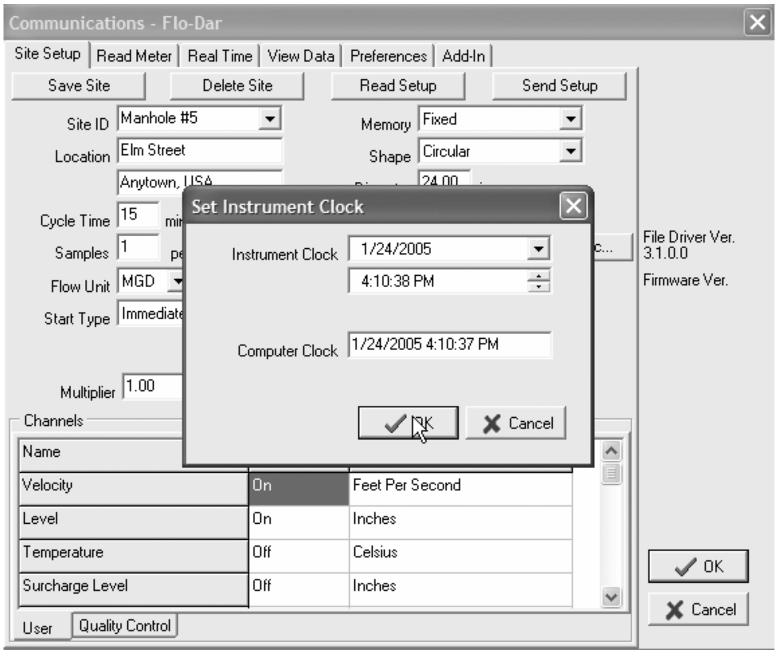
7)Save the site information to your hard drive by clicking on the "Save Site" button near the upper left-hand corner of the set-up screen.

8) Download the site information to the data logger by clicking on the "Send Setup" button near the upper right-hand corner of the site set-up screen.

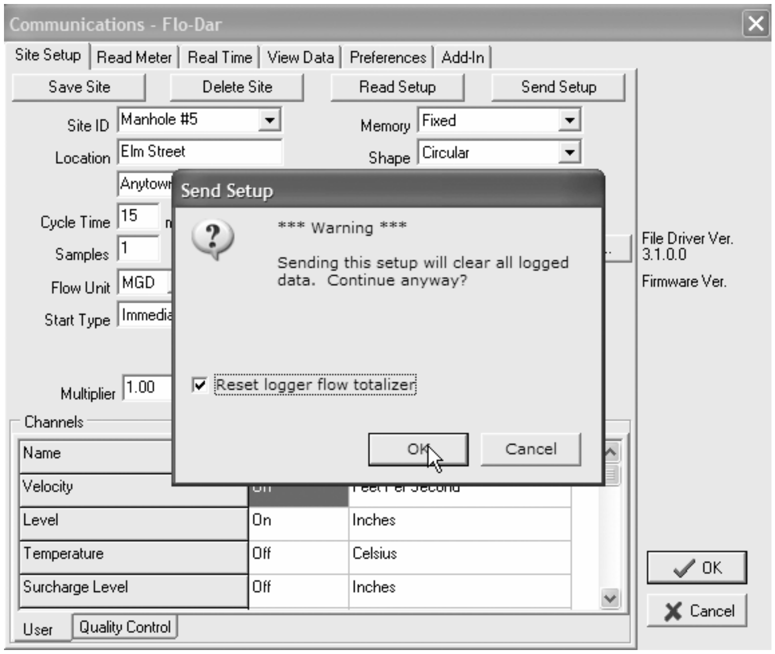


9) Turn on (check the boxes) both of the SVS channels as shown above.

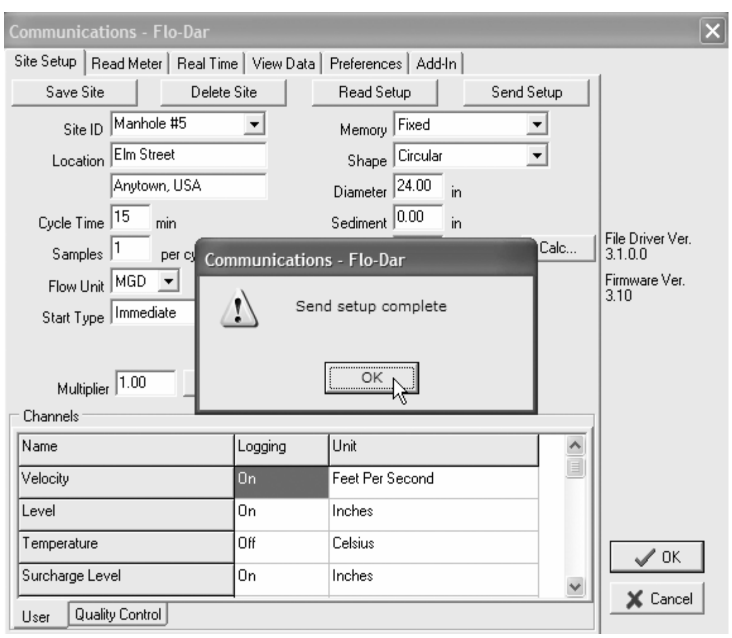
10) Adjust the instrument clock to match your laptop computer clock as shown below. Use the pull-downs next to the date and time to help you set the instrument clock time. Click OK.



11) A warning screen will appear as shown below. Select whether or not you want to reset the logger flow totalizer, then click OK.

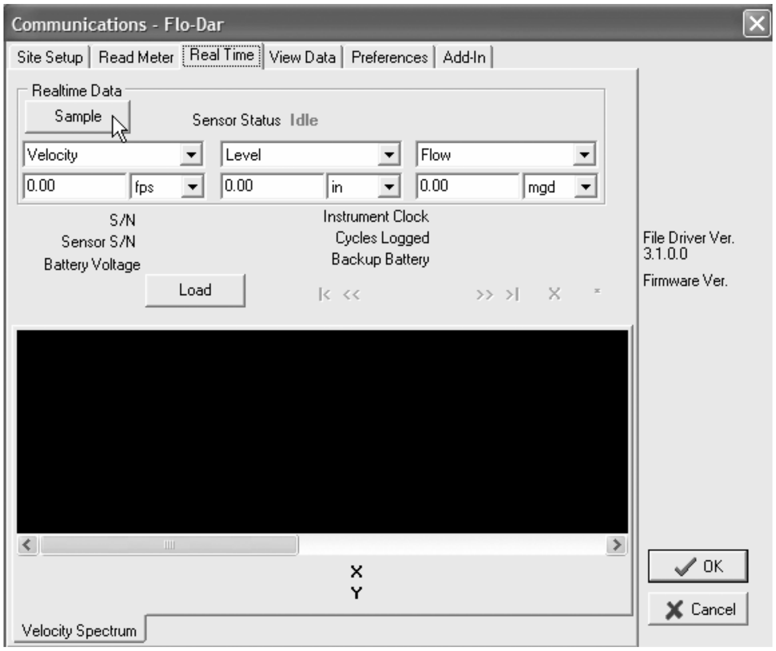


12) The "Send setup complete" screen (shown below) will appear, indicating that you have successfully sent the setup data to the instrument. The instrument will now begin collecting data.

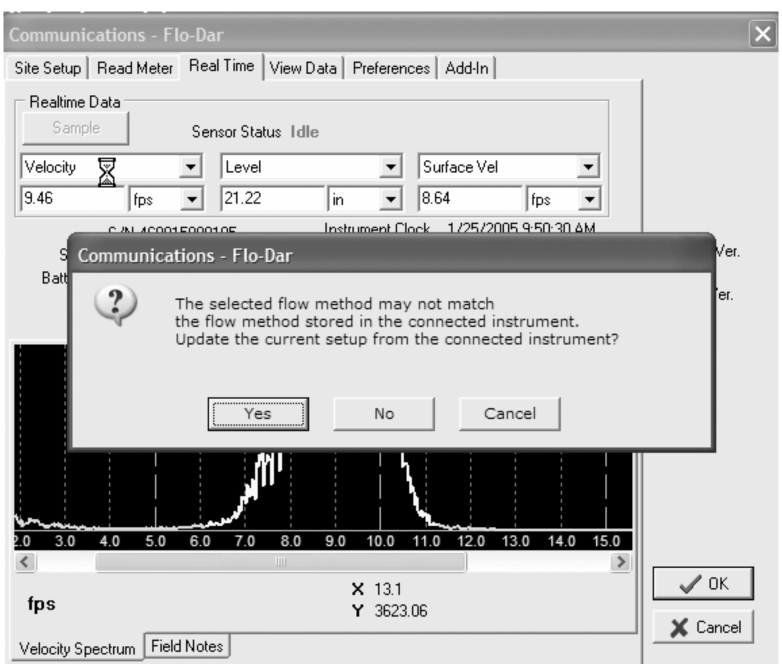


13) Collect real-time readings to confirm proper operation of the instrument before leaving the metering site.

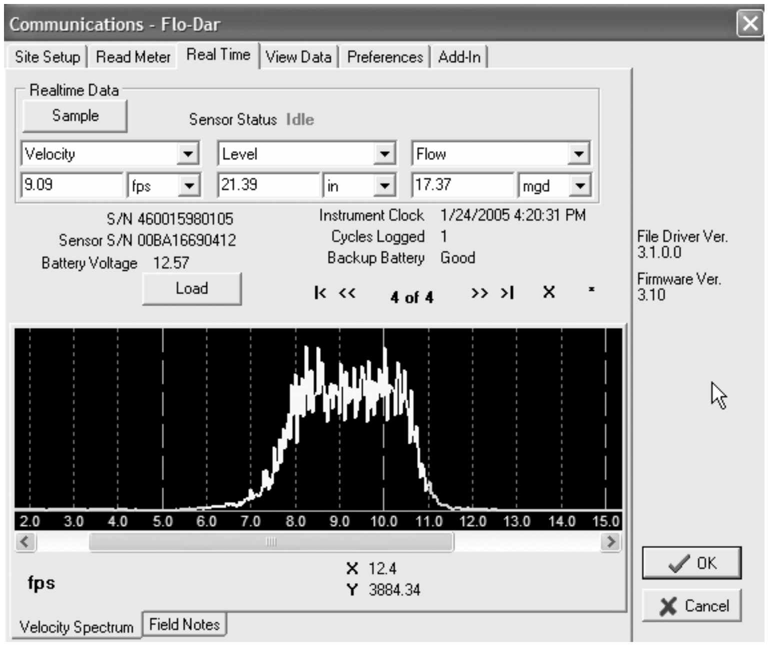
A) Single-click on the “Real Time” tab on the Communications Screen. The real time screen will appear as shown below.



B) Single-click on the “Sample” button. You may or may not see the following pop up window appear.



C) Single-click the “Sample” button. It will take about 45 to 60 seconds for the meter to sample velocity, level, and send the data packet to the data logger. It will then display the real time sample on the screen (see below).



D) Confirm the level reading on the screen matches the actual water level in the pipe. Confirm that the velocity reading on the screen matches the velocity you approximate in the pipe.

14) Close the real time window and Flo-Ware main screen.

15) Disconnect the communications cable from your laptop to the data logger.

16) Screw the protective metal cap onto the communications port connector. in order to protect the connector from damage due to water or dirt.

17) Coil the sensor cables and secure them to the top ladder rung. Hang the data logger from the top ladder rung. (See Figure 9 next page.)

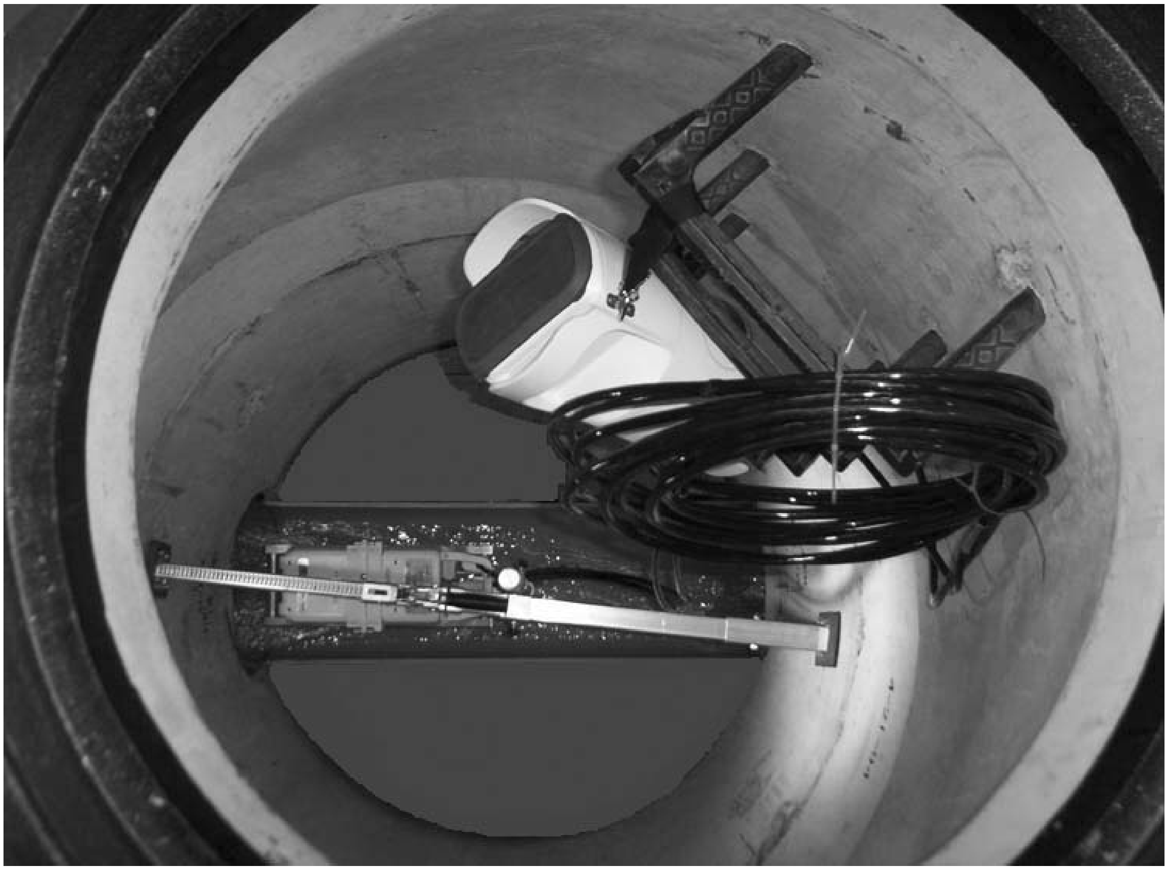


Figure 9

You have successfully installed the Flo-Dar Flowmeter. Please remember to secure the manhole lid prior to leaving the site.

If you have any questions regarding this flowmeter, please contact Marsh-McBirney. Please note that telephone support is available Monday through Friday between 9:00 AM and 5:00 PM U.S. Eastern Time.

MARSH McBIRNEY

A Higher Level of Flow Measurement

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www.marsh-mcbirney.com

Catalog Number 4975

Sigma Flow Meter Models 910 & 920

USER MANUAL

September 2005 Edition 10

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Table of Contents

Section 1 Specifications

Specifications are subject to change without notice.

Model 910

Dimensions	11.4 cm dia. x 44.8 cm L (4.5" dia. x 17.625" L)
Weight	3.54 kg (7.8 lb) with batteries
Enclosure Material	PVC
Enclosure Rating	NEMA 6P (IP67)
Operating Temperature Range	–18 to 60 °C (0 to 140 °F)
Storage Temperature Range	– 40 to 60 °C (– 40 to 140 °F)
Power Source	One Energizer EN-529, Alkaline, 6 V dc battery
Battery Life	60 days typical, with a 15-minute recording interval, one level and one velocity, one data download per week, at 10 °C (50 °F) (also affected by site conditions)
User Interface	PC
Monitoring Intervals	1, 2, 3, 5, 6, 10, 12, 15, 20, 30, 60 minutes
Program Memory	Non-volatile, programmable flash, can be updated via RS232 port
Time-Based Accuracy	± 1 second per day
Units of Measurement	**Level:** in., m, cm, ft
	Flow: gps, gpm, gph, lps, lpm, lph, mgd, afd, cfs, cfm, cfh, cfd, m^3s, m^3m, m^3h, m^3d
	Totalized Flow: gal., ft^3, acre-ft., L, m^3
Data Storage	**Capacity:** 90 days of one level reading and one velocity reading at 15-minute recording intervals
	Data Types: Level and velocity
	Storage Mode: Wrap or slate
	RAM Memory: 128K
Communications	Serial connection to IBM compatible computer with Hach analysis software
Velocity Measurement Accuracy	**Method:** Doppler ultrasonic
	Transducer Type: Twin 1 MHz piezoelectric crystals
	Typical minimum depth for velocity: 2 cm (0.8 in.)
	Range: –1.52 to 6.10 m/s (–5 to 20 fps)
	Zero Stability: 0.015 m/s (<0.05 fps)
	Accuracy: ± 2% of reading
	Operating Temperature: –18 to 60 °C (0 to 140 °F)

Model 920

Dimensions	16.8 cm dia. x 44.7 cm L (6.625" dia. x 17.625" L)
Weight	7.5 kg (16.5 lb) with batteries
Enclosure Material	PVC
Enclosure Rating	NEMA 6P (IP67)
Operating Temperature Range	–18 to 60 °C (0 to 140 °F)
Storage Temperature Range	–40 to 60 °C (–40 to 140 °F)
Power Source	Two Energizer EN-529, Alkaline, 6 V dc batteries
Battery Life	90 days typical, with a 15-minute recording interval, one level and one velocity, one data download per week, at 10 °C (50 °F) (also affected by site conditions)
User Interface	PC
Monitoring Intervals	1, 2, 3, 5, 6, 10, 12, 15, 20, 30, 60 minutes
Program Memory	Non-volatile, programmable flash, can be updated via RS232 port
Time-Based Accuracy	± 1 second per day
Units of Measurement	**Level:** in., m, cm, ft
	Flow: gps, gpm, gph, lps, lpm, lph, mgd, afd, cfs, cfm, cfh, cfd, m^3s, m^3m, m^3h, m^3d
	Totalized Flow: gal., ft^3, acre-ft., L, m^3
Data Storage	**Capacity:** 240 days of two level readings and two velocity readings at a 15-minute recording intervals
	Data Types: Level, velocity, and rainfall
	Storage Mode: Wrap or slate
	RAM Memory: 128K
Communications	Serial connection to IBM compatible computer with Hach analysis software
Modem	14400, V.32 bis,V.42, MNP2-4 error correction. V.42 bis, MNP5 data compression. MNP10EC Cellular Protocol
Local Terminal	RS232 at 19.2k baud
Velocity Measurement Accuracy	**Method:** Doppler ultrasonic
	Transducer Type: Twin 1 MHz piezoelectric crystals
	Typical minimum depth for velocity: 2 cm (0.8 in.)
	Range: –1.52 to 6.10 m/s (–5 to 20 fps)
	Zero Stability: 0.015 m/s (<0.05 fps)
	Accuracy: ± 2% of reading
	Operating Temperature: –18 to 60 °C (0 to 140 °F)

Section 2 General Information

2.1 Safety Information

Please read this entire manual before unpacking, setting up, or operating this instrument.

Pay particular attention to all danger and caution statements. Failure to do so could result in serious injury to the operator or damage to the equipment.

To ensure the protection provided by this equipment is not impaired, do not use or install this equipment in any manner other than that which is specified in this manual.

2.1.1 Use of Hazard Information

If multiple hazards exist, this manual will use the signal word (Danger, Caution, Note) corresponding to the greatest hazard.

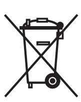
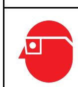
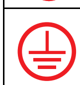
DANGER
Indicates a potentially or imminently hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION
Indicates a potentially hazardous situation that may result in minor or moderate injury.

NOTE
Information that requires special emphasis.

2.1.2 Precautionary Labels

Read all labels and tags attached to the instrument. Personal injury or damage to the instrument could occur if not observed.

	This symbol, if noted on the instrument, references the instruction manual for operation and/or safety information.
	Electrical equipment marked with this symbol may not be disposed of in European public disposal systems after 12 August of 2005. In conformity with European local and national regulations (EU Directive 2002/96/EC), European electrical equipment users must now return old or end-of life equipment to the Producer for disposal at no charge to the user. ***Note:*** *For return for recycling, please contact the equipment producer or supplier for instructions on how to return end-of-life equipment, producer-supplied electrical accessories, and all auxiliary items for proper disposal.*
	This symbol, when noted on a product enclosure or barrier, indicates that a risk of electrical shock and/or electrocution exists and indicates that only individuals qualified to work with hazardous voltages should open the enclosure or remove the barrier.
	This symbol, when noted on the product, identifies the location of a fuse or current limiting device.
	This symbol, when noted on the product, indicates the presence of devices sensitive to Electro-static Discharge and indicates that care must be taken to prevent damage to them.
	This symbol, when noted on the product, identifies a risk of chemical harm and indicates that only individuals qualified and trained to work with chemicals should handle chemicals or perform maintenance on chemical delivery systems associated with the equipment.
	This symbol, if noted on the product, indicates the need for protective eye wear.
	This symbol, when noted on the product, identifies the location of the connection for Protective Earth (ground).

2.1.3 Hazardous Locations

The 910 and 920 Flow Meters are not approved for use in hazardous locations as defined in the National Electrical Code.

DANGER
Although some Hach products are designed and certified for installation in hazardous locations as defined by the National Electrical Code, many Hach products are not suitable for use in hazardous locations. It is the responsibility of the individuals who are installing the products in hazardous locations to determine the acceptability of the product for the environment. Additionally, to ensure safety, the installation of instrumentation in hazardous locations must be per the manufacturer's control drawing specifications. Any modification to the instrumentation or the installation is not recommended and may result in life threatening injury and/or damage to facilities.

2.1.4 Confined Space Entry

The following information is provided to guide users of 950 Flow Meters on the dangers and risks associated with entry into confined spaces.

DANGER
Additional training in Pre-Entry Testing, Ventilation, Entry Procedures, Evacuation/Rescue Procedures and Safety Work Practices is necessary to ensure against the loss of life in confined spaces.

On April 15, 1993, OSHA's final ruling on CFR 1910.146, Permit Required Confined Spaces, became law. This standard directly affects more than 250,000 industrial sites in the United States and was created to protect the health and safety of workers in confined spaces.

Definition of Confined Space
A Confined Space is any location or enclosure that presents or has the immediate potential to present one or more of the following conditions:

- An atmosphere with less than 19.5% or greater than 23.5% oxygen and/or more than 10 ppm Hydrogen Sulfide (H_2S).
- An atmosphere that may be flammable or explosive due to gases, vapors, mists, dusts, or fibers.
- Toxic materials which upon contact or inhalation, could result in injury, impairment of health, or death.

Confined spaces are not designed for human occupancy. They have restricted entry and contain known or potential hazards.

Examples of confined spaces include manholes, stacks, pipes, vats, switch vaults, and other similar locations.

Standard safety procedures must always be followed prior to entry into confined spaces and/or locations where hazardous gases, vapors, mists, dusts, or fibers may be present. Before entering any confined space check with your employer for procedures related to confined space entry.

2.1.5 FCC Requirements

1. The Federal Communications Commission (FCC) has established Rules which permit this device to be directly connected to the telephone network. Standardized jacks are used for these connections. This equipment should not be used on party lines or coin lines.

2. If this device is malfunctioning, it may also be causing harm to the telephone network; this device should be disconnected until the source of the problem can be determined and until repair has been made. If this is not done, the telephone company may temporarily disconnect service.

3. The telephone company may make changes in its technical operations and procedures; if such changes affect the compatibility or use of this device, the telephone company is required to give adequate notice of the changes.

4. If the telephone company requests information on what equipment is connected to their lines, inform them of:

   a. The telephone number that this unit is connected to,

   b. The ringer equivalence number [1.4B]

   c. The USOC jack required [RJ11C], and

   d. The FCC Registration Number

Items (b) and (d) are indicated on the label. The ringer equivalence number (REN) is used to determine how many devices can be connected to your telephone line. In most areas, the sum of the RENs of all devices on any one line should not exceed five. If too many devices are attached, they may not ring properly.

2.1.6 Equipment Attachment Limitations

Notice: The Canadian Industry Canada label identifies certified equipment. This certification means that the equipment meets certain telecommunications network protective, operational and safety requirements. The Department does not guarantee the equipment will operate to the user's satisfaction.

Before installing this equipment, users should ensure that it is permissible to be connected to the facilities of the local telecommunications company. The equipment must also be installed using an acceptable method of connection. In some cases, the company's inside wiring associated with a single line individual service may be extended by means of a certified connector assembly (telephone extension cord). The customer should be aware that compliance with the above conditions may not prevent degradation of service in some situations.

Repairs to certified equipment should be made by an authorized Canadian maintenance facility designated by the supplier. Any repairs or alterations made by the user to this equipment, or equipment malfunctions, may give the telecommunications company cause to request the user to disconnect the equipment.

Users should ensure for their own protection that the electrical ground connections of the power utility, telephone lines and internal metallic water pipe system, if present, are connected together. This precaution may be particularly important in rural areas.

CAUTION
Users should not attempt to make such connections themselves, but should contact the appropriate electric inspection authority, or electrician, as appropriate.

The Load Number (LN) assigned to each terminal device denotes the percentage of the total load to be connected to a telephone loop which is used by the device, to prevent overloading. The termination on a loop may consist of any combination of devices subject only to the requirement that the total of the Load Numbers of all the devices does not exceed 100.

2.2 Items Required for Installing and Using the Flow Meter

Batteries
Use only Energizer EN-529, Alkaline, 6 V dc batteries (Cat. No. 3667).

Battery Compartment Desiccant
Use a desiccant cartridge to avoid moisture damage to the batteries and electronics. See Desiccant Maintenance on page 26 for more information.

Level and Velocity Sensors
Select the level or velocity sensors that best suit your application. For more information, see Choosing the Appropriate Meter and Sensor Combination on page 11.

Mounting Apparatus
Select the appropriate Logger and Sensor mounting apparatus from Replacement Parts and Accessories on page 38.

Programming and Data Retrieval Software
These flow meters require the use of InSight® or Vision®, a high-end, integrated sewer system management application. InSight is recommended for small- to medium-sized flow studies. For broader applications, Vision supports automated data collection with an unlimited number of sensors. See Software and Communications on page 13 for more information.

2.3 Optional Accessories for Use with the Flow Meter

Rain Gauge
Connect your flow meter to the Hach tipping bucket rain gauge to record rainfall. See Rain Gauge on page 23 for more information.

Wastewater Sampler
Connect an optional Hach wastewater sampler to the flow meter. Models 920 and 930 can set the pace for an external sampler in proportion to flow. In storm water applications, these models can trigger the sampler in response to water level or rainfall.

2.4 Planning for Success: Considerations for Installing Your Flow Meter

2.4.1 Choosing the Proper Site

The accuracy of flow measurements greatly depends on the suitability of the monitoring site. Select sites that have normalized flow and minimal turbulence. Turbulence can make it difficult to detect an average velocity in the flow stream. Obstructions, vertical drops, pipe bends, and elbows can create turbulence and affect the accuracy of your measurements. Table 1 contains suggestions for preventing turbulence.

Table 1 Suggestions for Preventing Turbulence

Site Condition	Suggested Remedy
Outfalls	Attach the sensor at least ten times the maximum expected level upstream of the outfall.
Vertical drops in the channel floor	Attach the sensor at least ten times the maximum expected level upstream of the vertical drop.
	Attach the sensor at least ten times the maximum expected level downstream of the vertical drop.
Elbows, sharp turns, and “Y” connections	Locate the sensor at least ten times the maximum expected level upstream of the impediment.
	Locate the sensor at least ten times the maximum expected level downstream of the impediment.

2.4.2 Dealing with Difficult Sites

Some sites may be difficult to monitor due to poor site conditions. The direction and the speed of the particles in the flow stream contribute to the signal received by the velocity sensor. If turbulence near the measurement point is excessive, it may be difficult for the sensor to determine the average velocity of the stream. Hach loggers provide several unique features to help deal with these problem sites. See Compensating for Velocity Direction in your sensor manual.

2.4.3 Using the Proper Batteries

Use only Energizer EN-529, Alkaline, 6 V dc batteries. These batteries are **required** to achieve the rated performance of the flow meter. Other batteries will produce unacceptable results. See Installing and Replacing the Batteries on page 19 for more information.

2.4.4 Mounting the Flow Meter with the Proper Orientation

You must mount the flow meter so that the connectors face down. The end of the meter that contains the batteries should face up. If the connectors face up, they may corrode and allow water to seep into the instrument.

2.4.5 Preventing Damage to the Flow Meter in a Harsh Environment

The connectors on your flow meter have protective caps. Cover the connectors with the protective caps when not in use to prevent corrosion.

2.5 Choosing the Appropriate Meter and Sensor Combination

Use Table 2 to determine which sensors to use.

Table 2 Flow Meter and Sensor Configuration Options

Flow Meter Model	Level and Velocity Sensor Configuration Options
910	Meter plus one Submerged Depth/Velocity Sensor or one Velocity Only Sensor
920	Meter plus two Submerged Depth/Velocity Sensors or Meter plus one Submerged Depth/Velocity Sensor and one Ultrasonic 75 kHz Sensor

2.5.1 Types of Sensors

Submerged Depth/Velocity Sensors
Submerged Depth/Velocity sensors can measure level and velocity simultaneously. A submerged pressure transducer measures level. Velocity is measured with sound waves, using the Doppler principle.

Wafer Velocity Sensor
The Wafer Velocity Sensor (Cat. No. 88005 or 88006) is an extremely low-profile velocity sensor. It does not measure level. The streamlined shape of the wafer probe allows velocity measurement in very low-flow conditions. When used in conjunction with a level sensor (such as the In-Pipe Ultrasonic Level Sensor), you can calculate flow.

In-Pipe Ultrasonic Sensor
Use the In-Pipe Ultrasonic Level Sensor (Cat. No. 3702-01 or 3702-02) in pipes where level measurement to the top of the pipe is desired. This sensor has no effective deadband and will read the level until liquid reaches the bottom of the sensor housing. The entire deadband is contained horizontally within the sensor body.

Ultrasonic Sensor (Downlook)
Downlook ultrasonic sensors are available with different beam angles,
beam spread, and deadbands. Use the 75 KHz sensor with the 920 Flow Meter.

Section 3 Software and Communications

3.1 Required Software

You can program or retrieve data from your flow meter via modem, DTU II, or direct connection to the RS232 serial port using a PC and one of the following software packages:

- InSight® Data Analysis Software is a Microsoft Windows® program for small- to medium-sized flow monitoring jobs.
- Vision® Integrated Sewer System Management Software provides high-end, automated data collection and automated batch report processing, using an unlimited number of meters. Vision is a Microsoft Windows® program.

3.2 Programming and Analysis Options

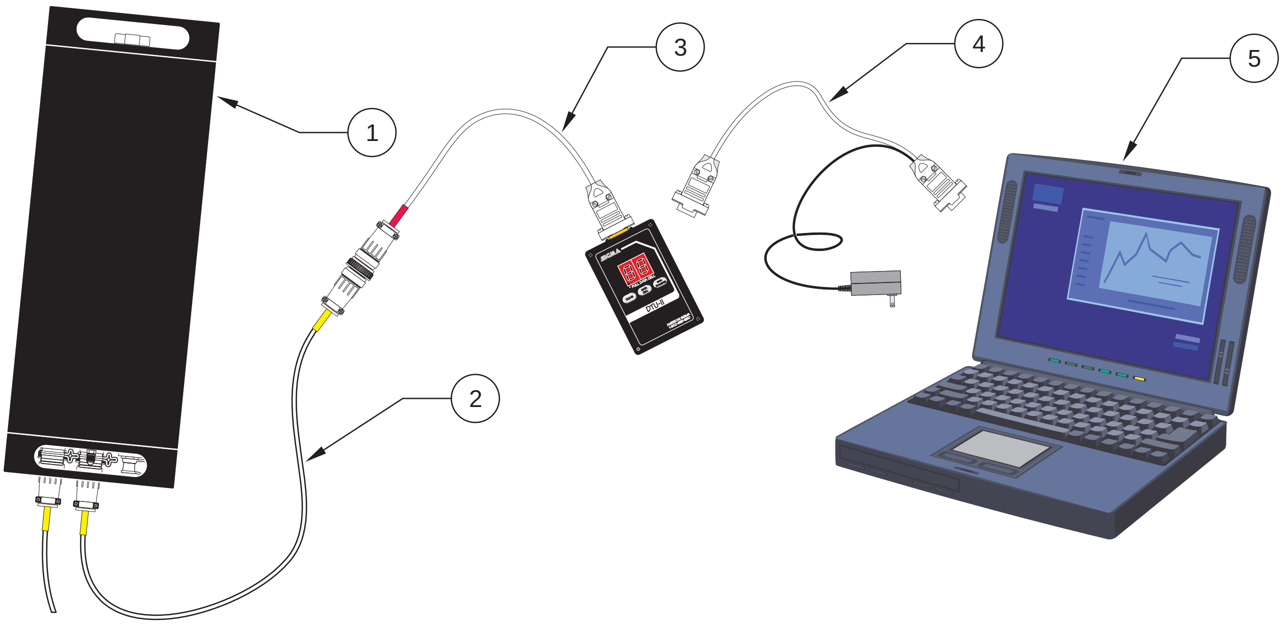
- Built-in flow equations
- Pager activation upon alarm condition
- 2-way modem and serial communications
- Storage of 116,000 data points in battery-backed RAM Memory
- Storm water sampling trigger
- Rainfall measurement
- Flow proportional sampler output
- High, low, rate of change and trouble alarms
- For details on programming your flow meter, refer to your software manual.

3.3 RS232 Serial Port (All Models)

The high speed RS232 serial port communicates with a PC or Data Transfer Unit (DTU) at speeds from 1200 to 19,200 baud as shown in Figure 1.

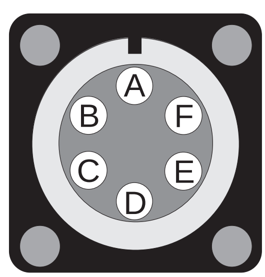
The optional extension cable (Cat. No. 3358) includes a built-in ladder hook and is designed to connect to a cable (Cat. No. 1727) near the surface for easy reach in manholes. See Figure 1.

Figure 1 Communications with the Flow Meter, DTU, and PC



1. Flow Meter	**4.** DTU II Connection Cable
2. RS232 Cable	**5.** Personal Computer
3. DTU II	

Figure 2 Serial Port Pins



Pin Letter	Description	Wire Color
A	B+ (used to power DTU)	White
B	Ground	Blue
C	DSR	Yellow
D	RCD	Black
E	DTR	Red
F	TXD	Green

3.4 Modem Communications (Model 920 Only)

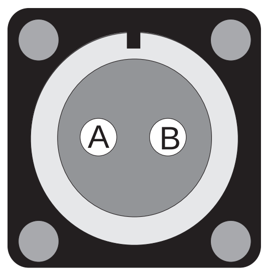
CAUTION
Use care when making modem connections as high voltage may be present on the phone wires!

The 920 Flow Meter can be configured with a 14,400 baud, cellular capable internal telephone modem (Cat. No. 4872).

These advanced, very low power modems let you communicate with Hach loggers over long distances using public telephone lines or a cellular phone.

The 920 Flow Meter modems communicate at speeds from 300 to 14,400 baud. Connect the red and green wires from the logger modem connector to the red and green wires provided by the telephone company.

Figure 3 Modem Receptacle Pins



Pin Letter	Designation	Wire Color	Description
A	Tip	Green	Ground
B	Ring	Red	Signal

3.5 Sampler Receptacle (Model 920 Only)

3.5.1 Sampler Receptacle Pin Descriptions

The optional “sampler” port lets you connect Model 920 or 930 to a Hach wastewater sampler. This option provides several features:

- Flow proportional sampling
- Stormwater trigger, based on level and/or rate of rainfall. Useful for the USEPA NPDES permitting program
- Sample history logging

Table 3Sampler Receptacle Pin Description

Pin Letter	Wire Color	Description
A	White	Not used.
B Ground	Blue	Provides the ground line that is used in conjunction with the other signals on this connector.
C Flow Pulse Output	Yellow	Used in conjunction with Pin B (ground) to tell a sampler that a pre-determined amount of flow has accumulated. Rating: +8 V dc. Output current is 100 mA dc (max.) with a duration of 500 ms.
D Sampler Start	Black	Used to “wake up” a wastewater sampler when a level and/or rainfall set-point condition is met so that it can begin sampling. Used in conjunction with Pin B (ground), this line is normally allowed to float and is switched to ground (by transistor) once the set-point conditions are met. Rating: +24 V dc (max.)
E Event Input	Red	This signal is received from a Hach wastewater sampler. It confirms that a sample has been collected. The time and date of each water sample appears on the data printout when downloaded using a Data Transfer Unit or Hach PC software. Rating: +12 V dc (max.) minimum 3 sec. pulse.
F Bottle Number Input	Green	This signal is received from a Hach wastewater sampler. It is used in conjunction with the “Event Input” signal described above. It tells the flow meter which bottle was used and when a sample was taken. This information will appear in the data printout (see “Sample Times and Dates”) when downloaded using a Data Transfer Unit or Hach Support Software. **Bottle Number signal description** If the Program Complete Output (pin F of the aux. connector) is disabled on the sampler, then it is used to transmit the bottle number to the connected device. Time A = 200 msec Time B = 100 msec (50 ms HI 50 ms LO) ***Note:*** *If a sample attempt fails, the first pulse width 'B' is 150 msec HI and 50 msec LO.* ***Note:*** *If Sample Distribution is programmed for multiple bottles per sample mode, only the first bottle number of the set is transmitted via pin-F.* **Cable Required** Multi-Purpose Half Cable Assembly (Cat. No. 941): 3 m (10') long, 6-pin connector on one end, tinned wire leads on the other end. For use with non-Hach samplers. or Multi-Purpose Full Cable Assembly (Cat. No. 940): 3 m (10') long, 6-pin connector on both ends. Custom sizes: 7.6 m lengths (25 ft.) and custom sizes are also available.

3.5.2 Logging Sample Information in the 920 Flow Meter from a Hach Sampler

1. Connect the appropriate cable (Cat. No. 940 or 540) to the “Sampler” receptacle on the flow meter and the “Auxiliary” receptacle on the sampler.

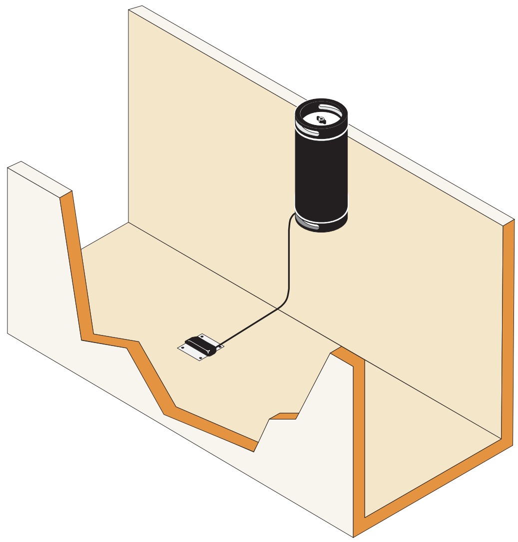
2. Program the sampler for Special Output/Sample Output. See the appropriate sampler manual for details.

Section 4 Channel Installation Options

Figures 4 through 7 show how to install the 910 and 920 for various applications.

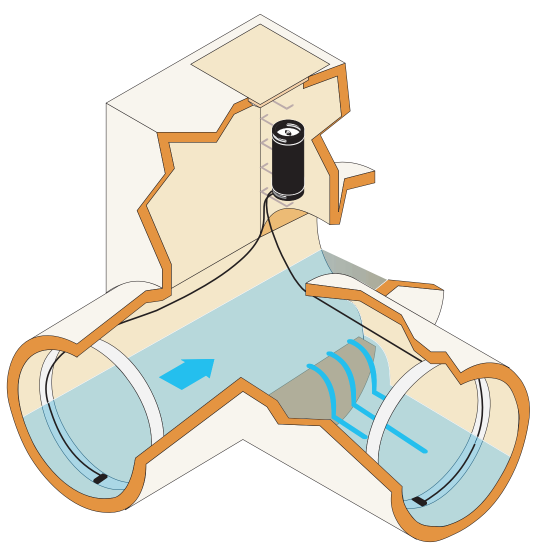
Models 910 and 920 do not require profiling to establish average velocity, allowing setup in a dry channel (Figure 4). Rapid signal processing and temperature compensation accurately record the change from dry to wet conditions.

Figure 4 Installation Setup in a Dry Channel



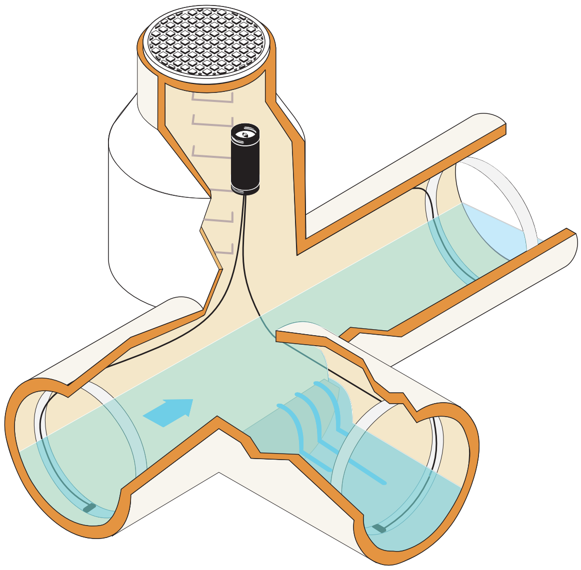
When a Combined Sewer Overflow (CSO) is conducive to accurate flow measurement, a Model 920 can measure depth and velocity in the primary channel and measure discharge in the overflow channel with ±5% accuracy. See Figure 5.

Figure 5 Installation for Combined Sewer Overflow (CSO) Applications



In some instances, the overflow in some CSO applications may be too turbulent for accurate measurement. Figure 6 shows Model 920 with two depth/velocity probes that will measure flow upstream and downstream of the outfall to determine the volume and duration of the overflow.

Figure 6 Installation for Combined Sewer Overflow (CSO) Applications with Turbulence in the Overflow



Custody transfer or interagency billing demand redundant measurement for chain of custody. In Figure 7, one Model 920 provides ultrasonic measurement of flow in a Parshall flume while also measuring flow upstream using the Continuity Equation (Q=AV). This ensures no loss of data in a submerged flow condition.

Figure 7 Installation for Custody Transfer or a Billing Arrangement

5.1 Installing and Replacing the Batteries

CAUTION
Use only alkaline batteries in this product. Other types of batteries can result in safety hazards.

Use only Energizer®* EN-529, alkaline, 6 V dc batteries. These batteries are **required** to achieve the rated performance of the flow meter. Other batteries will produce unacceptable results. Non-alkaline or non-industrial grade batteries will damage the battery compartment and may void the warranty.

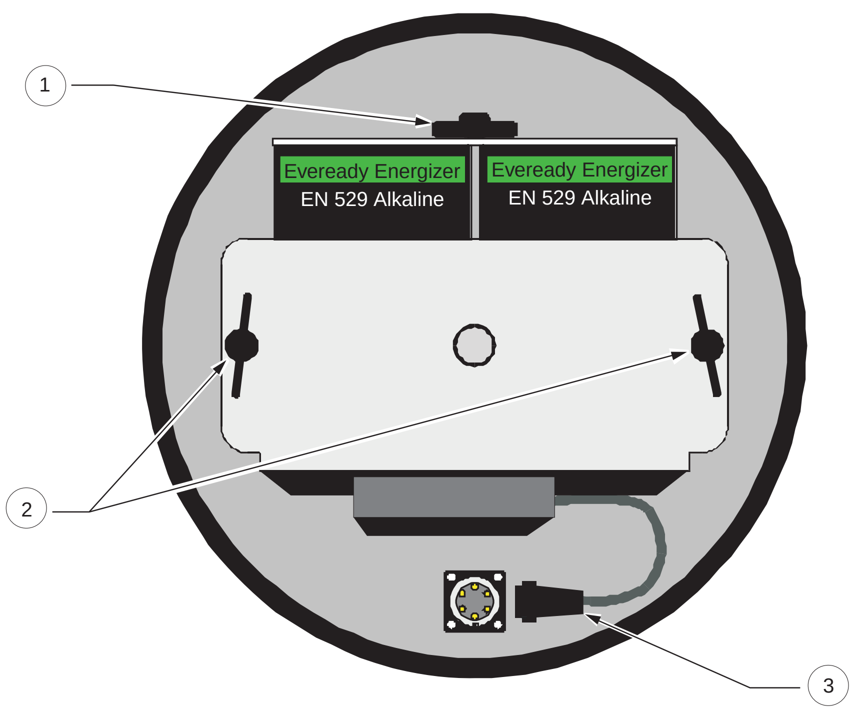
Energizer EN-529 batteries are readily available and provide sufficient power to operate the flow meter for extended periods. Use this model battery to obtain the rated operating duration and to safeguard the logger circuitry. Replacement batteries are available from Hach (Cat. No. 3667).

Note: *Do not soil or damage the two rubber O-rings on the end cap while removing or replacing the end cap. The O-rings provide a watertight seal for the battery compartment. Replace them if they are lost or damaged.*

The 910 uses one 6 V dc alkaline battery and the 920 uses two 6 V dc alkaline batteries. Install the fresh battery(s) into the battery compartment, terminal-end first. It does not matter which way the battery is rotated when it is inserted. The battery holder will accept the batteries regardless of polarity. Use two fresh batteries each time in 920. Do not mix fresh batteries with used ones.

Grasp the logger by the handle opposite of the interface connectors and twist that end counter-clockwise to open. Unscrew the end cap.

Figure 8 Battery Pack Compartment



1.	Loosen to remove batteries (after removing the battery pack).
2.	Loosen to remove the battery pack from the meter.
3.	Remove power cable.

*Energizer is a registered trademark of Eveready Battery Company, Inc.

5.1.1 Battery-Life Estimates

When using Energizer EN-529, alkaline, 6 V dc batteries, battery life is based on:

- Number of sensors installed
- Recording intervals (longer intervals increase battery life)
- Number of channels logged in memory
- Temperature (colder temperatures decrease battery life)
- Site hydraulics (second order effect caused by excessive turbulence)

The chart below provides typical expected battery life for each logger model:

Table 4 Estimated Battery Life

Model	Battery Life in Days
910	60
920	90

You can access a real-time battery voltage check via InSight® software. Select the 'Current Status' display. The chart below shows the estimated dc voltage readings when approximately 30 days of battery life remain.

Table 5 Battery Voltage when a 30-Day Battery Capacity Remains

Model	Battery Voltage (dc)
910	3.8
920	9.0

5.2 Mounting the Flow Meter

Important Note: *Before using the flow meter, insert the port/vent plug into the top hole of the unit with a $^{7}/_{16}$” wrench.*

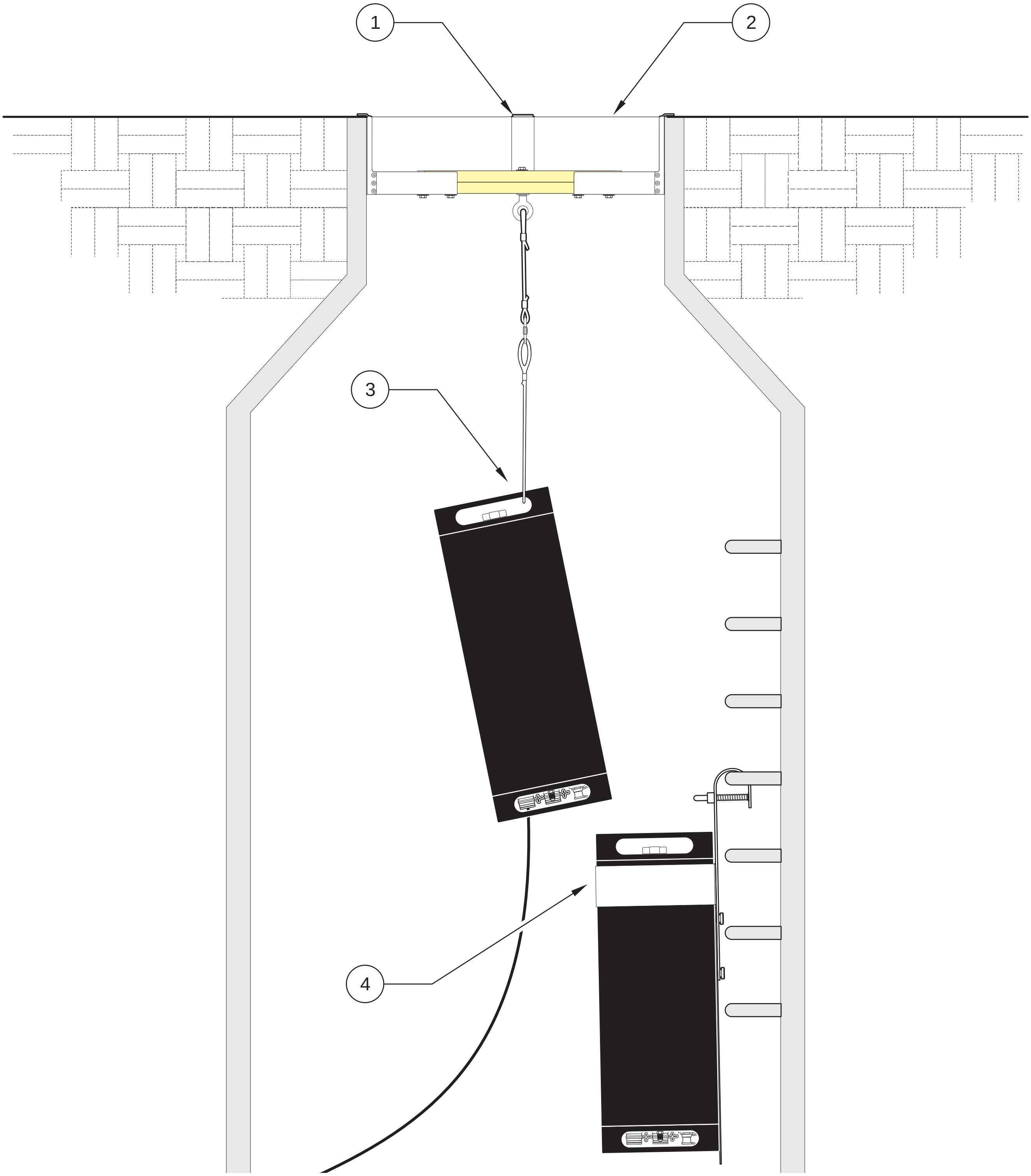
DANGER
Not for use in hazardous locations where combustible gases may be present.

When mounting the flow meter, remember to:

- **Mount the meter so that the connectors face down.** The end of the meter that contains the batteries should face up. If the connectors face up, they may corrode and allow water to seep into the instrument. See Figure 9.
- When not in use, cover the connectors with their protective caps to prevent corrosion.

Use the appropriate manhole support bracket/spanner bar. See Replacement Parts and Accessories on page 38.

Figure 9 Installation Options



1.	Instrument Support Bracket (Cat. No. 5713000)	**3.**	Suspension Harness (Cat. No. 4920)
2.	Manhole Cover	**4.**	Wall/Ladder Mount Suspension Bracket (Cat. No. 4874)

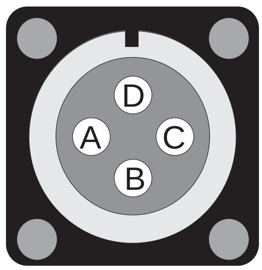
5.3 Connecting Sensors to the Flow Meter

5.3.1 Ultrasonic Level Sensor

One 75 kHz Ultrasonic Sensor can be attached to each 'U-SONIC' receptacle. Loggers that use more than one ultrasonic sensor have ultrasonic receptacles labeled 'U-SONIC A', 'U-SONIC B', etc. Each sensor may be assigned in the software as the primary sensor or as one or more secondary sensors. The primary sensor is used for all flow calculations in InSight software. Vision® software allows the use of any sensor in flow calculation.

Figure 10 describes the pins on all of the sensor receptacles.

Figure 10 Ultrasonic Sensor Receptacle Pins



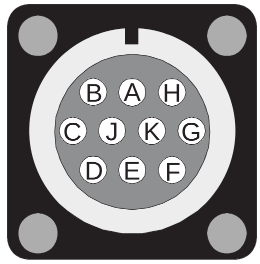
Pin Letter	Description	Wire Color
A	Temperature(+)	Red
B	Temperature (-)	Black
C	Ultrasonic (+)	Shield
D	Ultrasonic (-)	Clear

5.3.2 Level/Velocity Sensor

Velocity receptacles A, B, and C accept Submerged Area/Velocity sensors, Velocity-Only probes, or any combination of the two.

Figure 11 describes the pins on all of the velocity receptacles.

Figure 11 Velocity Receptacle Pins



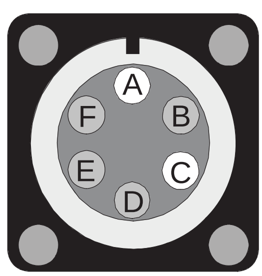
Pin Letter	Description	Wire Color
A	+12 V dc	Red
B	Ground	Green
C	Velocity receive (ground)	B/W shield
D	Velocity receive (+)	B/W center
E	Velocity transmit (ground)	Black shield
F	Velocity transmit (+)	Black center
G	Depth (-)	Black
H	Depth (+)	White
J	Not used	NA
K		

5.3.3 Rain Gauge

An optional Hach tipping bucket rain gauge may be connected to the 'RAIN GA.' connector of Model 920 flow meter. Each tip of the bucket in the rain gauge transmits a dry contact closure to the flow meter. Each dry contact closure represents 0.01" (0.0254 cm) of rainfall. A constant dc voltage is supplied on Pin C of the rain gauge receptacle. The dry contact closure in the rain gauge returns a voltage pulse into Pin A with each tip.

Figure 12 describes the pins on all of the rain gauge receptacles.

Figure 12 Rain Gauge Receptacle Pins



Pin Letter*	Description
A	Tip Signal / 0.01" (2.54 cm) of rainfall
C	Source Voltage

*. Pins B, D, E and F are not used in the rain gauge connector.

Section 6 Maintenance

DANGER
Only qualified personnel should conduct the maintenance task described in this section of the manual.

6.1 General Maintenance

6.1.1 Cleaning the Flow Meter

Clean the outside of the logger case with warm water and mild detergent. Do not use solvents or harsh cleaners to clean the logger. Do not use high pressure washing equipment to clean the case.

6.1.2 Storing the Flow Meter

Remove the 6 volt alkaline batteries from the logger when storing for long periods (more than 3 months). Store the sensors in a dry area. Make sure that all desiccant materials in the probes are kept fresh (blue) at all times.

6.1.3 Maintaining the O-Ring Gasket on the End Cap

Note: *Do not use petroleum jelly to lubricate the O-rings.*

Two O-ring gaskets are installed in each end cap of the flow meter. They maintain the water tight seal on the flow meter. Use care when the end caps are removed—do not soil, cut, or nick the gaskets. Replace them immediately if any physical damage is apparent. A light coating of O-ring lubricant is sufficient to maintain a water-tight seal. Table 6lists replacement O-ring gaskets.

Table 6Replacement O-rings

Description	Part Number
Model 910 End Cap O-ring	4912
Model 920 End Cap O-ring	4863

6.1.4 Electronics Compartment Maintenance

Important Note: *The electronics compartment is only serviceable by a qualified electronics technician familiar with static sensitive CMOS components. Permanent damage to electronic circuitry may result from improper handling. Always wear a wrist grounding strap when handling CMOS electronic components.*

To open the electronics compartment, remove the four pins that hold the electronics compartment end cap in place. The pins are located under a protective tape on the outside surface of the logger near the end cap. The end cap pulls straight off after all pins are removed.

6.1.4.1 Fuses

All internal fuses are self-resetting and require no maintenance. There are no other user-serviceable components inside the electronics compartment

6.1.4.2 Memory Batteries

An internal battery pack that contains two, 1.5 V dc alkaline “C” batteries powers RAM memory, the real time clock, and associated circuitry. The batteries also prevent the loss of programmed settings and logged data if the main power fails or is removed.

The memory batteries are located inside the electronics compartment. The two cells will provide many years of trouble-free operation. Use only alkaline replacement batteries.

You can set a low memory battery indicator using InSight® or Vision® Software. See the software manual for details.

6.2 Desiccant Maintenance

6.2.1 Reusing Desiccant

The desiccant material is a silica gel indicator. When the gel is saturated with moisture, the beads turn from blue to pink. To rejuvenate the beads for reuse, remove them from the assembly. Heat the beads in an oven at 100 to 180 °C (212 to 350 °F) until the beads turn blue again. Discard and replace the beads if they do not turn blue after heating.

6.2.2 Replacing the Sensor Desiccant

Note: *Before calibrating or installing the Submerged Sensor it is absolutely essential that the red plastic protective cap be removed from the atmospheric reference port of the desiccant cartridge.*

The air dryer assembly is an integral part of the velocity probe cable. A small diameter tube is contained within the sensor cable to supply a reference port from the logger to the transducer in the sensor. The reference air passes through the in-line desiccant where all moisture is removed.

To remove or replace the sensor desiccant:

1. Remove the fill plug from the assembly.
2. Remove the pink desiccant beads and allow the assembly to air dry.
3. Fill the assembly with fresh (blue) desiccant.
4. Replace the fill plug.

6.2.3 Replacing the Battery and Electronics Compartment Desiccant

A small desiccant cartridge in the battery compartment prevents moisture damage to the batteries and power circuitry. The electronics compartment desiccant cartridges should be changed whenever you service the electronics (see section 6.1.4 on page 25) to assure a moisture free environment inside the enclosure. Table 7contains replacement part numbers.

If the normally blue desiccant beads turn pink, replace the cartridge or remove the cartridge end cap and recharge or replace the desiccant material. See Reusing Desiccant on page 26.

A small clip holds the desiccant cartridge in place. Pull the cartridge straight out of the clip to remove it.

Table 7Replacement Desiccant

Description	Part Number
Model 910 Battery Compartment Desiccant Cartridge	4933
Model 920 Battery Compartment Desiccant Cartridge	4933
Bulk Desiccant Refill (1.5 lb)	3624

6.3 Sensor Calibration

6.3.1 Velocity Sensor Calibration

The velocity sensor does not require calibration. The transmit frequency is fixed by a highly accurate quartz crystal-controlled frequency generator.

6.3.2 Zeroing the Sensor

The sensor has been factory-calibrated and compensated for temperature. The sensor needs to be zeroed during each installation, but does not require calibration. The sensor should be zeroed when moving it from one flow meter or sample to another.

To zero the sensor:

1. Install InSight version 5.7 or greater and start the program.
2. From the InSight software menu, select Remote Programming.
3. From the Real Time Operations list, select the level sensor to be calibrated.
4. Remove the probe from the liquid and place the sensor flat on the tabletop or floor with the sensor (the plate with the holes) facing down onto the surface.
5. Press **OK** on the dialog box when complete.

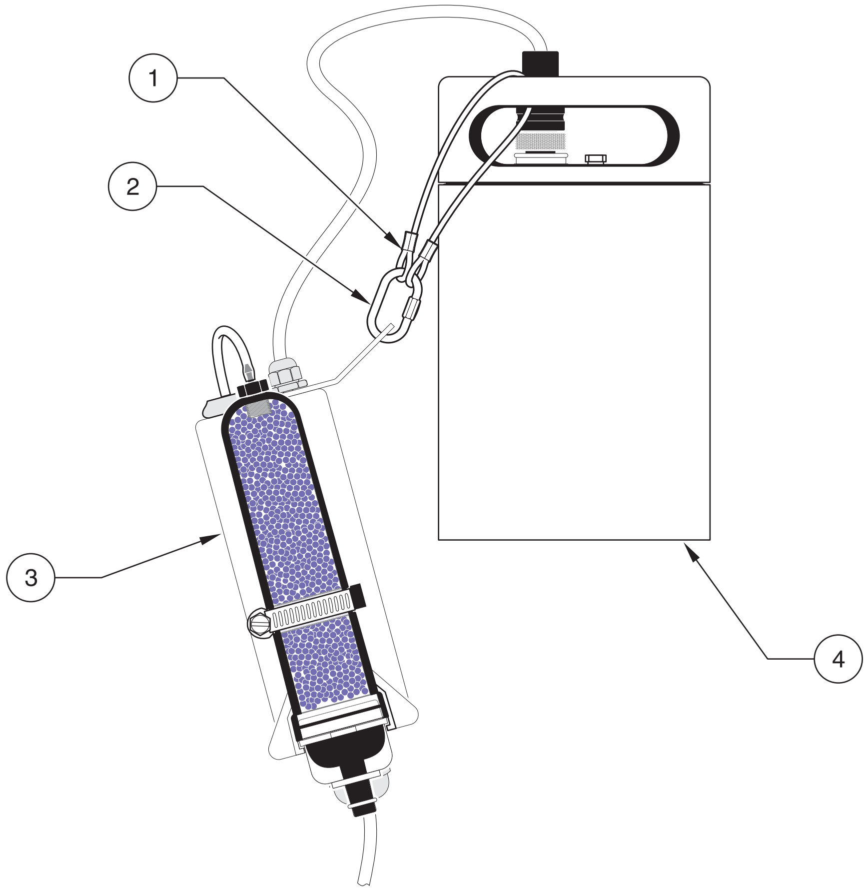
6.3.3 Important Guidelines for Sensor Installation

- Do not install more than one sensor at a time in pipes less than 61 cm (24 inches). Multiple sensors in smaller pipes can create turbulent or accelerated flows near the sensors that may cause inaccurate measurements.
- Mount the sensor as close as possible to the bottom of the pipe invert to most accurately measure low velocity levels.
- Do not monitor flows in the invert of the manhole itself. The best sensor location is 3 to 5 times the sewer diameter/height upstream of the invert.
- Locate monitoring sites as far from inflow junctions as possible to avoid interference caused by combined flows.
- Avoid sites that contain flow obstacles within 2 to 4 pipe diameters in front of the sensor installation (rocks, stones, pipe joints, valve stems, etc.) as these will contribute to turbulence and generate high speed flows in the immediate vicinity of the obstruction.
- Avoid any sites with slow moving flows that will encourage the buildup of silt in the invert or channel. Excessive silting around the sensor may inhibit the Doppler signal and decrease sensor accuracy, and may affect depth measurement accuracy.
- Avoid sites with deep, rapid flows that will make it physically difficult or dangerous to install the sensor.
- Avoid sites with high velocity, low-depth flows. Splash-over and excessive turbulence will be present around the sensor and data may be inaccurate.

6.3.3.1 Proper Strain Relief of Sensor Cable

Attach the desiccant hub to the instrument handle to provide a strain relief for the sensor cable and connector (Figure 13).

Figure 13 Proper Strain Relief



1. Lanyard	**3.** Desiccant Hub
2. Carabineer	**4.** Flow Meter

6.3.4 Connecting the Sensor to the Mounting Bands

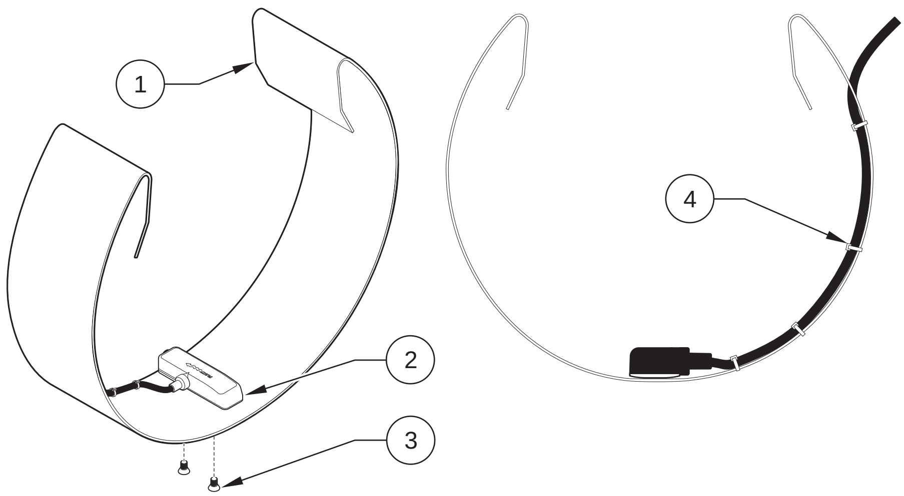
Important Note: *If using an oil-filled sensor, replenish the oil prior to mounting the sensor to a mounting band. Refer to section 4.1.2 on page 19 for oil replenishment instructions, if applicable.*

1. Attach the sensor to the spring ring. Mounting bands come with pre-drilled holes for direct mounting of the sensor to the band.

2. To reduce the likelihood of debris collecting on the cable and mounting band, route the cable along the edge of the band and fasten the cable to the mounting band with nylon wire ties (Figure 14). The cable should exit the tied area at, or near, the top of the pipe to keep it out of the flow stream.

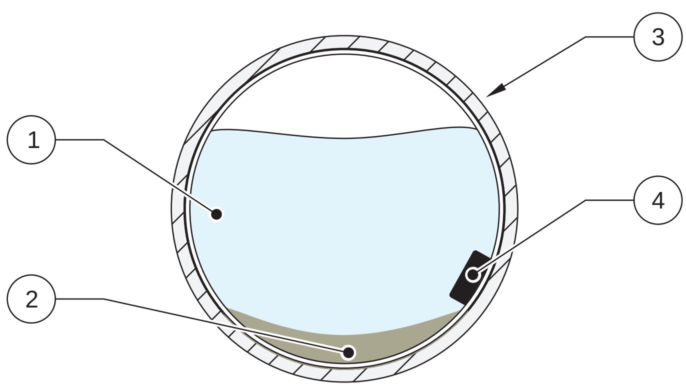
Note: *If there is a large amount of silt in the bottom of the pipe, rotate the band until the sensor is out of the silt (Figure 15), assuring that the sensor remains below the minimum expected water level at all times. Silt should not be disturbed and must be measured frequently.*

Figure 14 Attaching the Sensor to the Mounting Band



1. Spring Ring	**3.** Screws (2)
2. Sensor	**4.** Nylon Wire Ties

Figure 15 Avoiding Silt when Mounting the Sensor



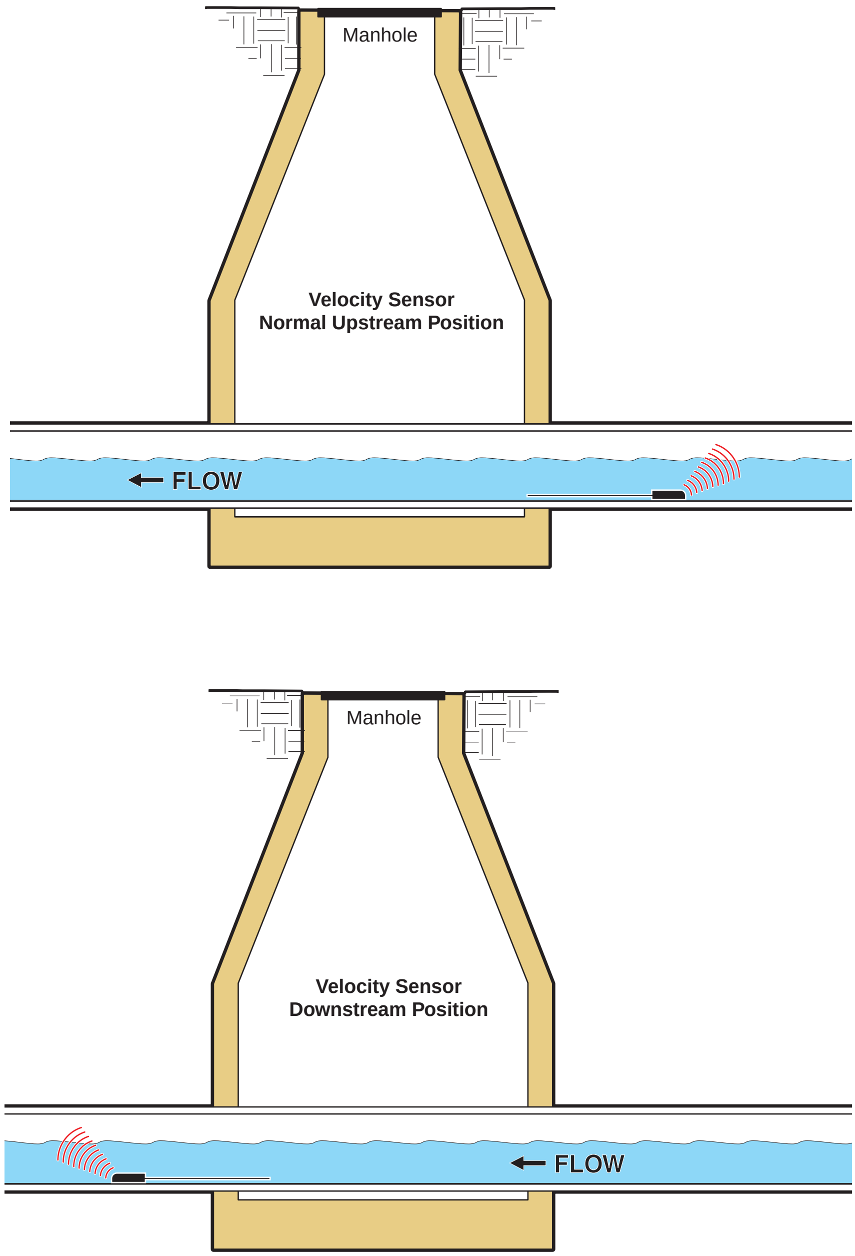
1. Water	**2.** Silt	**3.** Pipe	**4.** Sensor

6.3.5 Placing the Sensor and Mounting Band into the Pipe

Point the angle-face of the sensor into the flow. The manufacturer recommends placing the sensor with the arrow pointing with the flow (Figure 16). For other mounting configurations, see the appropriate flow meter manual.

Slide the mounting band as far into the pipe as possible to eliminate drawdown effects near the end of the pipe. Locate the sensor at the bottom-most point in the channel. If excessive silt is present on the bottom of the pipe, rotate the band in the pipe until the sensor is out of the silt.

Figure 16 Placing the Sensor into the Flow



6.3.6 Compensating for Velocity Direction

When programming the sensor the following may be selected:

Option*	Description
Upstream (recommended for most applications)	Use this option at sites with fairly consistent velocities, and low to medium turbulence. The flow stream over the sensor should be relatively straight, with no drops or turns near the measurement point.
	Mount the sensor in the pipe, beveled edge facing into the flow, where the flow stream enters the measurement area (Figure 16).

Option*	Description
Downstream	Use this option when the sensor is installed downstream of the measurement point (where the flow stream exits the site). This option is useful when more than one flow stream enters a site and the combined flow of all streams at a single exit point is measured.
	Mount the sensor in the downstream direction rather than the typical, upstream direction. Mounting the sensor 'backwards' in this manner (Figure 16) causes the velocity direction readings to be the opposite of actual stream flow. By selecting the Downstream choice when programming, the logger reverses the measured signal to show actual flow direction (beveled edge downstream). The maximum velocity obtained in this type of installation is 5 fps.

*. Additional options may be available depending on the flow meter or sampler used. Refer to the appropriate flow meter or sampler manual for more information.

6.3.7 Performing a Level Adjustment

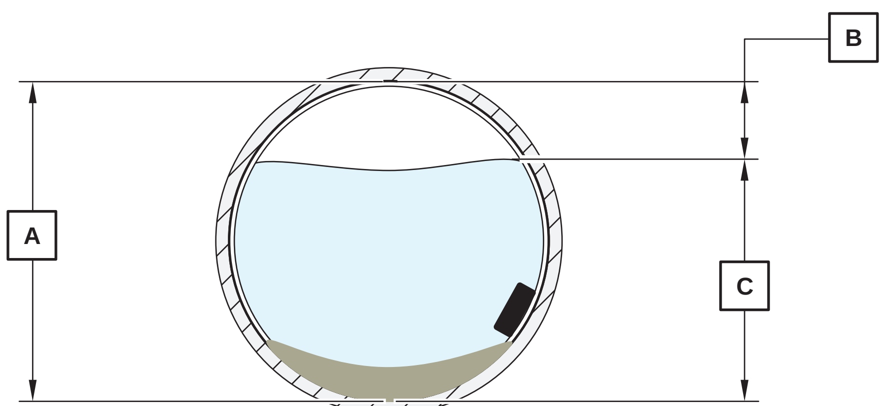
The manufacturer recommends doing a level adjustment whenever a sensor is first installed into a flow stream. This adjustment accounts for the various physical tolerance stack-ups in the system (i.e., thickness of the mounting band, angular placement of the sensor relative to the “6 O’ clock” position in the pipe, etc.)

1. With the sensor installed in the flow, use a PC or display (950 and 980 flowmeter) to monitor Current Status.

2. Take a physical measurement of the water depth by measuring the distance from the top of the pipe to the surface of the water (item B, Figure 17), and subtracting this number from the pipe diameter (item A, Figure 17). The resulting number is the water depth (item C, Figure 17).

3. Enter the physically-measured water depth into the software using the Adjust Level function.

Figure 17 Measuring the Water Level



6.4 Sensor Maintenance

6.4.1 Cleaning the Sensor (Oil-filled and Standard)

Clean the transducer port when:

- Unexpected increase or decrease in flow or level trend occurs
- Level data are missing or incorrect but velocity data are valid.
- Excessive silt has deposited between the transducer and its protective cover.

6.4.1.1 Cleaning the Sensor (Oil-filled and Non-oil)

Important Note: *Do NOT interchange an oil-filled protective cover plate with a non-oil cover plate. This will adversely affect level readings. It is possible to convert one type of sensor to the other using the Oil Probe Conversion Kit (Cat. No. 7730000), refer to the Oil Probe Conversion Kit Instruction Sheet, Cat. No. 7730089 for more information.*

Important Note: *When cleaning the transducer, use the most gentle technique possible. Do not use sharp or pointed objects to remove sediment from the face of the transducer. If you nick or dent the transducer, it will break!*

1. Soak the sensor in soapy water

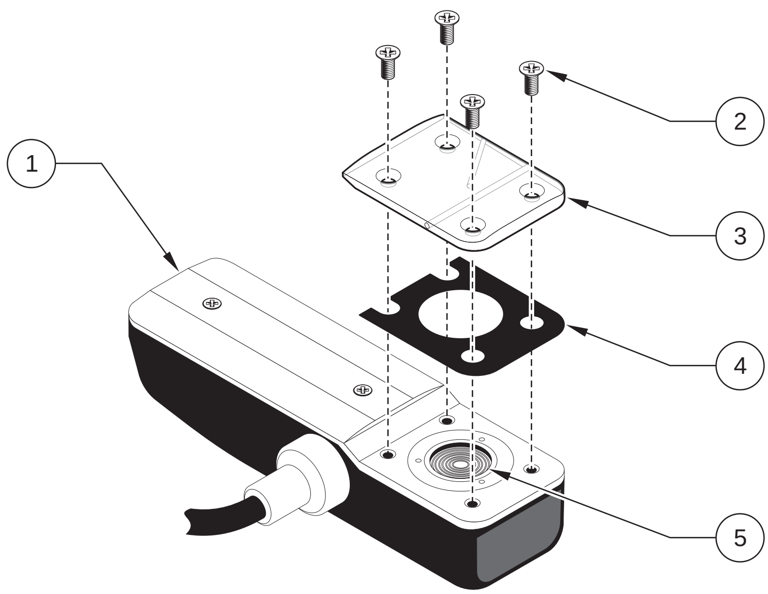
Note: *Do not soak the sensor in bleach. Bleach will permanently damage the sensor. Refer to Table 8 for acceptable cleaning solutions.*

Table 8 Cleaning Solutions

Acceptable	Unacceptable
Dish Detergent and Water	Concentrated Bleach
Window Cleaner	Kerosene
Isopropyl Alcohol	Gasoline
Dilute Acids	Aromatic Hydrocarbons

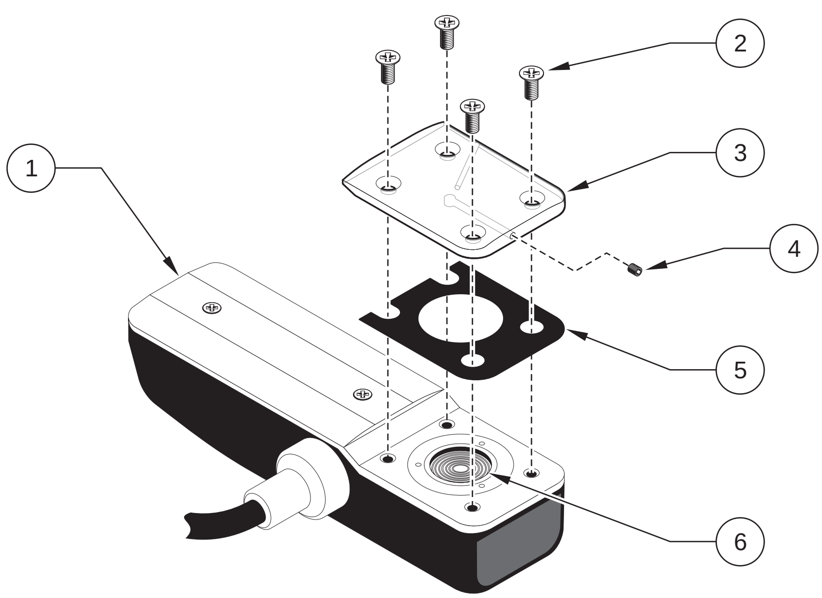
2. Remove the screws from the protective cover (Figure 18).
3. Remove the cover and gasket.
4. Carefully swirl the sensor in an appropriate cleaning solution to remove soil. Use a spray or squeeze bottle to wash away heavier deposits.
5. Clean the gasket and cover. Replace the gasket (Cat. No. 7722000) if it is torn or damaged. Level readings will be adversely affected if the gasket is damaged or not installed.
6. Reattach the gasket and cover (note orientation in Figure 18). Tighten the screws until the gasket starts to compress.
7. If using an oil-filled sensor, continue to Oil Replenishment (Oil Kit Cat. No. 7724800) on page 34.

Figure 18 Removing the Protective Cover (Non-Oil Sensor)



1. Sensor	**4.** Gasket
2. Screws (#6–32 x 5/16)	**5.** Pressure Transducer
3. Protective Cover	

Figure 19 Removing the Protective Cover (Oil-filled Sensor)



1. Sensor	**4.** Screw, set, #2-56
2. Screws (#6–32 x 5/16)	**5.** Gasket
3. Protective Cover	**6.** Pressure Transducer

6.4.2 Oil Replenishment (Oil Kit Cat. No. 7724800)

The manufacturer recommends inspecting the oil in the sensor for large air bubbles during the customer-scheduled service duty cycle, and prior to every installation. Small bubbles (less than ¼-in. diameter) of air within the oil do not affect performance. Larger bubbles may minimize the anti-fouling benefit of the oil.

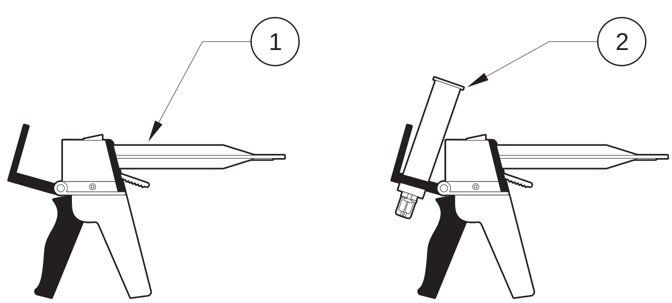
To replenish sensor oil:

1. If the sensor is new, remove the yellow tape on the sensor.
2. Remove any debris from the sensor.
3. Load the oil cartridge into the dispensing gun (Figure 20).
4. Twist the feed tube onto the cartridge and attach the syringe tip to the feed tube (Figure 21).
5. Press the dispenser gun handle to purge any air bubbles from the syringe tip.
6. Remove the set screw in the transducer cover with the supplied 0.035 hex wrench. Retain the set screw.
7. Slowly insert the syringe tip into the set screw hole and dispense the oil (Figure 22). While dispensing the oil, hold the probe at an angle to allow the air to be pushed out the side port (Figure 22). Continue to dispense the oil until all the air bubbles are removed.

***Note:** Slowly insert the syringe tip and do not dispense oil during insertion or damage to the transducer may occur if too much pressure is applied.*

8. Continue to dispense the oil while removing the syringe from the set screw hole to prevent air bubbles. Replace the set screw until it is flush with the transducer cover and remove any excess oil around the screw hole or on the sensor.
9. Clean the entire probe and place a piece of electrical tape over the side port to prevent oil from leaking out. Remove the tape from the sensor prior to zeroing and installing the sensor.

Figure 20 Loading the Cartridge into the Dispensing Gun



1. Dispensing Gun	**2.** Silicone Oil Cartridge

Figure 21 Attaching the Feed Tube and Syringe

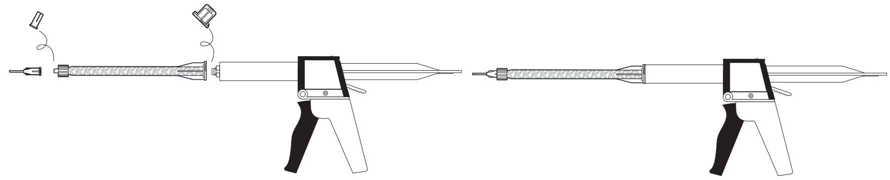
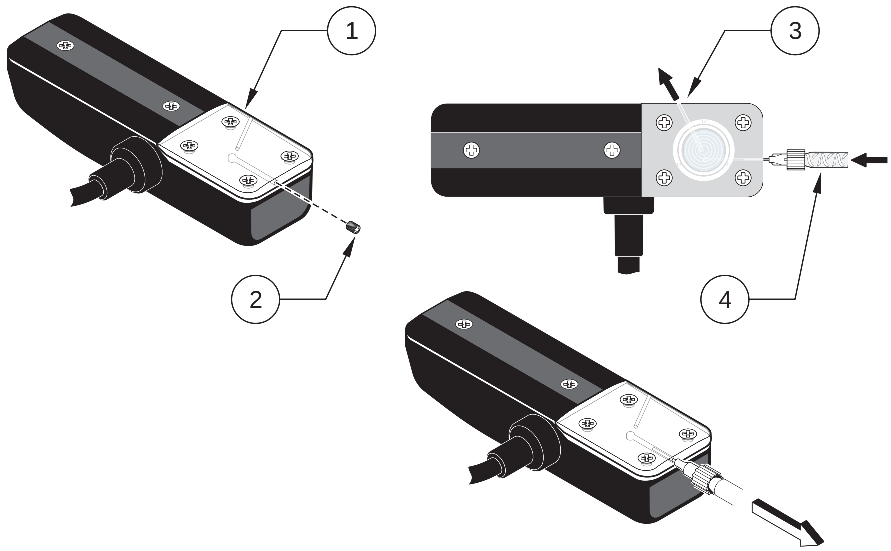


Figure 22 Oil Replenishment



1. Sensor	**3.** Side port
2. Set screw	**4.** Syringe

6.4.3 Changing the Sensor Desiccant

The desiccant canister contains beads of silica gel which ensure proper orientation of the pressure transducer. When the beads are blue, they can remove moisture from the air. When they are pink, they are saturated and cannot absorb any more moisture from the air, and they must be replaced immediately.

Important Note: *When the beads begin to turn pink, replace or rejuvenate the beads. Permanent damage to the sensor may occur if the desiccant is not maintained. Never operate the sensor without the proper desiccant. When rejuvenating beads, remove them from the canister and heat at 100–180 °C (212–350 °F) until the beads turn blue. If the beads do not turn blue, replace them with new beads. Do not heat the canister.*

6.4.3.1 Desiccant Replacement Procedure

Note: *Replacing the desiccant does not require that the desiccant container be removed from the desiccant box.*

1. Use a slight twisting motion to twist the bottom end-cap until its slots align with the retaining clips (Figure 23).
2. Gently remove the end cap by grasping it and pulling it straight out.
3. Pour the desiccant beads out of the canister.
4. Hold the canister up to the light and inspect the hydrophobic filter.

- If you see a small, dim light spot while looking through the hole, the filter is in good condition. If you see a bright light spot, the filter is probably torn. Replace the filter.
- If the desiccant beads were completely saturated with water or the filter has saturated with water or grease, replace the filter.

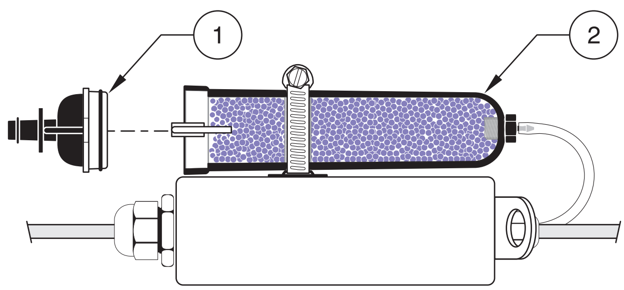
5. Refill the canister tube with blue desiccant beads (Cat. No. 3624). Inspect the O-ring (Cat. No. 5252) on the bottom cap for cracking, pits, or evidence of leakage. Replace if necessary.

Note: *Applying O-ring grease to new or dry O-rings improves the ease of insertion, sealing, and life span of the O-ring.*

6. Make sure that the O-ring is clean and free of dirt or debris before replacing the end cap.

7. Reinstall the end cap.

Figure 23 Removing the Bottom End Cap



1. End Cap	**2.** Desiccant Container

6.4.4 Hydrophobic Filter Description

A single Teflon® hydrophobic filter (Cat. No. 3390) is installed in the top of the canister to prevent liquid from entering the vent tube.

For best performance and to avoid grease buildup on the filter during submergence or surcharge conditions, hang the canister vertically so that the end facing the sensor points downward.

Note: *The Hydrophobic Filter may need replacement at any time the cartridge is submerged or exposed to excess moisture. Refer to section 6.4.5.*

6.4.5 Hydrophobic Filter Replacement Procedure

1. Disconnect the tubing from the top of the desiccant canister.

2. Unscrew the hex-head tubing nipple from the top of the canister and discard the old filter.

3. Discard any remnants of Teflon tape from the nipple's threads. Reapply two turns of Teflon tape (Cat. No. 10851-45) to the threads, pulling the tape into the threads until it conforms to the shape of the threads.

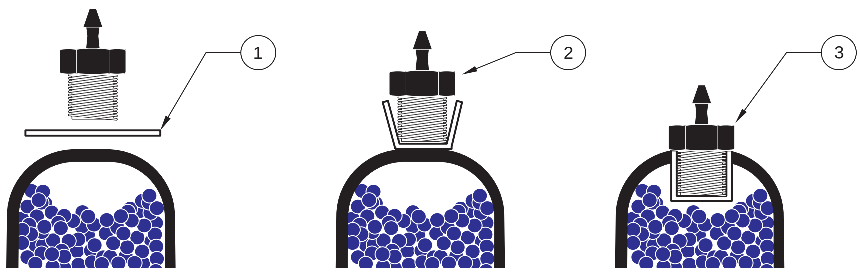
4. Place a new filter over the hole. Make sure that the smooth side of the filter faces the inside of the canister (Figure 24).

5. Place the threaded nipple on top of the filter.

6. With a slight pressure, press the filter into the hole with the nipple threads and begin threading the nipple into the hole. The filter will deflect upward and feed completely into the thread until it disappears. The filter must rotate with the nipple as it is threaded into the cap. If it does not, it is torn. Start over with a new filter.

7. Inspect the installation. In the upper cap, a small, dim light spot should be visible when held up to the light. A bright spot indicates a torn filter. Start over with a new filter.

Figure 24 Replacing the Hydrophobic Filter



1. Filter, smooth side down	**2.** Hex-head tubing nipple	**3.** Finished assembly.

Section 7 Replacement Parts and Accessories

Replacement Parts

Description	Model	Cat. No.
Ladder Hanger, for use with 4915 and 4873 Suspension Bracket	920	4874
Manhole Support Bracket/Spanner 45–68 cm (18–28”) (for use with Cat. No. 4920)	910/920	9542
Manhole Support Bracket/Spanner, 71–122 cm (28–48”) (for use with Cat. No. 4920)	910/920	9557
Manhole Support Bracket/Spanner, 107–183 cm (42–72”) (for use with Cat. No. 4920)	910/920	9556
Wall/Ladder Mount Suspension Bracket	910	4920
Wall/Ladder Mount Suspension Bracket	920	4915

In-Pipe Ultrasonic Sensor Mounting Accessories

Description	Model	Cat. No.
Mounting Band Set for 15–42” pipes Includes: (1) Extension Band (Cat. No. 1473) (2) Extension Bands (Cat. No. 1525) (3) Extension Bands (Cat. No. 1759) (1) Extension Band (Cat. No. 1318) (1) Scissors Jack Assembly (Cat. No. 3719)	910/920	3766
Mounting Clip (for use with Cat. No. 3766)	920	3868
Mounting Clip, permanent (screws to channel wall).	920	3875
Mounting Ring, 6”, w/ integral in-pipe sensor mounting clip and velocity sensor mounting holes	920	4021
Mounting Ring, 8”, w/ integral in-pipe sensor mounting clip and velocity sensor mounting holes	920	4022
Mounting Ring, 10”, w/ integral in-pipe sensor mounting clip and velocity sensor mounting holes	920	4023
Mounting Ring, 12”, w/ integral in-pipe sensor mounting clip and velocity sensor mounting holes	920	4024

Group 77000 Series

Description	Depth	Cat. No.
Oil-Filled Submerged AV Sensor, 0–10 ft range, 30 ft cable, with connector	0–10 ft	77064-030
Oil-Filled Submerged AV Sensor, 0–10 ft range, 50 ft cable, with connector	0–10 ft	77064-050
Oil-Filled Submerged AV Sensor, 0–10 ft range, 75 ft cable, with connector	0–10 ft	77064-075
Oil-Filled Submerged AV Sensor, 0–10 ft range, 100 ft cable, with connector	0–10 ft	77064-100
Oil-Filled Submerged AV Sensor, 0–10 ft range, custom cable, with connector	0–10 ft	77064-XXX
Oil-Filled Submerged AV Sensor, 0–30 ft range, 30 ft cable, with connector	0–30 ft	77074-030
Oil-Filled Submerged AV Sensor, 0–30 ft range, 50 ft cable, with connector	0–30 ft	77074-050
Oil-Filled Submerged AV Sensor, 0–30 ft range, 75 ft cable, with connector	0–30 ft	77074-075
Oil-Filled Submerged AV Sensor, 0–30 ft range, 100 ft cable, with connector	0–30 ft	77074-100
Oil-Filled Submerged AV Sensor, 0–30 ft range, custom cable, with connector	0–30 ft	77074-XXX

Oil-Filled Area Velocity Sensors with Bare Leads

Description	Depth	Cat. No.
Oil-Filled Submerged AV Sensor, 0–10 ft range, 30 ft cable, with bare leads for barrier box	0–10 ft	77264-030
Oil-Filled Submerged AV Sensor, 0–10 ft range, custom cable, with bare leads for barrier box	0–10 ft	77264-XXX
Oil-Filled Submerged AV Sensor, 0–30 ft range, 30 ft cable, with bare leads for barrier box	0–30 ft	77274-030
Oil-Filled Submerged AV Sensor, 0–30 ft range, custom cable, with bare leads for barrier box	0–30 ft	77274-XXX

Standard Area Velocity Sensors with Connectors

Description	Depth	Cat. No.
Submerged AV Sensor, 0–10 ft range, 30 ft cable, with connector	0–10 ft	77065-030
Submerged AV Sensor, 0–10 ft range, 50 ft cable, with connector	0–10 ft	77065-050
Submerged AV Sensor, 0–10 ft range, 75 ft cable, with connector	0–10 ft	77065-075
Submerged AV Sensor, 0–10 ft range, 100 ft cable, with connector	0–10 ft	77065-100
Submerged AV Sensor, 0–30 ft range, custom cable, with connector	0–10 ft	77065-XXX
Submerged AV Sensor, 0–30 ft range, 30 ft cable, with connector	0–30 ft	77075-030
Submerged AV Sensor, 0–30 ft range, 50 ft cable, with connector	0–30 ft	77075-050
Submerged AV Sensor, 0–30 ft range, 75 ft cable, with connector	0–30 ft	77075-075
Submerged AV Sensor, 0–30 ft range, 100 ft cable, with connector	0–30 ft	77075-100
Submerged AV Sensor, 0–30 ft range, custom cable, with connector	0–30 ft	77075-XXX

Standard Area Velocity Sensors with Bare Leads

Description	Depth	Cat. No.
Submerged AV Sensor, 0–10 ft range, 30 ft cable, with bare leads for barrier box	0–10 ft	77265-030
Submerged AV Sensor, 0–10 ft range, custom cable, with bare leads for barrier box	0–10 ft	77265-XXX
Submerged AV Sensor, 0–30 ft range, 30 ft cable, with bare leads for barrier box	0–30 ft	77275-030
Submerged AV Sensor, 0–30 ft range, custom cable, with bare leads for barrier box	0–30 ft	77275-XXX

Area Velocity Sensor Accessories

Description	Cat. No.
Custom cable connecting sensor to junction box. Cable lengths range from 1–99 ft	77155-PRB
Custom cable connecting junction box to hub. Cable lengths range from 1–99 ft	77155-HUB
Hub Assembly for Bare Wire	77228-00
Silicon oil dual 50-mL oil pack only. Refills 100 sensors	7724700
Silicon oil refill kit includes dispensing tool, dual 50-mL oil pack, instruction sheet and miscellaneous hardware. Refills 100 sensors	7724800
Instruction Sheet, Oil Fill Kit	7724789
Instruction Sheet, Bare Wire AV Probe	7725089
Instruction Sheet, Firmware Upgrade	7726089
Silicon Potting Gel Kit	7725600
Gel Fill (order three to fill a single junction box)	7729800
Gel Fill Dispensing Gun (also doubles as silicone oil fill gun)	7715300
Retrofit kit for transforming a sensor with a non-oil cover plate into Oil filled cover plate. Includes kit 77248-00	7730000

Submerged Area-Velocity Sensor Mounting Accessories

Description	Model	Cat. No.
Insertion Tool for street-level installation of mounting rings	910/920	9574
Mounting Ring for 6" diameter pipe (requires Cat. No. 3263)	910/920	1361
Mounting Ring for 8" diameter pipe (requires Cat. No. 3263)	910/920	1362
Mounting Ring for 10" diameter pipe (requires Cat. No. 3263)	910/920	1363
Mounting Ring for 12" diameter pipe (sensor mounts directly to band)	910/920	1364
Mounting Ring for 15" diameter pipe (sensor mounts directly to band)	910/920	1365
Mounting Ring for 18" diameter pipe (sensor mounts directly to band)	910/920	1366
Mounting Ring for 20–21" diameter pipe (sensor mounts directly to band)	910/920	1353
Mounting Ring for 24" diameter pipe (sensor mounts directly to band)	910/920	1370
Mounting Plate, wall mount sensor	910/920	4939

Mounting Band Selection Chart

Pipe Diameter	Mounting Band Selection*			
	Cat. No. 1473 6.25" (15.85 cm) long, adds 2" (5.08 cm) to band diameter	Cat. No. 1525 9.5" (24.13 cm) long, adds 3" (7.62 cm) to band diameter	Cat. No. 1759 19" (48.26 cm) long, adds 6"(15.24 cm) to band diameter.	Cat. No. 1318 50.25" (1.27 cm) long, adds 16" (40.64 cm) to band diameter
8" (20.32 cm)	0	0	1	0
10" (25.4 cm)	1	0	1	0
12" (30.48 cm)	0	1	1	0
15" (38.1 cm)	0	2	1	0
18" (45.72 cm)	0	1	2	0
21" (53.34 cm)	0	2	2	0
24" (60.96 cm)	0	1	3	0
27" (68.58 cm)	1	0	1	1
30" (76.2 cm)	1	1	1	1
33" (83.2 cm)	1	0	2	1
36" (91.44 cm)	1	1	2	1
42" (1.06 m)	1	1	3	1
45" (1.14 m)	1	1	1	2
48" (1.21 m)	1	0	2	2

*. In addition to the band segments shown below, a complete mounting band assembly also requires one AV Sensor Mounting Clip (Cat. No. 3263), and one Scissors Jack Assembly (Cat. No. 3719).

Section 8 Contact Information

Ordering Information for the U.S.A.

By Telephone:
(800) 635-4567

By Fax:
(970) 461-3915

Ordering information by E-mail:
orders@hach.com

By Mail:
Hach Company
P.O. Box 389
Loveland, Colorado 80539-0389
U.S.A

Information Required

- Hach account number (if available)
- Your name and phone number
- Purchase order number
- Brief description or model number
- Billing address
- Shipping address
- Catalog number
- Quantity

Ordering Information for Outside the U.S.A. and Europe

Hach maintains a worldwide network of dealers and distributors. To locate the representative nearest you, send E-mail to intl@hach.com or visit www.hach.com.

Technical Support

Technical and Customer Service Department personnel are eager to answer questions about our products and their use. In the U.S.A., call 1-800-635-1230. Outside the U.S.A. and Europe, send E-mail to intltech@hach.com.

Repair Service

Authorization must be obtained from Hach before sending any items for repair. Please contact the Hach Service Center serving your location.

Hach Company
P.O. Box 389
Loveland, Colorado, 80539-0389 U.S.A.
Telephone: 1-800-635-1230 or (970) 669-3050
Fax: (970) 669-2932

Section 9 Contact Information for Europe

For technical support, repair service, and ordering information please refer to the contact information below for your specific country. For additional information, visit www.hach-lange.com.

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Fax +41(0)1 9 45 66 76
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Section 10 Warranty

Hach Company warrants this product to the original purchaser against any defects that are due to faulty material or workmanship for a period of one year from date of shipment.

In the event that a defect is discovered during the warranty period, Hach Company agrees that, at its option, it will repair or replace the defective product or refund the purchase price, excluding original shipping and handling charges. Any product repaired or replaced under this warranty will be warranted only for the remainder of the original product warranty period.

This warranty does not apply to consumable products such as chemical reagents; or consumable components of a product, such as, but not limited to, lamps and tubing.

Contact Hach Company or your distributor to initiate warranty support. Products may not be returned without authorization from Hach Company.

Limitations

This warranty does not cover:

- Damage caused by acts of God, natural disaster, labor unrest, acts of war (declared or undeclared), terrorism, civil strife or acts of any governmental jurisdiction
- Damage caused by misuse, neglect, accident or improper application or installation
- Damage caused by any repair or attempted repair not authorized by Hach Company
- Any product not used in accordance with the instructions furnished by Hach Company
- Freight charges to return merchandise to Hach Company
- Freight charges on expedited or express shipment of warranted parts or product
- Travel fees associated with on-site warranty repair

This warranty contains the sole express warranty made by Hach Company in connection with its products. All implied warranties, including without limitation, the warranties of merchantability and fitness for a particular purpose, are expressly disclaimed.

Some states within the United States do not allow the disclaimer of implied warranties and if this is true in your state the above limitation may not apply to you. This warranty gives you specific rights, and you may also have other rights that vary from state to state.

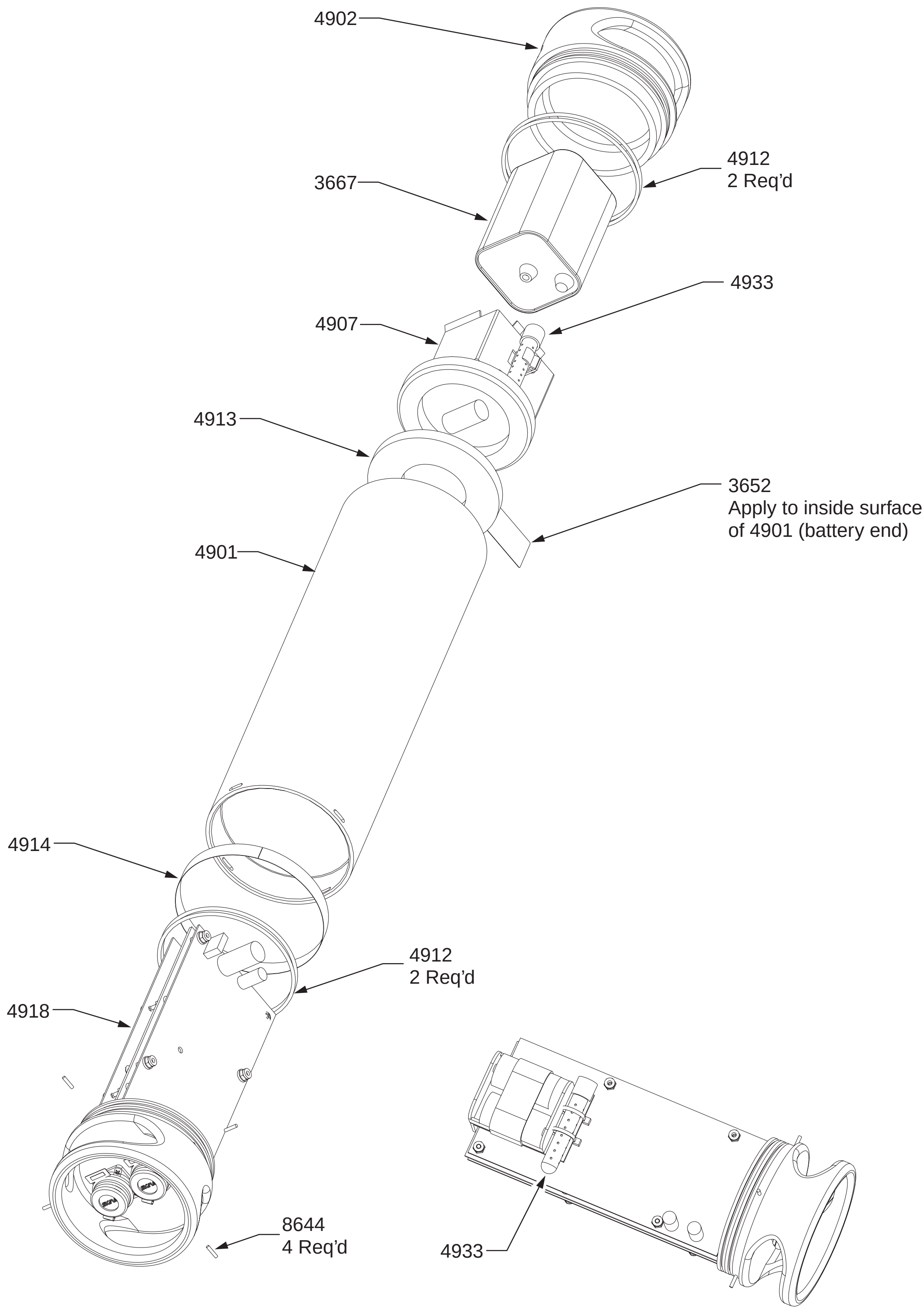
This warranty constitutes the final, complete, and exclusive statement of warranty terms and no person is authorized to make any other warranties or representations on behalf of Hach Company.

Limitation of Remedies

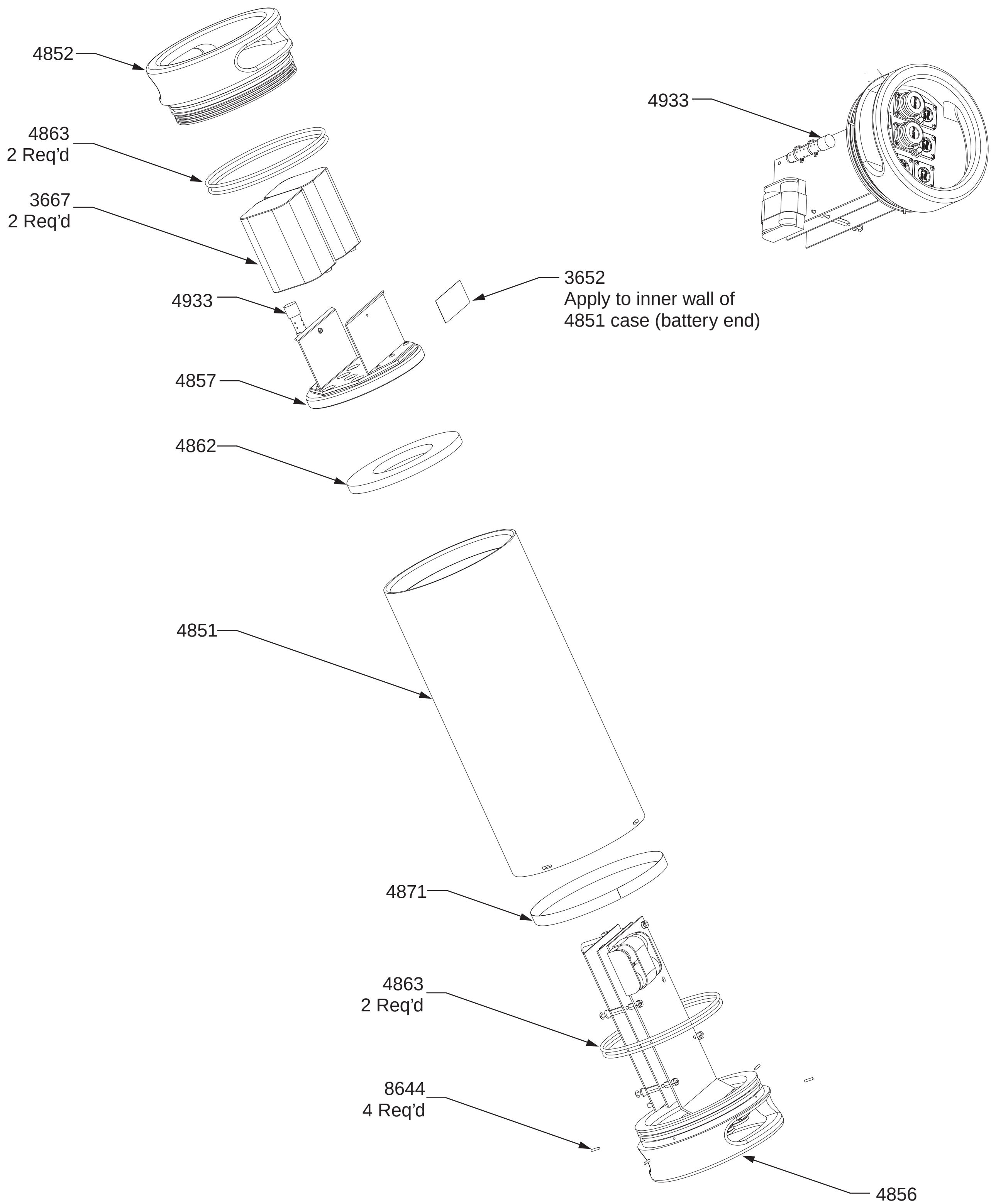
The remedies of repair, replacement or refund of purchase price as stated above are the exclusive remedies for the breach of this warranty. On the basis of strict liability or under any other legal theory, in no event shall Hach Company be liable for any incidental or consequential damages of any kind for breach of warranty or negligence.

Appendix A Exploded View Drawings

1.1 Model 910



1.2 Model 920


4852
4933
4863
2 Req'd
3667
2 Req'd
4933
3652
Apply to inner wall of
4851 case (battery end)
4857
4862
4851
4871
4863
2 Req'd
8644
4 Req'd
4856

Hach Sigma 950 Series Permanent/Portable Open Channel Flow Meters

Hach Sigma 950 Series Permanent/Portable Open Channel Flow Meters provide portable and/or permanent single-channel monitoring plus water quality testing, process control interface, and digital display. Both models offer maximum flexibility for multiple applications—including surcharge or reversed flow conditions, weirs and flumes, and small-to-large channels.Up to three different level sensor technologies and velocity in one meter.

Features and Benefits

Versatility and Customization

For applications that require more than a flow monitor, use the Hach Sigma 950 Open Channel Flow Meter with rainfall, pH, temperature, ORP, dissolved oxygen, and/or conductivity monitoring capability. Three standard level measurement technologies are available—ultrasonic, submerged, or bubbler. The Sigma 950 AV Optiflo flow meter has the additional option of Doppler velocity measurement. All Sigma 950 flow meters also have analog inputs for logging data from other instruments, such as total suspended solids monitors.

Sampler Pacing and Equipment Control

Use Hach Sigma 950 flow meters to control samplers, pumps, or other equipment based on monitored flow or selected parameter(s) based on high/low set points with built-in relay outputs. Sampler pacing provides the ability to document overflow problems.

Easy to Use Interface

The large LCD graphics quickly displays information on-site (available in 10 languages) without the inconvenience of paper charts. The built-in keypad makes using laptops in the field optional. A single keystroke can provide an instantaneous data summary and review of all program settings.

Communications and Data Storage Options

Industry standard SCADA MODBUS ASCII protocol is included in all Sigma 950 flow meters. 4-20 mA outputs are available for flexible integration with a SCADA system. Remote communications is available via modem or RS-232 connection. Store 18,000 data points in memory (expandable to 116,000 data points).

Superior Submersible Area Velocity Sensor for Open Channel Applications

The Hach Sigma 950 AV Optiflo flow meter provides Doppler velocity monitoring that uses advanced ultrasonic, one-MHz Doppler technology for flow measurements. This technology avoids signal dropouts and ensures high levels of accuracy in low-flow, full-pipe, or reversed-flow conditions. Installation is fast and single point atmospheric calibration is easy.

Applications

Hach Sigma 950 Permanent/Portable Open Channel Flow Meter

- *Long term or permanent flow studies*
- *Sanitary sewer evaluation studies*
- *CSO studies and monitoring*
- *NPDES stormwater compliance*
- *Industrial compliance monitoring*

Hach Sigma 950 AV Optiflo Permanent/Portable Open Channel Flow Meter

- *Applications involving frequent moving of meter to different site conditions*

HACH®
Be Right™

Specifications*

Flow Meter Specifications

Units of Measurement
Flow: gps, gpm, gph, lps, lpm, lph, mgd, afd, cfs, cfm, cfh, cfd, m^3s, m^3m, m^3h, m^3d
Totalized Flow: L, m^3, $ft.^3$, gal., acre-ft.

Primary Devices
Flumes: Parshall, Palmer Bowlus, Leopold-Lagco, H, HL, HS, trapezoidal
Weirs: V-notch (15 to 120°) contracted/non-contracted rectangular, Thelmar, compound Cipolletti
Manning Equation: Round, U and rectangular trapezoidal channels
Flow Nozzles: Kennison, parabolic, California pipe
Head vs. Flow: Custom programmable curve (up to 99 points)

Operating Temperature
-10 to 65.5°C (14 to 150°F)

Storage Temperature
-40 to 80°C (-40 to 176°F)

Time-Based Accuracy
±1 second per day (one level and one velocity, data download once per week, at 10°C (50°F), also affected by site conditions)

Totalizers
8-digit resettable and 8-digit non-resettable LCD software totalizer
Optional 6-digit non-resettable mechanical totalizer

Graphics Display
Back lit LCD
Auto-off when not in use
SCII Mode: 8 line x 40 character
Graphics Mode: 60 x 240 dot
Dimensions: 3.8 x 12.7 cm (1.5 x 5 in.)
Displays: level vs. time, flow vs. time
Optional Displays: rainfall, pH, ORP, temperature, DO, conductivity vs. time, sampler events, and alarm events

Keypad
21 position sealed membrane switch with blinking green LED to indicate power on
Four “soft keys”, functions defined by display

Data Storage
Capacity: Up to 512k bytes (402 days of level, velocity, and rainfall readings at 15 minute inter-vals plus 300 events)
Monitoring Intervals: 1, 2, 3, 5, 15, 30 or 60-minute intervals

Program Memory
Non-volatile programmable flash, can be updated via RS-232 port

Sampler Output
12 to 17 Vdc pulse, 100 mA maximum at 500 ms duration

Communications
RS-232: up to 19,200 baud
SCADA MODBUS communication protocol via RS-232 or optional modem
*Modem (optional):*14,400 baud
Cellular Communications (optional): 14,400 bps, MNP 10-EC Cellular Protocol
Pager Alarms

Enclosure Material
ABS, UV resistant

Enclosure Rating
NEMA 4X,6

Power Source
12 Vdc

Power Options
6 amp-hr. gel electrolyte rechargeable battery
4 amp-hr. Ni-Cad rechargeable battery
Lantern battery case with two 6-Volt lantern batteries
115 Vac, 230 Vac, or 100 Vac power converter with battery charger

Dimensions
34.3 x 25.4 x 24.1 cm (13.5 x 10.0 x 9.5 in.)

Weight
6.8 kg (15 lbs.) with batteries

Sensor Specifications

<u>950 BUBBLER SENSOR</u>

Range
0.003 to 3.6 m (0.01 to 11.75 ft.)

Accuracy
0.01 to 11.75 ft. ±0.011 ft. (±0.003 m) (linearity and hysteresis at 22°C (72°F))

Ambient Operating Temperature
-18 to 63°C (0 to 145°F)

Compensated Temperature
0 to 59°C (32 to 138°F)

Temperature Error
±0.0003 ft./°F (maximum error within compensated temperature range per degree of change)

Air Intakes
Bubble source and reference port desiccant protected.
Fittings provided for remote intakes.

Filter
10 micron on bubble source intake

Line Purge
Bubble line is high pressure purged at programmed intervals, or in manual mode on demand

Line Size
0.32 cm (1/8 in.) ID standard

<u>950 ULTRASONIC SENSOR</u>

<u>50 kHz Ultrasonic Transducer</u>

Range
38.1 cm to 9.1 m (15 in. to 30 ft.) sensor to liquid

Accuracy
1 to 10 ft. ±0.01 ft. (±0.003 m) (at 22°C (72°F), still air, 40 to 70% relative humidity)

Span
50 kHz, 0 to 29 ft.

Ambient Operating Temperature
-18 to 60°C (0 to 140°F)

Temperature Error
±0.000047 ft./F° (maximum error within compensated temperature range per degree of change)

Resolution
0.0011 ft.

Material
PVC housing
Buna-N acoustic window

Cable
4-conductor with integral stainless steel support cable
Length: 7.6 m (25 ft.) standard

Continued on next page.

Specifications *continued*

Crystal Specification
50 kHz, 11.5° included beam angle

Dimensions
9.5 x 7 cm (3.75 x 2.75 in.)

Weight
0.7 kg (1.5 lbs.)

75 kHz Ultrasonic Transducer

Range
23 cm to 3.3 m (14 in. to 1 ft.)
sensor to liquid

Accuracy
1 to 10 ft. ±0.01 ft. (±0.003 m)
(at 22°C (72°F), still air, 40 to 70%
relative humidity)

Span
0 to 15 ft.

Ambient Operating Temperature
-18 to 60°C (0 to 140°F)

Temperature Error
±0.000047 ft./F° (maximum error within
compensated temperature range per
degree of change)

Resolution
0.0011 ft.

Material
PVC housing
Buna-N acoustic window

Cable
4-conductor with integral stainless steel
support cable
Length: 7.6 m (25 ft.) standard

Crystal Specification
5° beam angle with horn

Dimensions
12.7 x 5.7 cm (5.0 x 2.25 in.)

Weight
0.7 kg (1.5 lbs.)

75 KHZ ULTRASONIC LEVEL SENSOR
(IN-PIPE)

Range
0 to 3.35 m (0 to 11 ft.)

Accuracy
0.038 to 4.57 m ±.003 m
(0.125 to 15 ft. ±0.01 ft.)
(at 22°C (72°F), still air, 40 to 70%
relative humidity)

Span
0.038 to 4.57 m (0.125 to 15 ft.)

Ambient Operating Temperature
-18 to 60°C (0 to 140°F)

Temperature Error
±0.00005 m/°C (±0.0001 ft./F°)
maximum error within compensated
temperature range per degree of change

Resolution
0.019 cm (0.0075 in.)

Material
Stainless steel housing
Buna-N acoustic window

Cable
4-conductor
Length: 7.6 m (25 ft.) standard; 305 m
(1000 ft.) using RS-485 two wire remote
sensor option

Crystal Specification
75 kHz, 7° included beam angle

Dimensions
3.81 x 30 cm (2.0 x 12 in.)

950 SUBMERGED PRESSURE SENSOR

Range
Choice of:
2.5 psi: 0.01 to 1.75 m (0.04 to 5.75 ft.)
5.0 psi: 0.01 to 3.58 m (0.04 to 11.75 ft.)
10.0 psi: 0.01 to 7.0 m (0.04 to 23 ft.)

Accuracy
±0.1% full scale (non-linearity and
hysteresis)

Transducer
Type: Differential piezo resistive with
balanced bridge
Orientation: Inverted

Maximum Allowable Level
6x over pressure

Operating Temperature
0 to 71 °C (32 to 160°F)

Compensated Temperature
0 to 36 °C (32 to 96°F)

Temperature Error:
2.5 psi: 0.04 to 5.75 ft. ±.006 ft./F°
5.0 psi: 0.04 to 11.75 ft. ±.0012 ft./F°
10.0 psi: 0.04 to 23 ft. ±.0024 ft./F°
(Maximum error within compensated
temperature range per degree of
change)

Air Intake
Atmospheric pressure reference is
desiccant protected

Material
316 stainless steel body with titanium
diaphragm

Cable
4-conductor polyurethane sensor
cable with air vent
Length: 7.6 m (25 ft.) standard;
76 m (250 ft.) maximum

Dimensions
2.54 x 17.2 cm (1 x 6.75 in.)
Probe Frontal Area: 0.875 in^2

Weight
0.7 kg (1.5 lbs.)

SUBMERGED DEPTH/AREA VELOCITY
SENSOR

Level Measurement

Method
Doppler principle/pressure transducer

Range
Standard: 0.005 to 3.5 m ±0.007 m
(0.018 to 11.5 ft. ±0.023 ft.)
Extended: 0.005 to 10.5 m ± 0.021 m
(0.018 to 34.6 ft. ±0.07 ft.)
(Non-linearity and hysteresis)

Maximum Allowable Level
3x over pressure

Operating Temperature
0 to 71°C (32 to 160°F)

Compensated Temperature
0 to 30°C (32 to 86°F)

Temperature Error
0.005 to 3.5 m ±0.0022 m/°C
(0.018 to 11.5 ft. ±0.004 ft./°F)
0.018 to 10.5 m ±0.006 m/°C
(0.018 to 34.6 ft, ±0.012 ft./°F)
(Maximum error within compensated
temperature range per degree of
change)

Velocity Induced Error on Depth (patent pending)
0 to 3.05 m/s (0 to 10 ft./sec.) = 0.085%
of reading

Air Intake
Atmospheric pressure reference is
desiccant protected

Continured on next page.

Specifications *continued*

Velocity Measurement

Method
Doppler ultrasonic

Transducer Type
Twin 1 MHz piezoelectric crystals

Range
-1.52 to 6.10 m/s (-5 to 20 fps)

Zero Stability
< 0.015 m/s (0.05 fps)

Accuracy
±2% of reading

Depth for Velocity
2 cm (0.8 in.) minimum, typical

Operating Temperature
-18 to 60°C (0 to 140°F)

General

Material
Polymer body with stainless steel diaphragm

Cable
Urethane sensor cable with air vent
Length: 7.6 m (25 ft.) standard;
76 m (250 ft.) maximum

Dimensions
2 x 3.8 x 12.7 cm (0.8 x 1.5 x 5 in.)

BUBBLER LEVEL/AREA VELOCITY SENSOR

Level Measurement

Method
Doppler principle/pressure transducer

Range
0.003 to 3.6 m (0.01 to 11.75 ft.)

Accuracy
0.01 to 11.75 ft. ±0.011 ft. (0.033 m)
(linearity and hysteresis at 22°C (72°F))

Ambient Operating Temperature
-18 to 63°C (0 to 145°F)

Compensated Temperature
0 to 59°C (32 to 136°F)

Temperature Error
±0.0003 ft./°F (maximum error within compensated temperature range per degree of change)

Air Intakes
Bubble source and reference port desiccant protected.
Fittings provided for remote intakes.

Filters
10 micron on bubble source intake

Line Purge
Bubble line is high pressure purged at programmed intervals, or in manual mode on demand

Velocity Measurement

Method
Doppler ultrasonic

Transducer Type
Twin 1 MHz piezoelectric crystals

Range
-1.52 to 6.10 m/s (-5 to 20 fps)

Zero Stability
< 0.015 m/s (0.05 fps)

Accuracy
±2% of reading

Depth for Velocity
2 cm (0.8 in.) minimum, typical

Operating Temperature
-18 to 60°C (0 to 140°F)

Dimensions
1.12 x 3.81 x 6.86 cm
(0.44 x 1.5 x 2.7 in.)

VELOCITY SENSOR

Method
Doppler principle

Accuracy
±2% of reading

Zero Stability
±1.52 cm (±0.05 fps)

Nose Angle
20° from horizontal

Cable
Length: 7.6 m (25 ft.) standard;
custom cable lengths to 76 m (250 ft.)
Diameter: 0.57 cm (0.225 in.)

Materials
Sensor: Polymer
Cable: Urethane
Mounting Hardware: Stainless steel

Dimensions
1.5 x 3.8 x 9.7 cm (0.5 x 1.5 x 3.7 in.)

Factory Installed Options

pH-TEMPERATURE/ORP METER

Control/Logging
Field selectable to log pH-temperature or ORP independent of flow or in conjunction with flow; also controls sample collection in response to value exceeding low/high set points

pH/Temperature Sensor
Temperature compensated; impact resistant ABS plastic body; combination electrode with porous Teflon® junction

Range
2 to 12 pH within specifications;
0 to 14 pH maximum range

Operating Temperature
-18 to 80°C (0 to 176°F)

Recording Intervals
1, 2, 3, 5, 6, 10, 12, 15, 30, and 60 minutes

Probe Pre-Amplifier/Junction Box
NEMA 4X with labeled terminal strip

Dimensions
1.9 x 15.2 cm (0.75 x 6 in.) with
1.9-cm (0.75-in.) MPT cable end

INTEGRAL DISSOLVED OXYGEN/TEMPERATURE METER

Control/Logging
Field selectable to log dissolved oxygen independent of flow or in conjunction with flow; also controls sample collection in response to value exceeding low/high set points

Measurement Method
Polargraphic

Sensor
Temperature compensated; impact resistant polypropylene body

Continured on next page.

Specifications continued

Range
0 to 20 mg/L dissolved oxygen

Resolution
0.01 mg/L

Accuracy
±0.2 mg/L

Operating Temperature
0 to 50°C (32 to 122°F)

Recording Intervals
1, 2, 3, 5, 6, 10, 12, 15, 20, 30, and 60 minutes

Dimensions
1.65 x 12.7 cm (0.65 x 5 in.) with 1.9-cm (0.75-in.) MPT cable end

INTEGRAL CONDUCTIVITY/TEMPERATURE METER

Control/Logging
Field selectable to log conductivity independent of flow or in conjunction with flow, also controls sample collection in response to value exceeding low/high set points

Sensor
Temperature compensated;
impact resistant polypropylene body

Range
0 to 20 mS/cm

Resolution
0.01 mS/cm or 0.01 µS/cm
(user selectable)

Accuracy
±1% of reading +0.05 mS/cm

Operating Temperature
0 to 50°C (32 to 122°F)

Recording Intervals
1, 2, 3, 5, 6, 10, 12, 15, 20, 30, and 60 minutes

Dimensions
1.70 x 12.7 cm (0.67 x 5 in.)
with1.9-cm (0.75-in.) MPT cable end

RAIN GAUGE INPUT

For use with Hach Tipping Bucket Rain Gauge.
Flow Meter records rainfall data in 0.01-in. increments.
Flow measurement can be initiated based upon field selectable rate of rain.

ANALOG INPUT DATA-LOGGING CHANNELS

Up to seven additional data-logging channels record data from external sources.
Field assignable channel name(s) and units.
-4 to +4 Vdc; ±0.5% full scale voltage accuracy
0 to 20 mA; ±0.2% full scale 4-20 mA accuracy with 200 ohm impedance

4 TO 20 MA OUTPUTS

Up to two integral field assignable outputs
Optically isolated
Up to 600 ohm load per output
0.1 % FS error

ALARM RELAYS

Up to four integral alarm relays
10 amp, Form C
User assignable to any internal or external data channel

MECHANICAL TOTALIZER

6-digit non-resettable mechanical totalizer
Selectable units: gal., liters, $ft.^3$, m^3, acre-ft.

MODEM

14,400 baud rate
CRC auto to check sum
FCC approved
Cellular compatible

EXPANDED MEMORY

Increase memory from 18,432 data points to 116,736 data points

AC POWER BACKUP

Provides power in the event of an AC power failure
Internal trickle charger maintains 6 amp-hour battery

Teflon® is a registered trademark of E.I. Dupont de Nemours Inc.

**Specifications subject to change without notice.*

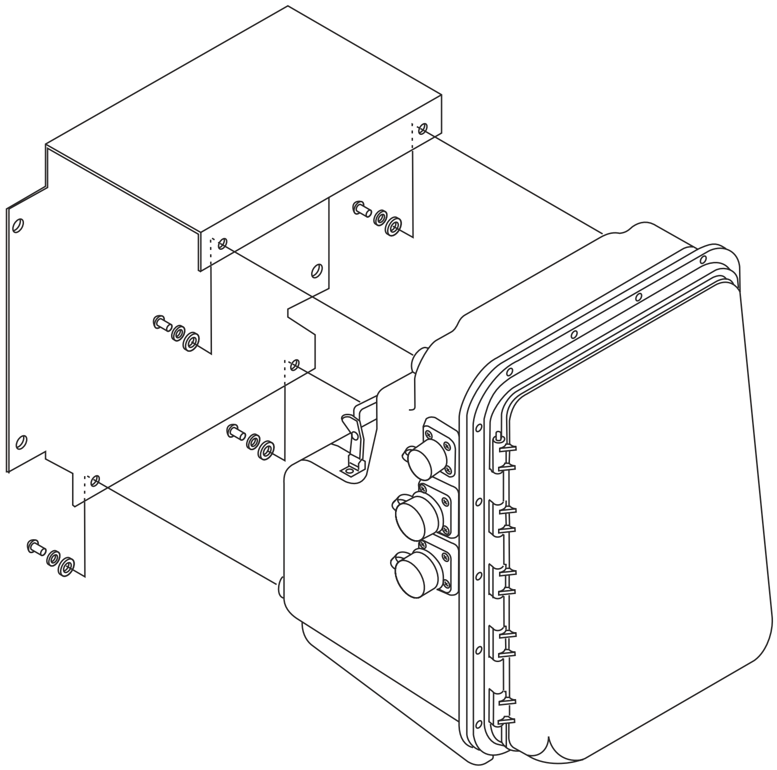
Engineering Specifications

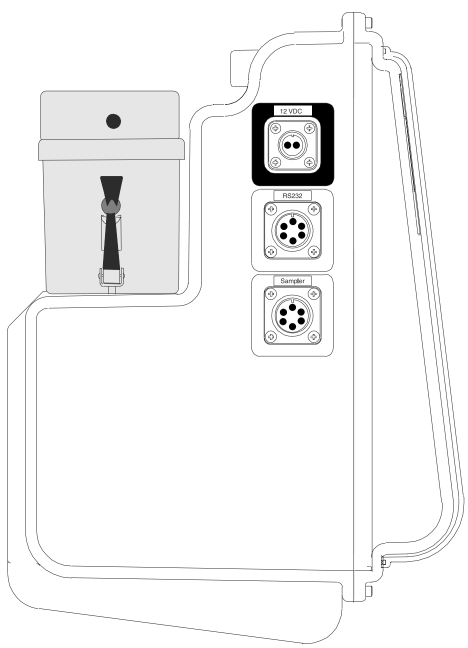
Flow Meter

1. The flow meter shall operate on 12 Vdc, which is supplied by a battery or 115 Vac power converters.
2. All electrical components shall be enclosed in a NEMA 4X-6 enclosure. The enclosure shall have a continuous hinged front cover to protect the display and keypad and shall maintain NEMA 4X,6 with the cover open.
3. The enclosure shall contain desiccant and a front panel humidity indicator.
4. Current data shall be displayed on the flow meter front panel by means of an external push button on the enclosure. The meter shall not require opening of a cover to see current status.
5. The meter shall have an 8 line x 40-character backlit liquid crystal graphics display. In addition to indicating all programming steps and current status such as level, velocity and flow rate, the display shall show all logged data in field selectable tabular and graphics (x-y plot) formats.
6. All program entries shall be entered via a sealed front panel keypad, and indicated on the front panel display. The keypad and display shall meet NEMA 4X-6 standards.
7. A personal computer or any other external means shall not be required to program the flow meter or integral logger or access data.
8. Flow meter programming/measurements:
   a. The flow meters shall be field programmable for primary devices including:
      i. Weirs: V-notch weirs (any angle from 22.5 to 120 degrees, compound V-notch/rectangular weirs, contracted and non-contracted rectangular weirs, trapezoidal weirs, and Thel-Mar weirs.
      ii. Flumes: Parshall (1 to 144 inch), Palmer Bowlus (4 to 72 inch), trapezoidal (60 degree small, large, and extra large, 45 degree 2 and 12 inch), H. HL, and HS type flumes, and Leopold-Lagco (4 to 72 inch).
      iii. Nozzle: California pipe method; Manning equation for round, U-channel, rectangular, and trapezoidal cross sections; power curve equation.
      iv. Head vs. flow tables: Two tables of up to 99 (head, flow) points per table (tables may be stored in flow meter's memory and retrieved as required).
   b. Field selectable units of measurement shall include:
      i. Level: Inches, feet, centimeters, and meters.
      ii. Flow rate: GPS, GPM, GPH, MGD, AFD, LPS, LPM, LPH, CFS, CFM, CFH, CFD, CMS, CMM, CMH, CMD.
      iii. Total flow: Gallons, cubic feet, acre-feet, liters, and cubic meters.
9. Flow totalizing:
   a. The flow meter shall have two software totalizers, one resettable and the other resettable.
   b. (Optional) The meter shall include a 6-digit non-resettable electro-mechanical totalizer, protected to meet NEMA 4X, 6 standards.
10. Sampler pacing:
   a. The flow meter shall have a 12 Vdc pulse output for pacing an automatic liquid sampler in proportion to flow, with field selectable flow volume between pulses.
   b. The meter shall be capable of initiating a sampler on level, flow rate, and flow rate of change.
11. Integral metering devices (optional):
   a. The meter shall be equipped with an integral pH-temperature/ORP meter. The pH meter shall have a range of 0 to 14 pH with a ±1% resolution over an operating range of 0 to 176 degrees F.
   b. The meter shall be equipped with an integral temperature meter. The temperature meter shall have an operating range of 0 to 176 degrees F. The meter shall include a platinum RTD probe in a stainless steel body with 25-foot cable.
   c. The meter shall be equipped with an integral dissolved oxygen (DO) meter. The DO meter shall have a range of 0 to 20 mg/L (DO) with 0.01 mg/L resolution and 3% (1 ppm) accuracy.
   d. The meter shall be equipped with an integral conductivity meter. The conductivity meter shall have a range of 0 to 20 mS/cm with 0.01 mS/cm resolution and 2% (0.01ms) of reading accuracy.
   e. The meter shall be equipped with a rain gauge input. The sampler shall accept contact closure inputs from an external rain gauge.
   f. The meter shall be equipped with seven external analog inputs. The first four channels shall be capable of logging a 4-20 mA current input, and the remaining three channels shall be set up to log -4.5 to +4.5 Vdc voltage input.
12. The flow meter and sensor shall be the Sigma Model 950 Permanent/Portable Open Channel Flow Meter OR Sigma Model 950 AV Optiflo Permanent/Portable Open Channel Flow Meter manufactured by Hach Company.

Dimensions

Placement of Hach Sigma 950 Series Permanent/Portable Open Channel Flow Meters depends on the suitability of the monitoring site. Select sites that have normalized flow and minimal turbulence. Turbulence can make it difficult to detect an average velocity in the flow stream. Obstructions, vertical drops, pipe bends, and elbows can create turbulence and affect the accuracy of measurements. Mounting options for Sigma 950 flow meters include wall mounting, suspension harness installation, or manhole rung hanger.





Ordering Information

Flow Meter Bundles

36729-50	950 Bubbler Flow Meter; includes 25 ft. tubing
36809-50	950 Submerged Pressure Flow Meter; includes 25 ft. sensor cable
32869-51	950 75 kHz Down-look Ultrasonic Flow Meter; includes 25 ft. sensor cable
32869-52	950 75 kHz In-Pipe Ultrasonic Flow Meter; includes 25 ft. sensor cable
32489-50	950 Bubbler AV Flow Meter; includes 25 ft. of sensor cable
35229-50	950 Submerged AV Flow Meter; includes 25 ft. of sensor cable
39599-52	950 75k Hz Ultrasonic AV Flow Meter with In Pipe Ultrasonic and Velocity Sensors

Integral Water Quality Options and Sensors

2684	Factory Installed Integral pH-Temp/ORP Sensor; includes pre-amp interface
3328	pH-Temperature Sensor (grounded); includes 25 ft. cable
2080	ORP Sensor; includes 25 ft. cable
3226	Factory installed DO and Conductivity Sensor; includes pre-amp interface
3228	Factory installed DO and EC Option with three 4-20mA Input Data Logging, includes pre-amp interface
3216	DO Probe Kit; includes 25 ft. cable.
3225	Conductivity Probe Kit; includes 25 ft. cable
3222	DO Probe only; includes 25 ft. cable
3223	Conductivity Probe only; includes 25 ft. cable

Communication and Control Interfaces

2676	First 4-20 mA Output; includes 25 ft. cable
2923	Second 4-20 mA Output
2691	First Set Two (2) Alarm Relays with settable trip points
2707	Second Set Two (2) Alarm Relays with settable trip points
4578	Modem; 14,400 baud (domestic lines only)

Sensor Mounting Hardware

1361	Spring Ring for 6-in. diameter pipe
1362	Spring Ring for 8-in. diameter pipe
1363	Spring Ring for 10-in. diameter pipe
1364	Spring Ring for 12-in. diameter pipe
3263	Sensor Mounting Clip; for 88000, wafer velocity, and bubbler level velocity sensors
3868	Portable Bracket; for in-pipe ultrasonic sensor mounting clip
3875	Permanent In-Pipe Ultrasonic Sensor Mounting Bracket
3305	Velocity Sensor Mounting Plate
9574	Insertion Tool; for non-confined space entry
2974	Permanent Wall Mount Bracket; for down-looking ultrasonic sensor
2904	Floor or Wall Adjustable Mounting Bracket; for down-looking ultrasonic sensor
9538	Tripod Mounting Bracket; for down-looking ultrasonic sensor
2883	Cable Straightener; for down-looking ultrasonic sensor
3183	Cable Grip; for down-looking ultrasonic sensor

Cables and Interfaces

1727	Sampler or Flow Meter to PC Cable
3358	RS232 Extension Cable

Accessories

77247-00	Silicon Oil; dual 50-ml pack (refills 100 sensors)
77248-00	Silicon Oil Refill Kit; includes dispensing tool and oil packs
77256-00	Oil-Filled Sub-AV Sensor Kit
77300-00	Retrofit Kit (converts non oil-filled to oil-filled); includes Silicon Oil Refill Kit

Lit. No. 2547
F63 Printed in U.S.A.
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In the interest of improving and updating its equipment, Hach Company reserves the right to alter specifications to equipment at any time.

At Hach, it's about learning from our customers and providing the right answers. It's more than ensuring the quality of water—it's about ensuring the quality of life. When it comes to the things that touch our lives...

Keep it pure.

Make it simple.

Be right.

For current price information, technical support, and ordering assistance, contact the Hach office or distributor serving your area.

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www.hach-lange.com

HACH®

Be Right™

GE
Sensing

Features

- Ranges from 0.6 mH_2O to 700 mH_2O (1 to 1000 psi)
- Accuracy ±0.06% Full Scale (FS) Best Straight Line (BSL)
- Fully welded 316 stainless steel construction
- 4:1 downranging
- 4 to 20 mA output
- Full range of installation accessories

The Druck RTX 1930 transmitter (4 to 20 mA output) is a new generation rangeable fully submersible high performance sensor for measurement of hydrostatic liquid levels.

The RTX 1930 Series, through the use of digital correction techniques and a serial configuration interface, offers a 4 to 20 mA sensor with unparalleled accuracy, flexibility and reliability.

RTX 1930 Series

Remote Rangeable Level Pressure Sensor

RTX 1930 is a Druck product.
Druck has joined other GE high-technology sensing businesses under a new name—GE Industrial, Sensing.

GE
Sensing

Asset Management

The accuracy and flexibility of the 1930 Series reduces the whole life cost for the user in a variety of level applications.

- Surface water
- Tank level
- Borehole water
- Waste water and remediation

Flexibility

The ability of each unit to be configured across a wide spectrum of levels through the use of a simple Windows® based software via the serial interface, reduces inventory and simplifies site installation and maintenance.

Reliability

The fully welded construction of the RTX 1930 sensor, which contains no O-rings and incorporates all the enhanced features of Druck level sensors developed over 25 years of application use, provides an ideal long-term solution for a reliable, accurate and economical level measurement.

The Druck micro-machined silicon diaphragm is sealed within an all 316 stainless steel pressure module assembly. This is contained within a 1.2 in (30 mm) diameter body, incorporating a sophisticated package of analog through-path and digital electronics, terminating in an injection molded cable assembly. The cable features are a Kevlar® strain relief cord and IP68/Type 6 rating for indefinite immersion in 700 mH2O (1000 psi).

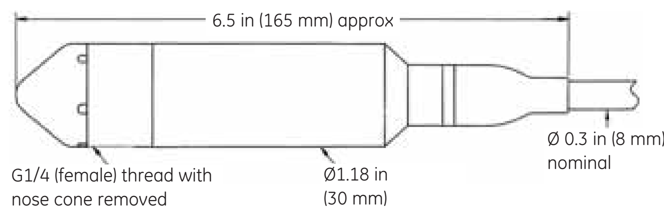
Ease of Use

A simple datum marked cable system is provided for ease of installation. Incremental 1 meter datum points are clearly marked for quick and accurate alignment below ground level. In addition, a range of related accessories simplifies installation, operation and maintenance.

- Windows® Remote Configuration Software (RCS)
- Rugged hardware interface for digital communication
- Sink weights
- Moisture-proof Sensor Termination Enclosure
- mA loop calibrator

GE
Sensing

RTX 1930 Series Specifications



Installation drawing

Pressure Measurement

Operating Pressure Ranges
Any zero based FS from 0.625 mH$_2$O to 700 mH$_2$O gauge

Standard Pressure Ranges
The standard Upper Range Limit (URL) can be configurered by the customer to any intermediate range determined by the Range Adjustment Limits.
mH$_2$O: 2.5, 5, 10, 15, 20, 35, 50, 100, 150, 200, 350, 700
ftH$_2$O: 8, 16, 33, 50, 66, 115, 160, 335, 500, 650, 1150, 2300

Sensors can be provided with a pressure calibration at a downranged FS, (e.g., 17 mH$_2$O) at an additional cost (refer to Option C).

Other units are software selectable e.g. mmH$_2$O, ftH$_2$O, inH$_2$O, mbar, psi, bar.

Range Adjustment Limits
Downranging (4:1)—full 4 to 20 mA output change for any user zero based span setting up to the Upper Range Limit (URL) from 25 to 100% (URL).
Reverse (20 to 4 mA)—output can be inverted to give reducing current with increasing level, e.g. 0 to 10 mH$_2$O (0 to 15 psi) range provides a 20 to 4 mA output as a power saving feature.
Elevation—the 4 mA output can be elevated within 0 to 75% of the Upper Range Limit (URL), e.g. 0 to 10 mH$_2$O (0 to 15 psi) range can be elevated up to 7.5 to 10 mH$_2$O (10 to 15 psi), with corresponding 4 to 20 mA output, e.g for water tower applications.

Overpressure
Standard Pressure Ranges (URL) can be exceeded by the following multiples with negligible effect on performance:
- 6 x for ranges to 2.5 mH$_2$O (4 psi)
- 4 x for ranges above 2.5 mH$_2$O (4 psi) (1400 mH$_2$O (2000 psi) max)

Pressure Containment
- 10 x for ranges to 2.5 mH$_2$O (4 psi)
- 6 x for ranges above 2.5 mH$_2$O (4 psi) (1400 mH$_2$O (2000 psi) max)

Media Compatibility
Fluids compatible with 316 stainless steel (body), acetyl (nose cone) and polyurethane (cable assembly).

RTX 1930 Electrical Connections

Red:	Analog Supply Positive
Blue:	Analog Supply Negative
Screen wire connected to case	
Orange:	Digital Configuration V+ comms
White:	Digital Configuration Tx comms
Yellow:	Digital Configuration Rx comms
Black:	Digital Configuration Ground comms

Excitation Voltage
10 to 30 V

The minimum supply voltage (V_{MIN}) which must appear across the pressure transmitter terminals is 9 V and is given by the following equation:
$V_{MIN} = V_{SUP} - (0.02 \times R_{LOOP})$
Where V_{SUP} is supply voltage in Volts, R_{LOOP} is total loop resistance in Ohms

Pulse Power Excitation
Recommended power-on time before output sample taken is 600 ms.

Output Signal
- 4 to 20 mA proportional to the level input in normal operation
- 3.8 to 20.5 mA proportional to the Loop Cal input in Remote Configuration Software (RCS) operation

Performance Specification

Accuracy
The combined effects of Non-Linearity, Hysteresis and Repeatability on standard pressure ranges (URL)
- Standard: ±0.1% FS BSL maximum
- Option A: ±0.06% FS BSL maximum

Zero Offset and Span Setting
Customer controlled with Remote Configuration Software (RCS).

Long Term Stability
0.1% URL per annum 0.2% for ranges below 5 mH$_2$O (7.5 psi).

Operating Temperature Range
- Direct mount: -40 to 185 °F (-40 to 85 °C)
- Fluid immersed: 14 to 176 °F (-10 to 80 °C)

GE
Sensing

Temperature Effects
- ± 0.1% URL (narrow) 14 to 122 °F (-10 to 50 °C)
- ± 0.2% URL (wide) -40 to 176 °F (-40 to 80 °C)

Shock and Vibration
MIL-STD-810E, method 514.4. Category 10 min.
Figure 514.4-16
The product will withstand 20 g peak shock half sine wave, 9 ms duration in all axes, also 2000 g peak shock 0.5 ms duration in all axes.

Insulation
>10 MΩ at 500 VDC

Electromagnetic Compatibility
EN 61326
Immunity EN 61000-6-2
Emission EN 61000-6-3

Software
Remote Configuration Software (RCS) provided free of charge with each sensor, along with installation, maintenance and application instructions.

Physical Specification

Cable Lengths
To be specified as required in 3.2 ft (1 m) increments up to 1500 ft (500 m).

Documentation
Units provided with traceable calibration certificate.

Pressure Connection
G1/4 female fitted with detachable nose cone assembly, applicable for direct mount or immersed applications.

Electrical Connection
Vented polyurethane cable with integral Kevlar® strain relief cord rated to 119 lb (54 kg) load. Water ingress protection to IP68/Type 6 to 700 mH_2O (1000 psi).
Analog 4 to 20 mA - 2 wires.
Isolated digital interface - 4 wires, each unit provided with digital interface splash-proof cable assembly for use with PC Configuration Interface Module (Option B).

Options

(A) Improved Accuracy
Improved accuracy of ±0.06% FS BSL for standard URL ranges.

(B) PC Configuration Interface Module
Hardware RS232 serial interface assembly with 7 ft (2.5 m) lead fitted with splash proof cable assembly.
Essential option for interfacing the RTX 1930 with the RCS software.

(C) Downranged Pressure Calibration
The unit will be provided with a pressure calibration certificate at your specified range (e.g., 17 mH_2O etc).

Accessories
A full range of accessories is available to enhance installation, operation and maintenance of the RTX 1930 Series as listed below:
- STE sensor termination enclosure (202-034-01)
- Long sink weight 0.7 in (17.5 mm) diameter (222-116-01)
- 1930 sink weight 1.18 in (30 mm) diameter (222-156-01)
- Cable clamp system (192-373-01)
- 360° rotatable calibration adaptor to:
  G1/8 (DA4112-3-01), 1/8 NPT (DA4112-4-01)
- Economical direct calibration adaptor to:
  G1/8 (DA2536-1-01), 1/8 NPT (DA2536-2-01)

Ordering Information
(1) Select model number
(2) If Option C is selected, please state calibrated range.

RTX1930 Base model number

Code	Pressure ranges	
03	2.5 mH_2O	8 ftH_2O
04	5 mH_2O	16 ftH_2O
05	10 mH_2O	33 ftH_2O
06	15 mH_2O	50 ftH_2O
07	20 mH_2O	66 ftH_2O
08	35 mH_2O	115 ftH_2O
09	50 mH_2O	160 ftH_2O
11	100 mH_2O	335 ftH_2O
12	150 mH_2O	500 ftH_2O
13	200 mH_2O	650 ftH_2O
14	350 mH_2O	1150 ftH_2O
15	700 mH_2O	2300 ftH_2O

Code	Units
m	meters
f	feet

Code	Options
A	Improved accuracy
B	PC configuration interface module
C	Down ranged pressure calibration
0	no option

RTX1930 — 06 — m — BC Typical model number

(3) Cable length required and units.

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920-366B

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PTX 500 SERIES

Industrial Pressure Transmitters

- **Hastelloy and stainless steel wetted parts**
- **Absolute and gauge configurations**
- **DIN pressure ranges or custom scaled**
- **Electrical and pressure connection options**
- **Intrinsically safe units available**
- **Low cost**

The PTX 500 series combines micro machined silicon diaphragms with fully welded stainless steel and Hastelloy pressure ports to provide a highly accurate, stable pressure transmitter with the materials and environmental protection required for industrial applications.

The silicon sensors incorporate developments derived from aerospace applications to improve output noise, non-linearity and hysteresis and long term stability.

Batch manufacturing ensures optimum pricing, with the ability to custom calibrate to alternate ranges and pressure units prior to completion with the required electrical connection and rapid despatch.

Detachable electrical connectors (not available on submersible units) provide access to the independent zero and span trim controls, and if a configuration change to the electrical or pressure connections are required on-site replacement parts and screw in pressure adaptors are available.

Each transmitter incorporates RFI/EMC and electrical spike protection, and Intrinsically Safe approved units are available as an option.

STANDARD SPECIFICATION

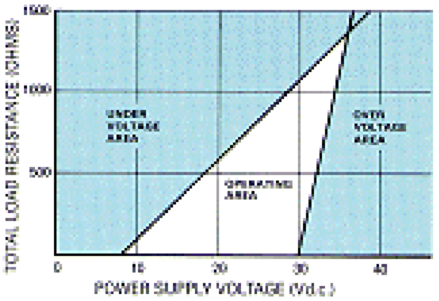
Operating Pressure Range
Any pressure unit and (zero based) span available between 250mbar and 700 bar full scale to gauge and absolute formats: spans down to 100mbar available in gauge format only.

Standard Ranges:
0 to 100, 160mbar (gauge only)
0 to 250, 400, 600mbar, 1, 1.6, 2.5, 4, 6, 10, 16, 25, 40, 60 bar gauge and absolute.
0 to 100, 160, 250, 400, 600, 700 bar sealed gauge and absolute.

Overpressure
The rated pressure can be exceeded by the following multiples without degrading performance:-
2 bar for ranges up to 600mbar
3 x for 1 bar to 40 bar ranges
2 x for ranges above 40 bar.

Pressure Media
Fluids compatible with a fully welded assembly of 316 stainless steel and Hastelloy C276 (NACE compatible grades).

Transmitter Supply Voltage
9-30V d.c.
This voltage must appear across the transmitter terminals.



Output Current
4-20mA (two-wire configuration) proportional for zero to full scale pressure.

Zero Offset and Span Setting
±0.05mA
±5% site adjustable by sealed, non-interacting potentiometers (resolution of potentiometers ±1 uA).
(PTX 530 not adjustable).

Combined Non-Linearity, Hysteresis and Repeatability
Terminal definition: The output will not deviate from the straight line connecting zero and full scale output by more than 0.3% F.S. (Typically 0. 15% F.S.).
Best straight line definition:
±0.2% F.S. (Typically ±0.1% F.S.)

Operating Temperature Range
Ambient: -20^{0} to $+80^{0}$C
Process media: -30^{0} to $+120^{0}$C
Storage: -40^{0} to $+125^{0}$C

Temperature Effects
For ranges of 400mbar and above the output will not deviate from room temperature calibration by more than:
1% F.S. over -10^{0} to $+50^{0}$C
2% F.S. over -20^{0} to $+80^{0}$C
Typically 0.7% F.S., -10^{0} to $+50^{0}$C
1.5% F.S., -20^{0} to $+80^{0}$C.
For ranges below 400mbar these values will increase pro-rata with calibrated span.

Weight
PTX 500 core: 330 gms, excluding optional electrical connections, cable etc.

Pressure Connection
$G^{1}/_{4}$ female
Screw-in male/male adaptors available (see accessories).

Electrical Connection
Versions available for IP50 to IP68 ratings (see ordering information).
Mating parts supplied with plug/socket versions (PTX 510 and 560)
1 metre integral cable supplied as standard on PTX 520 and PTX 530 models.
Longer lengths available on request.

Intrinsic Safety (Optional)
These transmitters can be certified for use with barrier systems to EEx is gas group IIC with a T4 rating for ambient temperatures up to 80^{0}C to BS5501 part 7 and Cenelec EN50 020.

Marine Approval
Certified for use in vessels classed with RINA (certificate 5/438/93).

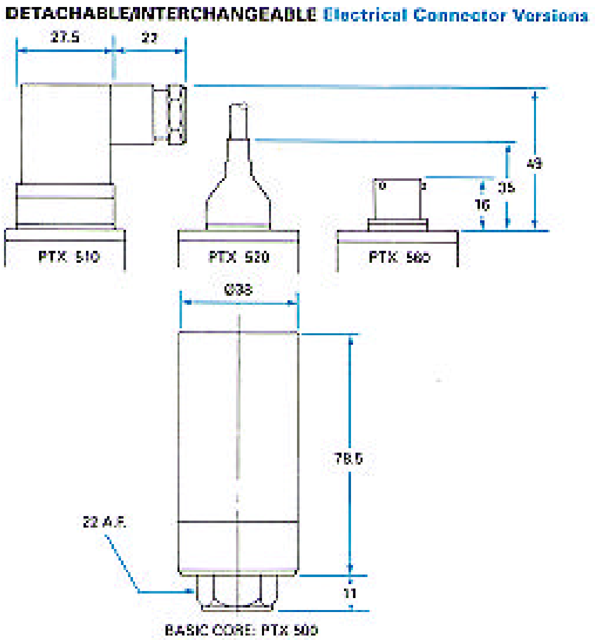
ACCESSORIES AVAILABLE TO ORDER:
Screw-in Male/Male Adaptors
$G^{1}/_{4}$ male (P/N 190-040)
$^{1}/_{4}$ NPT male (P/N 190-038)
$^{7}/_{16}$ UNF male (MS33656-4 compatible) (P/N 190-042)
M14 x 1.5 male (P/N 190-036)
G1/2 (pressure gauge connection) (P/N 190-039)
Adaptors manufactured in 316 stainless steel.
Bonded Seal (P/N 204-053)
To fit between transmitter and screw-in male/male adaptors (Nitrile and zinc plated steel).

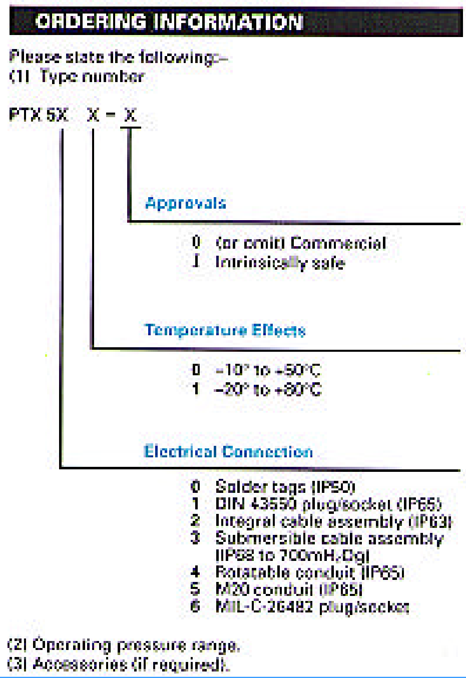
Cable (P/N 192-004)
For gauge ranges of 60 bar and below the PTX 510 requires this 6mm O.D. vented cable.

Continuing development sometimes necessitates specification changes without notice.

INSTALLATION DRAWINGS

Dimensions: mm





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I/A Series® Electronic Pressure Transmitters Model IDP10 with 4 to 20 mA Analog Output for Differential Pressure Measurement

IDP10
TRADITIONAL
STRUCTURE

IDP10
LOW PROFILE
STRUCTURE LP1

IDP10
LOW PROFILE
STRUCTURE LP2

This analog output, two-wire d/p Cell® Transmitter provides precise, reliable, measurement of differential pressure, and transmits a 4 to 20 mA analog output signal.

HIGH DEPENDABILITY AND VALUE

- Available with traditional or low profile structures.
- Superior Performance and long term stability from micoprocessor-based technology.
- Industry standard 316L ss, Co-Ni-Cr, Hastelloy C, Monel, or Tantalum sensor materials, depending on transmitter structure.
- Durable aluminum or 316 ss housing available; both meet NEMA 4X and IEC IP66.
- Optional mounting bracket sets allow pipe, surface, or manifold mounting of transmitter.
- CE marked; complies with applicable EMC, ATEX, and PED European Directives.
- Designed for hazardous area installations. Versions available to meet Agency flameproof and zone requirements.
- Standard 5-year warranty.

INTELLIGENT TRANSMITTER FEATURES AT AN ECONOMICAL PRICE

When you want the flexibility and performance of a configurable, intelligent transmitter but you don't need a digital output signal, these transmitters provide exceptional benefits at a very affordable price:

- Liquid Crystal Display (LCD) digital indicator with on-board pushbuttons
- Pushbutton configuration and calibration:
  - Linear or square root output
  - Adjustable damping
  - Forward or reverse output
  - Failsafe output; upscale or downscale
  - Reranging without applying pressure
- Easily upgradeable to fully intelligent version (FoxCom™, HART, FOUNDATION Fieldbus, or PROFIBUS)

invensys®
FOXBORO®

I/A Series PRESSURE TRANSMITTER FAMILY

This complete family of d/p Cell®, gauge, absolute, multirange, multivariable, and premium performance transmitters, as well as transmitters with remote or direct connect pressure seals, all using field-proven silicon strain gauge sensors and common topworks.

MODULAR ELECTRONICS

Select the electronics module you need to provide just the right level of intelligence for your application and budget. If your needs change, the modular design allows easy migration to other protocols — including FoxCom, HART FOUNDATION Fieldbus, PROFIBUS, and 1 to 5 V dc versions.

ELECTRONICS VERSION -A TRANSMITTER

This transmitter uses the -A electronics module. It is a very economical analog output transmitter that provides full configuration capability. It represents an Invensys Foxboro advancement in providing the greatest functionality for the largest number of applications at the least possible cost to you. It even provides the ability to rerange to new calibrated ranges, using the standard LCD Indicator, without the need to apply calibration pressure.

It is designed for use in Division 1 hazardous areas, and complies with Division 2 requirements. Also versions are available to meet Agency flameproof and zone requirements. See Electrical Safety Specifications section.

WIDE MEASUREMENT RANGE WITH A MINIMUM OF SENSORS

Five sensors are provided to cover measurement spans from 0.12 to 21 000 kPa (0.018 to 3000 psi). The high turndown capability of the transmitter means that nearly all applications can be satisfied with only these five ranges, greatly simplifying your spare transmitter and spare parts requirements.

STANDARD LCD DIGITAL INDICATOR

A two-line digital indicator, shown in Figure 17, is provided as standard with this transmitter. The indicator displays the measurement with a choice of units. Two on-board pushbuttons allow zero and span adjustments, as well as local configuration, without the need for a PC-Based Configurator.

SENSOR CORROSION PROTECTION

For traditional structure, choice of 316L ss, Co-Ni-Cr, Hastelloy C, Monel, Gold-Plated 316L ss, and Tantalum materials. High corrosion resistance of Co-Ni-Cr (TI 037-078) means long service life in many difficult applications without the extra cost for exotic materials. See TI 037-75b for process applicability with Co-Ni-Cr and other process wetted materials.

For low profile structures LP1 and LP2, 316L ss and Hastelloy C are offered as sensor materials. Refer to Transmitter Structures section that follows for description and application of traditional and low profile (LP1 and LP2) structures.

HIGH PERFORMANCE

These transmitters utilize microprocessor-based correction to achieve both excellent accuracy and ambient temperature compensation.

EASE OF INSTALLATION

<u>Rotatable Topworks</u> allows transmitter installation in tight places, allows indicator to be positioned in preferred direction, and eases field retrofit.

<u>Two Conduit Entrances</u> offer a choice of entry positions for ease of installation and self-draining of condensation regardless of mounting position and topworks rotation.

<u>Wiring Guides and Terminations</u> provide ease of wire entry and support, plenty of space to work and store excess wire, and large, rugged screw terminals for easy wire termination.

PROCESS CONNECTORS

Removable, gasketed process connectors allow a wide range of selections, including 1/4 NPT, 1/2 NPT, Rc 1/4, Rc 1/2, and weld neck connections. For highly corrosive chemical processes when a traditional structure is used, two 1/2 NPT pvdf inserts (Figure 1) are installed in both 316 ss covers and are used as the process connectors. In these applications, tantalum is used as the sensor diaphragm material.

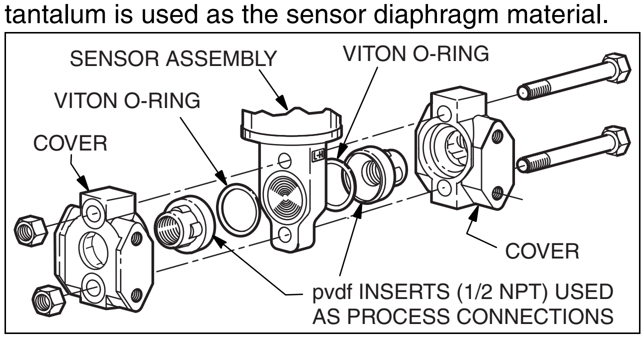


Figure 1. Bottomworks Shown with 1/2 NPT pvdf Inserts Installed in HI- and LO-Side Covers with Traditional Structure

OPTIONAL MOUNTING BRACKET SETS

In addition to the standard style mounting bracket sets optionally offered with these transmitters, a unique universal style mounting bracket has been developed to allow wide flexibility in transmitter mounting configurations consistent with installation requirements. All mounting bracket sets allow mounting to a surface, pipe, or manifold. Refer to Dimensions - Nominal section.

UNIQUE PROCESS COVER AND CELL BODY DESIGN

Biplanar Construction (Figure 2) maintains the traditional horizontal process connections and vertical mounting by providing a cell body contained between two process covers, while still achieving light weight, small size, and high standard static pressure rating of 25 MPa (3625 psi). This provides easy retrofit of any conventional differential pressure transmitter, and also is easily mounted in the horizontal position with vertical process connections, when required.

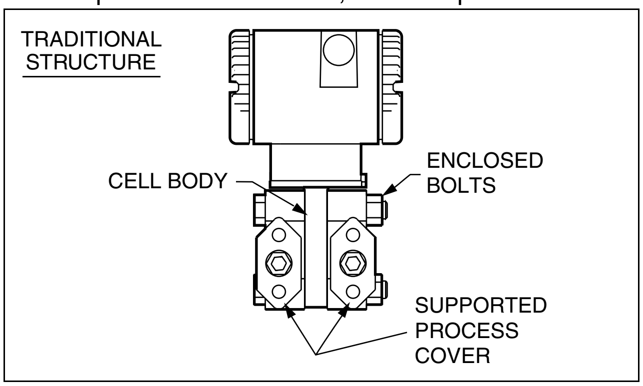


Figure 2. Biplanar Construction Shown with Traditional Horizontal Process Connections

Process Covers (Figure 2) are fully supported by the cell body over their entire height. This prevents bending and results in a highly reliable seal. Also, this provides dimensional stability to the process covers, ensuring that they will always mate properly with 3-valve bypass manifolds.

Process Cover Bolts (Figure 2) are enclosed to minimize corrosion and to minimize early elongation with rapid temperature increases. The design makes it less likely for the transmitter to release process liquid during a fire.

Process Cover Gaskets are ptfe as standard; ptfe provides nearly universal corrosion resistance, and eliminates the need to select and stock various elastomers to assure process compatibility.

Light Weight provides ease of handling, installation, and direct mounting without requiring costly pipe stands.

TRANSMITTER STRUCTURES

Traditional and low profile structures (LP1 and LP2) are offered to accommodate and to provide flexibility in transmitter installations. See paragraphs below.

Traditional Structure

The traditional structure (Figure 3) utilizes the right angle design common to most DP transmitters in use throughout the world. Process connections are oriented 90 degrees from the transmitter centerline. This traditional structure makes it easy to retrofit any transmitters of similar design.

Sensor cavity venting and draining is provided for both vertical and horizontal transmitter installation, using innovative tangential connections to the sensor cavity (Figures 4 and 5). Optional side vents are offered for sensor cavity venting in the upright position (Figure 6).

An extensive variety of process-wetted materials are available for the process covers on this highly versatile and widely used transmitter.

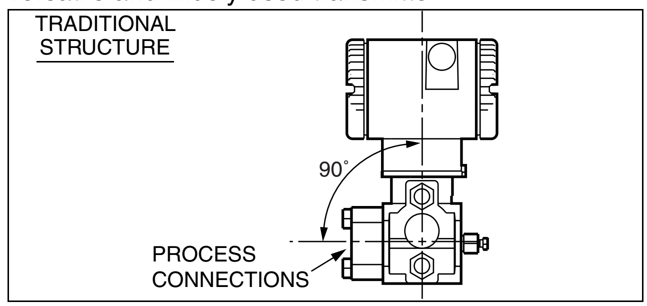


Figure 3. Vertical Mounting Showing Process Connections at 90 degrees

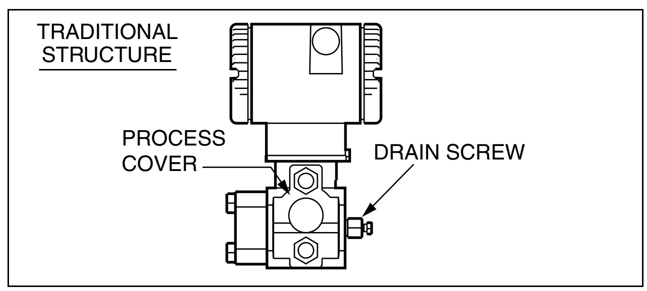


Figure 4. Vertical Mounting - Cavity Draining

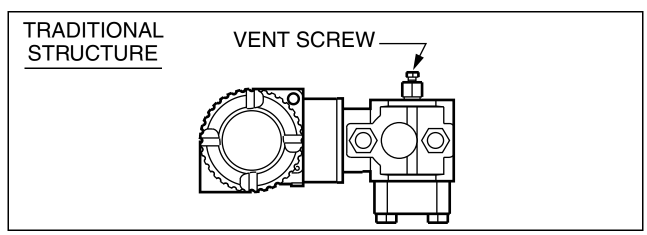


Figure 5. Horizontal Mounting - Cavity Venting, and Self-Draining into Process Line

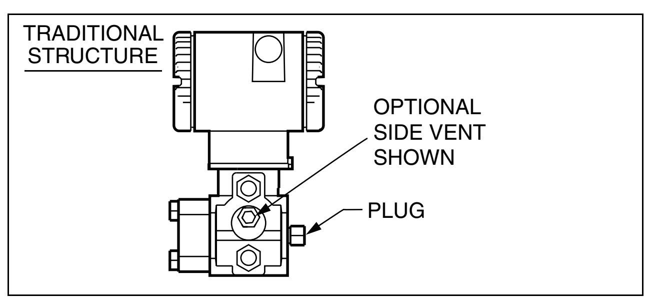


Figure 6. Vertical Mounting - Cavity Venting, and Self-Draining into Process Line

Low Profile Structures

The low profile structures utilize an in-line design, placing the process connections in line with the transmitter centerline (Figures 7 and 8). This allows mounting of the transmitter in the upright position with the process connections facing downward, for connection to vertical process piping or for mounting directly to a three- or five-valve manifold.

The low profile structures provide a mounting style similar to that used by competitive Coplanar™ transmitters. This makes it easy to select Foxboro transmitters for both retrofit and new applications where this type of installation is desired.

Transmitters with the low profile structure can be attached directly to existing, installed Coplanar manifolds, such as the Rosemount Model 305RC or Anderson Greenwood Models MC3, MC5G, MC5P, and MT3 by use of an optional adapter plate (Figure 9). Also, when assembled to the same process piping or manifold as a Coplanar transmitter, one of the electrical conduit connections is located within ± one inch of the similar conduit connection on the competitive transmitter, assuring ease of retrofit or conformance with installation design drawings.

All parts making up the low profile versions are identical to the parts in the traditional version except for the process covers and the external shape of the sensor cell body.

For user convenience, two types of low profile structures are offered, type LP1 and LP2. The process covers are the only transmitter parts that differ between structure types LP1 and LP2.

Refer to the sections that follow for further descriptions of low profile structures LP1 and LP2.

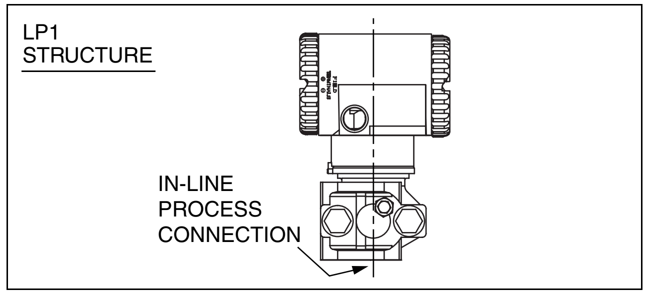


Figure 7. Low Profile Structure - LP1 Shown

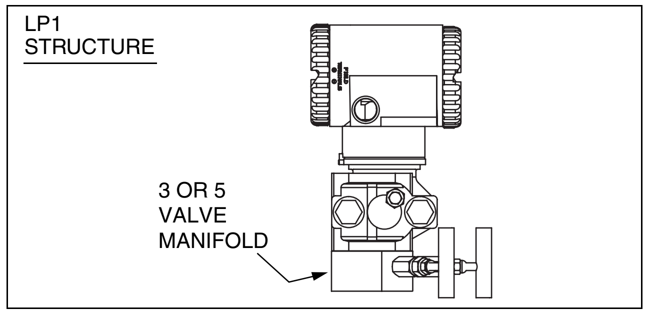


Figure 8. LP1 Shown Directly Mounted to Manifold

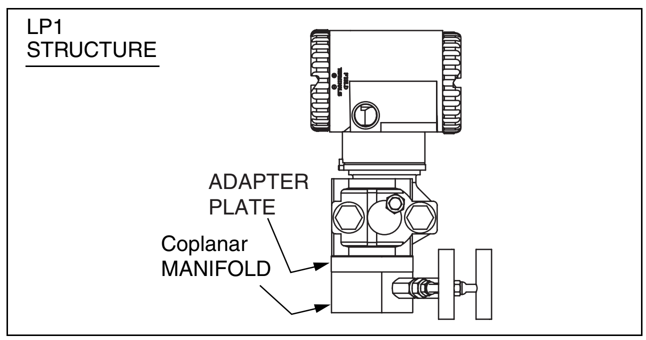


Figure 9. LP1 Shown Mounted to a Coplanar Manifold using an Optional Intermediate Adapter Plate

Low Profile Structure LP1 – Direct Mount

Low Profile Structure LP1 is a compact, inexpensive, lightweight design for direct mounting to a separately mounted manifold or process piping. These transmitters are not typically bracket-mounted.

They are supplied as standard with a single vent/drain screw in the side of each process cover. In conjunction with the standard tangential venting and draining design, they are suitable for mounting either vertically (Figure 10) or horizontally, and are suitable for nearly all applications, including liquids, gases, and steam. For horizontal installation, they can simply be “turned over” (rotated 180 degrees - Figures 11 and 12) to orient the high and low pressure sides in the preferred locations. There is no need to unbolt process covers. The topworks housing can also be rotated, as shown, to orient the conduit connections in the desired position.

In the vertical, upright position, they are also self-draining and are ideal for gas flow rate service, when directly mounted to a manifold located above the horizontal pipeline. The vent screw can be omitted for this or other applications, if desired.

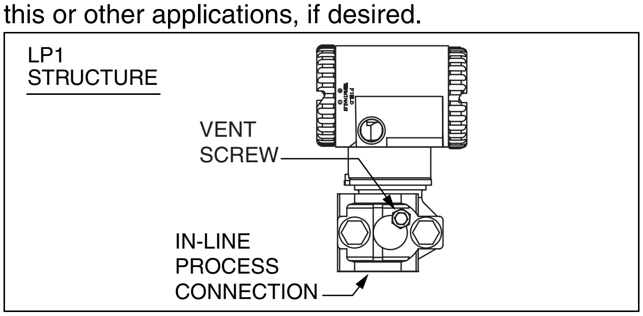


Figure 10. Upright Mounting

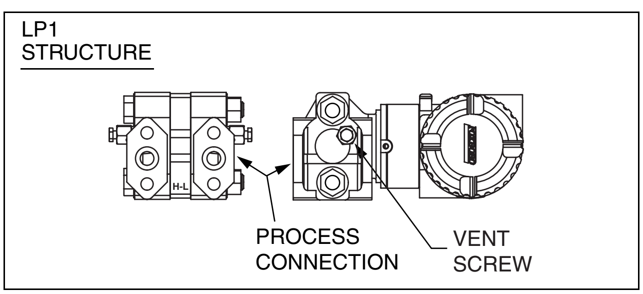


Figure 11. Horizontal Mounting with Vent Screw

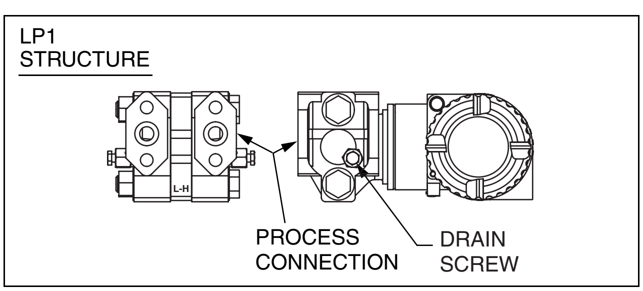


Figure 12. Horizontal Mounting with Drain Screw

Low Profile Structure LP2 - Bracket or Direct Mount

Low Profile Structure LP2 is a universal design for either bracket or direct mounting. Drilled and tapped mounting holes facilitate mounting to either new or existing Foxboro brackets (Options -M1, -M2, and -M3), as well as standard brackets supplied with existing Coplanar transmitters. See Figures 13 and 14.

These transmitters can also be directly mounted to manifolds or process piping and are available with the same optional adapter used with low profile structure LP1 to fit existing Coplanar manifolds (Figure 15).

For extra convenience, they use a full-featured vent and drain design, with separate vent and drain screws positioned in each cover for complete venting or draining directly from the sensor cavity. They are normally recommended for upright, vertical installation.

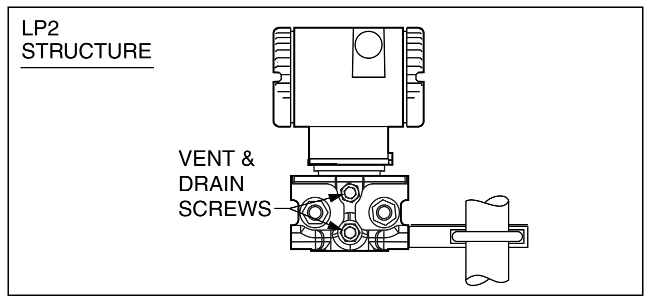


Figure 13. Shown on Foxboro Universal Bracket

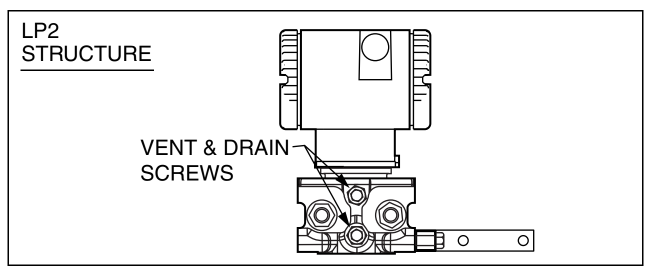


Figure 14. Shown on Coplanar Bracket

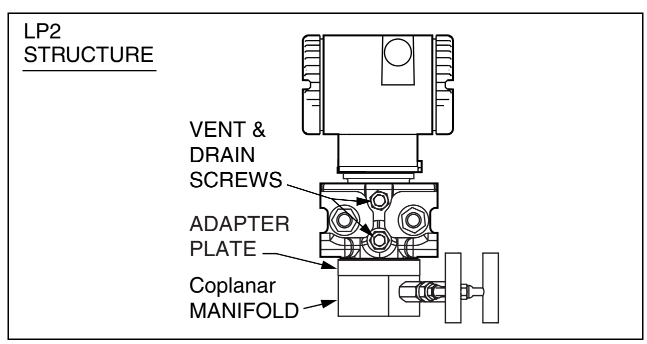


Figure 15. Adapter Mount to Existing Coplanar Manifold

PRESSURE SEALS

Pressure seals are used with transmitters having a traditional structure (see Transmitter Structures section above) when it is necessary to keep the transmitter isolated from the process. A sealed system is used for a process fluid that may be corrosive, viscous, subject to temperature extremes, toxic, sanitary, or tend to collect and solidify.

Table 1 lists the various pressure seals that can be used with an IDP10 Transmitter. To order a transmitter with seals, both a Transmitter Model Number and Seal Model Number are required. For a complete listing of pressure seal models and specifications, see PSS 2A-1Z11 A. Also see Figure 16 for typical pressure seal configurations.

Table 1. Pressure Seals Used with IDP10 Transmitters

Direct Connect Pressure Seal Assemblies		
Seal Model	**Seal Description**	**Process Connections**
PSFLT	Flanged, Direct Connect (Flanged Level), Flush or Extended Diaphragm	ANSI Class 150/300/600 flanges and BS/DIN PN 10/40, 10/16, 25/40 flanges
PSSCT	Sanitary, Direct Connect (Level Seal), Flush Diaphragm	Process Connection to Sanitary Piping with 2- or 3-inch Tri-Clamp
PSSST	Sanitary, Direct Connect (Level Seal), Extended Diaphragm	Process Connection to 2-in Mini Spud or 4-in Standard Spud; Tri-Clamp
Remote Mount, Capillary-Connected Pressure Seal Assemblies		
Seal Model	**Seal Description**	**Process Connections**
PSFPS	Flanged, Remote Mount, Flush Diaphragm	ANSI Class 150/300/600 flanges and BS/DIN PN 10/40 flanges
PSFES	Flanged, Remote Mount, Extended Diaphragm	ANSI Class 150/300/600 flanges and BS/DIN PN 10/40, 10/16, 25/40 flanges
PSFAR	Flanged, Remote Mount, Recessed Diaphragm	ANSI Class 150/300/600/1500 flanges
PSTAR	Threaded, Remote Mount, Recessed Diaphragm	1/4, 1/2, 3/4, 1, or 1 1/2 NPT internal thread
PSISR	In-Line Saddle Weld, Remote Mount, Recessed Diaphragm	Lower housing of seal is in-line saddle welded to nominal 3- or 4-inch (and larger) Pipe
PSSCR	Sanitary, Remote Mount, Flush Diaphragm	Process Connection secured with a Tri-Clamp to a 2- or 3-inch pipe
PSSSR	Sanitary, Remote Mount, Extended Diaphragm	Process Connection to 2-in Mini Spud or 4-in Standard Spud; Tri-Clamp

Figure 16. Typical IDP10 Pressure Seals

FUNCTIONAL SPECIFICATIONS

Span Limits for IDP10 d/p Cell Transmitters

Code	kPa	psi	mbar	mmHg	mmH_2O	inH_2O
A (a)	0.12 and 7.5	0.018 and 1.1	1.2 and 75	0.93 and 56	12 and 750	0.5 and 30
B	0.87 and 50	0.125 and 7.2	8.7 and 500	6.5 and 375	87 and 5000	3.5 and 200
C	7 and 210	1 and 30	70 and 2100	50 and 1500	700 and 21 000	28 and 840
Code	**MPa**	**psi**	**bar or kg/cm^2**	**mHg**	**mH_2O**	**ftH_2O**
D	0.07 and 2.1	10 and 300	0.7 and 21	0.5 and 15	7 and 210	23 and 690
E (b)	0.7 and 21(b)	100 and 3000 (b)	7 and 210 (b)	5 and 150 (b)	70 and 2100 (b)	230 and 6900 (b)

(a) Span Limit Code “A” not available when pressure seals are selected.
(b) When certain options are specified, the upper span and range limits are reduced as shown in the “Options Impact” table below.

Range Limits for IDP10 d/p Cell Transmitters (a)

Code	kPa	psi	mbar	mmHg	mmH_2O	inH_2O
A (b)	-7.5 and +7.5	-1.1 and +1.1	-75 and +75	-56 and +56	-750 and +750	-30 and +30
B	-50 and +50	-7.2 and +7.2	-500 and +500	-375 and +375	-5000 and +5000	-200 and +200
C	-210 and +210	-30 and +30	-2100 and +2100	-150 and +150	-21 000 and +21 000	-840 and +840
Code	**MPa**	**psi**	**bar or kg/cm^2**	**mHg**	**mH_2O**	**ftH_2O**
D	-0.21 and +2.1	-30 and +300	-2.1 and +21	-1.5 and +15	-21 and +210	-69 and +690
E (c)	-0.21 and 21 (c)	-30 and +3000 (c)	-2.1 and +210 (c)	-1.5 and +150 (c)	-21 and +2100 (c)	-69 and +6900 (c)

(a) Positive values indicate HI side of sensor at the high pressure, and negative values indicate LO side of sensor at the high pressure.
(b) Span Limit Code “A” not available when pressure seals are selected.
(c) When certain options are specified, the upper span and range limits are reduced as shown in the “Options Impact” table below.

Impact of Certain Options on Span and Range Limits (a)

Option	Description (Also see Model Code)	Span and Range Limits Derated to:
-B3	B7M Bolts and Nuts (NACE)	20 MPa (2900 psi, 200 bar, or kg/cm^2)
-D1	DIN Construction	16 MPa (2320 psi, 160 bar or kg/cm^2)
-D5 or -B1	DIN Construction or 316 ss Bolting	15 MPa (2175 psi, 150 bar or kg/cm^2)
-D2, -D4, -D6, or -D8 (a)	DIN Construction (a)	10 MPa (1500 psi, 100 bar or kg/cm^2) (a)

(a) Refer to Model Code section for application and restrictions related to the items listed in the table.

Maximum Static and Proof Pressure Ratings for IDP10 d/p Cell Transmitters (a)

Transmitter Configuration (See Model Code for Description of Options)	Static Pressure Rating			Proof Pressure Rating (b)		
	MPa	psi	bar or kg/cm^2	MPa	psi	bar or kg/cm^2
With Option -D9 or -Y	40	5800	400	100	14500	1000
Standard or with Option -B2, -D3, or -D7	25	3625	250	100	14500	1000
With Option -B3	20	2900	200	70	11150	700
With Option -D1	16	2320	160	64	9280	640
With Option -B1 or -D5	15	2175	150	60	8700	600
With Option -D2, -D4, -D6, or -D8	10	1500	100	40	6000	400
With Structure Codes 78 and 79 (pvdf insert)	2.1	300	21	8.4	1200	84

(a) Refer to Model Code section for application and restrictions related to the items listed in the table.
(b) Proof pressure ratings meet ANSI/ISA Standard S82.03-1988. Unit may become nonfunctional after application of proof pressure.

Output Signal
4 to 20 mA, Linear or Square Root (Configurable)

Electrically Adjustable Damping
Response time is normally 0.75 s, or setting of 0 (none), 2, 4, or 8 seconds, whichever is greater, for a 90% recovery from an 80% input step per ANSI/ISA S51.1. (For 63.2% recovery, 0.50 s with sensors B to E, and 0.60 s with sensor A.)

Suppressed Zero and Elevated Zero
Suppressed or elevated zero ranges are acceptable as long as Span and Range limits are not exceeded.

Field Wiring Reversal
No transmitter damage.

Zero and Span Adjustments (Figure 17)
Zero and span adjustments can be accomplished using the pushbuttons on the LCD indicator.

FUNCTIONAL SPECIFICATIONS (Cont.)

Standard Liquid Crystal Display (LCD) Indicator with On-Board Pushbuttons (Figure 17)

Indicator Provides:

- Two Lines; four numeric characters on top line and seven alphanumeric characters on bottom line.
- Measurement Readout; value on top line and units label on bottom line.
- Configuration and Calibration Prompts.

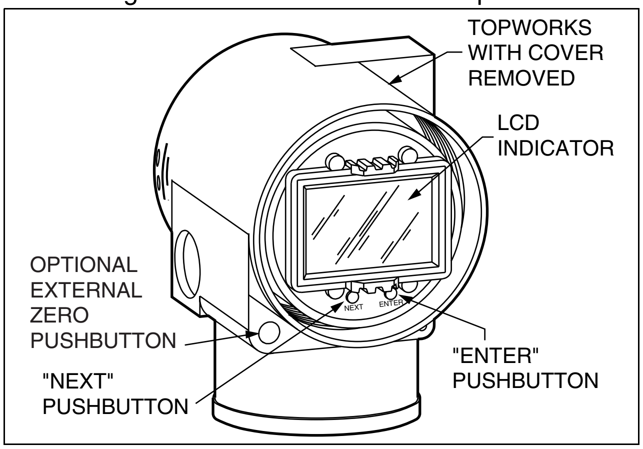


Figure 17. LCD Indicator with Pushbuttons

Optional External Zero Adjustment (Figure 17)

An external pushbutton mechanism is isolated from the electronics compartment and activates (magnetically) an internal reed switch through the housing. This eliminates a potential leak path for moisture or contaminants to get into the electronics compartment. The optional external zero adjustment can be disabled by a configuration selection.

European Union Directives

- Complies with Electromagnetic Compatibility Requirements of European EMC Directive 89/336/EEC by conforming to the following CENELEC and IEC Standards: EN 50081-2, EN 50082-2, and IEC 801-2 through 801-6.
- Complies with NAMUR Part 1 Interference Immunity Requirement.
- Conforms to Applicable European Union Directives ("CE" Logo marked on product).

Square Root Low Flow Cutoff

User configurable to provide:

- Cutoff to zero at flows <10% of maximum flow (1% of maximum differential pressure).
- Or active point-to-point line between zero and 20% of maximum flow (4% of maximum differential pressure).

Supply Voltage Requirements and External Loop Load Limitations (Figure 18)

Nominal minimum voltage shown in Figure 18 is 11.5 V dc. This can be reduced to 11 V dc using a plug-in jumper across the test receptacles in the field wiring compartment terminal block. An optional plug-in shorting bar (Figure 21) is offered for this purpose.

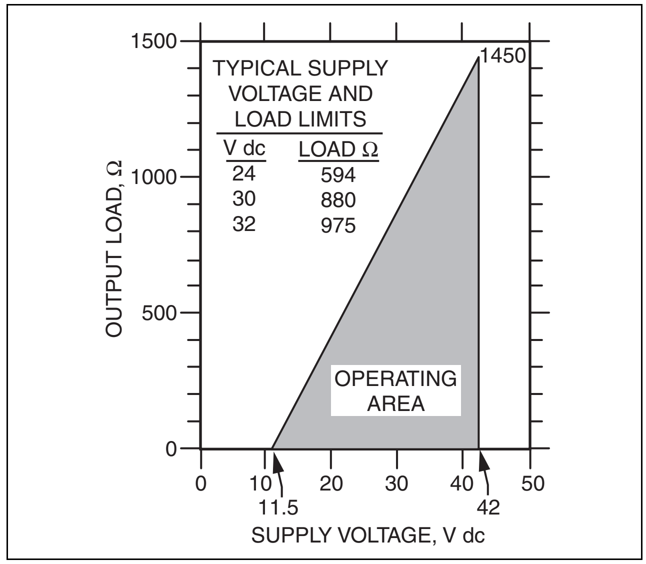


Figure 18. Supply Voltage vs. Output Load

Minimum Allowable Absolute Pressure vs. Transmitter Temperature

WITH SILICONE FILL FLUID

Full vacuum: up to 121°C (250°F)

WITH FLUORINERT FILL FLUID

Refer to Figure 19.

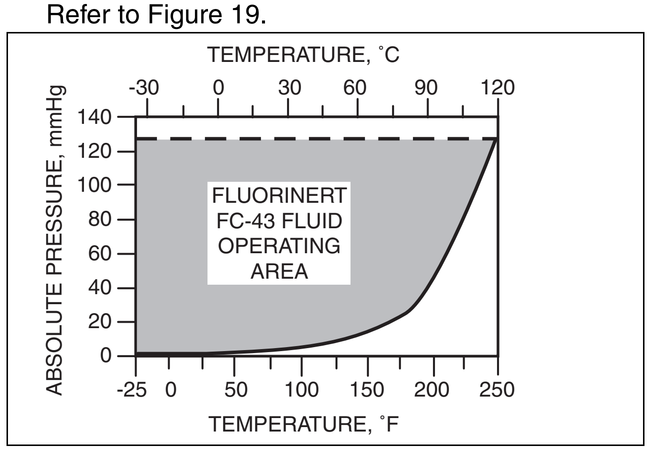


Figure 19. Minimum Allowable Absolute Pressure vs. Transmitter Temperature, Fluorinert FC-43, 2.6 cSt at 25°C (77°F)

Configuration and Calibration Data, and Electronics Upgradeability

Factory characterization, user configuration, and calibration data are stored in the sensor (see Figure 20). Therefore the electronics module can be replaced or changed from one type to another.

A module may be replaced without the need for reconfiguration or recalibration. Although module replacement can affect accuracy up to 0.20% of span, this error can be removed by an mA trim without application of pressure.

Changing module types may require reconfiguration and recalibration, as well as a different terminal block, if applicable, but all factory characterization data is retained.

Optional Custom Configuration (Option -C2)

For the transmitter to be custom configured by the factory, the user must fill out a data form. If this option is not selected, a standard (default) configuration will be provided; see Table 2 for allowable pressure units, and Table 3 for an example of Configuration Option -C2.

Table 2. Allowable Pressure Units for Calibrated Range (a)

inH_2O	psi	Pa	atm	g/cm^2
ftH_2O	inHg	kPa	bar	kg/cm^2
mmH_2O	mmHg	MPa	mbar	torr

(a) Displayed in upper case only on transmitter.

Table 3. Example of Configuration Option -C2

Parameter	Standard (Default) Configuration	Example of Configuration Option -C2
Calibrated Range		
• Pressure Units	per S.O.(a)	INH2O (a)
• LRV	per S.O.	0
• URV	per S.O.	100
Output Mode	Linear	Square Root
Output Direction	Forward	Forward
Damping	None	2
Failsafe Action	Upscale	Downscale
Ext. Zero Option	Enabled	Disabled
Other:		
If Linear:		
• Label (2nd line)	(b)	INH2O (b)
• Display LRV	(c)	0 (c)
• Display URV	(c)	100 (c)
If Square Root:		
• Label (2nd line)	%	GPM (d)
• Display LRV	0	0
• Display URV	100	500 (e)

(a) Select from list in Table 2.
(b) Same as units selected for calibrated range, or percent.
(c) Same as calibrated range, or 0 and 100 for percent.
(d) Up to 7 letters (upper case), numbers, or available symbols.
(e) Any value between and including -9999 and 9999.

NOTE: There is a maximum of 4 digits for entering range values.

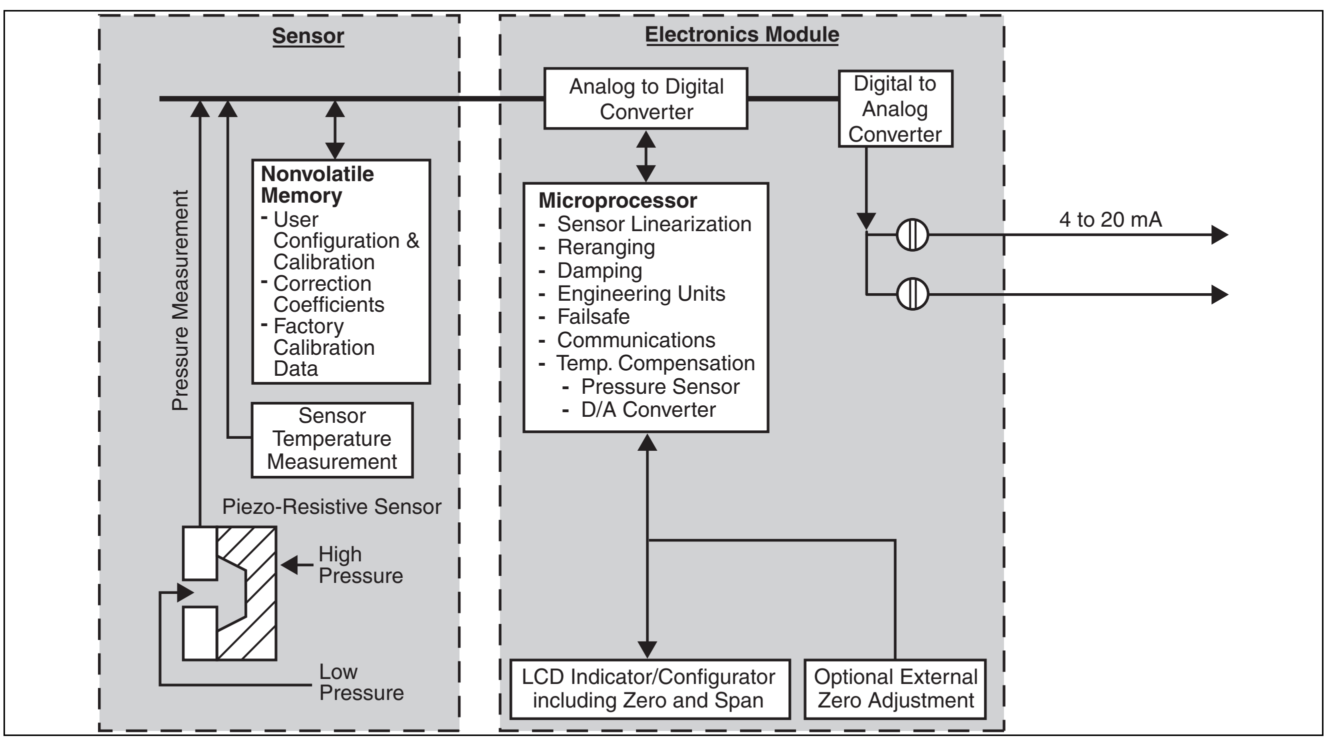


Figure 20. Transmitter Functional Block Diagram

OPERATING, STORAGE, AND TRANSPORTATION CONDITIONS

Influence	Reference Conditions	Normal Operating Conditions (a)	Operative Limits (a)	Transportation/ Storage Limits
Process Connection Temp. • with Silicone Fill Fluid • with Fluorinert Fill Fluid	 • 24 ±2°C (75 ±3°F) • 24 ±2°C (75 ±3°F)	 • -29 to + 82°C (-20 to +180°F) • -29 to + 82°C (-20 to +180°F)	 • -46 and +121°C (b) (-50 and +250°F) (b) • -29 and +121°C (-20 and +250°F)	 • Not Applicable • Not Applicable
Electronics Temperature (c)	• 24 ±2°C (75 ±3°F)	• -29 to + 82 °C (g) (-20 to +180 °F) (g)	• -40 and +85°C (b)(g) (-40 and +185°F) (b)(g)	• -54 and +85°C (-65 and +185°F)
Relative Humidity (d)	50 ±10%	0 to 100%	0 and 100%	0 and 100% Noncondensing
Supply Voltage – mA Output	30 ±0.5 V dc	11.5 to 42 V dc (e)	11.5 and 42 V dc (e)	Not Applicable
Output Load – mA Output	650 Ω	0 to 1450 Ω	0 and 1450 Ω	Not Applicable
Vibration	1 m/s^2 (0.1 "g")	6.3 mm (0.25 in) Double Amplitude: from 5 to 15 Hz with Aluminum Housing and from 5 to 9 Hz with 316 ss Housing 0 to 30 m/s^2 (0 to 3 "g") from 15 to 500 Hz with Aluminum Housing; and 0 to 10 m/s^2 (0 to 1 "g") from 9 to 500 Hz with 316 ss Housing		11 m/s^2 (1.1 "g") from 2.5 to 5 Hz (in Shipping Package)
Mounting Position	Upright or Horizontal (f)		No Limit	Not Applicable

(a) When Structure Codes 78/79 (pvdf inserts in Hi- and Lo-side process covers) are used, maximum overrange is 2.1 MPa (300 psi), and temperature limits are -7 and +82°C (20 and 180°F); when DIN Construction Options D2/D4/D6/D8 are used, temperature limits are 0 and 60°C (32 and 140°F).
(b) Selection of Option -J extends the low temperature operative limit of transmitters with silicone filled sensors down to -50°C (-58°F).
(c) The operative limits of the standard LCD Indicator are -29 and +85°C (-20 and +185°F), and the normal operating conditions are -20 to +82°C (-4 to +180°F). Although the LCD Indicator will not be damaged at any temperature within the "Storage and Transportation Limits", updates will be slowed and readability decreased at temperatures outside the "Normal Operating Conditions".
(d) With topworks cover on and conduit entrances sealed.
(e) 11.5 V dc can be reduced to 11 V dc by using a plug-in shorting bar; see "Supply Voltage Requirements" section and Figure 18.
(f) Sensor process wetted diaphragms in a vertical plane.
(g) Refer to the Electrical Safety Specifications section for a restriction in ambient temperature with certain electrical certifications.

PERFORMANCE SPECIFICATIONS

(Zero-Based Calibrations; Co-Ni-Cr or 316L ss Sensor with Silicone Fluid; Under Reference Operating Conditions unless otherwise specified; URL = Upper Range Limit; Span = Calibrated Span.)

Accuracy (includes Linearity, Hysteresis, and Repeatability)

±0.20% of Span. See Table 4 for Small Span Accuracy.

Table 4. Accuracy with Small Spans

For Span Code	If Span is:	Then Small Span Accuracy in % of Span is:
B	<5% of URL	$\pm\left[(0.10) + (0.005)\left(\frac{\text{URL}}{\text{Span}}\right)\right]$
A, C, D, E	<6.7% of URL	$\pm\left[(0.10) + (0.0067)\left(\frac{\text{URL}}{\text{Span}}\right)\right]$

Stability

Long term drift is less than ±0.05% of URL per year over a 5-year period.

Calibration Frequency

The calibration frequency is five years. The five years is derived using the values of allowable error (% span), TPE (% span), performance margin (% span), and stability (% span/month); where:

$$\text{Calibration Frequency} = \frac{\text{Performance Margin}}{\text{Stability}} = \text{Months}$$

RFI Effect

The output error is less than 0.1% of span for radio frequencies in the range of 27 to 1000 MHz and field intensity of 30 V/m when the transmitter is properly installed with shielded conduit and grounding, and housing covers are in place. (Per IEC Std. 61000-4-3.)

Vibration Effect

Total effect is ±0.2% of URL per “g” for vibrations in the frequency range of 5 to 500 Hz; with a double amplitude (DA) of 6.3 mm (0.25 in) in the range of 5 to 15 Hz, or accelerations of 3 “g” in the range of 15 to 500 Hz, whichever is smaller, for transmitter with aluminum housing; and with a DA of 6.3 mm (0.25 in) in the range of 5 to 9 Hz, or accelerations of 1 “g” in the range of 9 to 500 Hz, whichever is smaller, for transmitter with 316 ss housing.

Supply Voltage Effect

The output changes less than 0.005% of calibrated span for each 1 V change within the specified supply voltage requirements.

Position Effect

The transmitter may be mounted in any position. Any zero effect caused by the mounting position can be eliminated by rezeroing. There is no span effect.

Static Pressure Effect

The zero and span shift for a 7 MPa, 1000 psi change in static pressure is:

ZERO SHIFT (a)

Span Code	Zero Shift-Static Pressure Effect
A	±0.30% URL (b)
B and C	±0.10% URL
D	±0.50% URL (b)
E	±0.50% URL

(a) Can be calibrated out by zeroing at nominal line pressure.

(b) Per 3.5 MPa (500 psi) for Span Codes A and D.

SPAN SHIFT

±0.25% of Reading (±0.30% for Span Code A)

Switching and Indirect Lightning Transients

The transmitter can withstand a transient surge up to 2000 V common mode or 1000 V normal mode without permanent damage. The output shift is less than 1.0%. (Per ANSI/IEEE C62.41-1980 and IEC Std. 61000-4-5.)

Ambient Temperature Effect

Total effect for a 28°C (50°F) change within Normal Operating Condition limits is:

Span Code	Specification
A (a)	±(0.18% URL + 0.15% Span)
B and C	±(0.03% URL + 0.20% Span)
D	±(0.05% URL + 0.18% Span)
E	±(0.08% URL + 0.15% Span)

(a) Span Code A specifications apply to a transmitter with a stainless steel sensor only.

NOTE

For additional ambient temperature effect when pressure seals are used, see PSS 2A-1Z11 A.

PHYSICAL SPECIFICATIONS

Process Cover and Connector Material (Process Wetted)
Carbon Steel, 316 ss, Monel, Hastelloy C, or pvdf (Kynar) inserts in 316 ss covers for transmitter traditional structure; and 316 ss for transmitter low profile structures. For exceptional value and corrosion resistance, 316 ss is the least expensive material.

Process Cover and Process Connection Gaskets
Glass filled ptfe, or Viton when Structure Codes 78/79 (pvdf inserts) are used.

Process Cover Bolts and Nuts
ASTM A193, Grade B7 high strength alloy steel for bolts, and ASTM A194 Grade 2H high strength alloy steel for nuts are standard. Options include NACE Class B7M bolting, 17-4 ss bolting, and 316 ss bolting.

Sensor Material (Process Wetted)
Co-Ni-Cr, 316 L ss, Gold-Plated 316L ss, Monel, Hastelloy C, or Tantalum for transmitter traditional structure; and 316L ss or Hastelloy C for transmitter low profile structures. For exceptional value and corrosion resistance, 316L ss is the least expensive material. Refer to TI 037-078 and TI 37-75b for information regarding the corrosion resistance of Co-Ni-Cr and other sensor materials.

Sensor Fill Fluids
Silicone Oil or Fluorinert (FC-43)

Environmental Protection
Transmitter is dusttight and weatherproof per IEC IP66 and provides the environmental and corrosion resistant protection of NEMA Type 4X.

Electronics Housing and Housing Covers
Housing has two compartments to separate the electronics from the field connections. The housing and covers are made from low copper, die-cast aluminum alloy with an epoxy finish, or from 316 ss. Buna-N O-ring seals are used to seal the threaded housing covers, housing neck, and terminal block.

Electrical Connections
Field and RTD sensor wires enter through 1/2 NPT, PG 13.5, or M20 threaded entrances, as specified, on either side of the electronics housing. Wires terminate under screw terminals and washers on terminal block in the field terminal compartment. Unused entrance is plugged to insure moisture and RFI/EMI protection. See Figure 23.

Electronics Module
Printed wiring assemblies are conformally coated for moisture and dust protection.

Mounting Position
The transmitter may be mounted in any orientation.

Approximate Mass (with Process Connectors)
4.2 kg (9.2 lb) – with Traditional Structure
Add 0.1 kg (0.2 lb) – with Low Profile Structure LP1
Add 0.8 kg (1.8 lb) – with Low Profile Structure LP2
Add 1.1 kg (2.4 lb) – with 316 ss Housing
Add 0.2 kg (0.4 lb) – with LCD Indicator Option

Dimensions
See “Dimensions - Nominal” section and Dimensional Print DP 020-446.

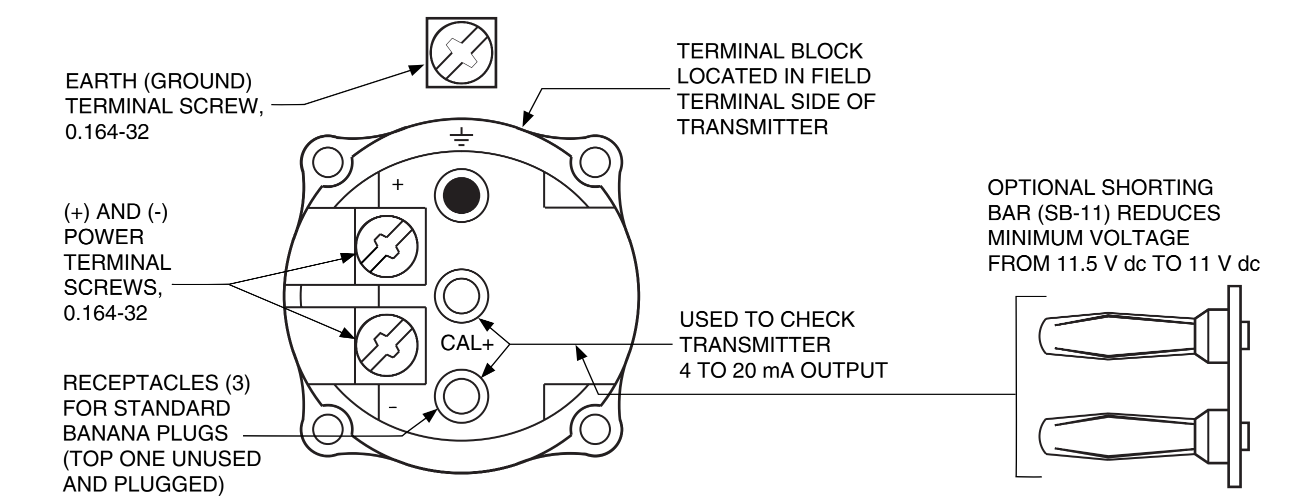


Figure 21. Field Terminal Block

ELECTRICAL SAFETY SPECIFICATIONS

<table>
<tr><th>Testing Laboratory,
Types of Protection,
and Area Classification</th><th>Application Conditions</th><th>Electrical Safety Design Code</th></tr>
<tr><td>ATEX flameproof: II 2 GD, EEx d IIC, Zone 1.</td><td>Temperature Class T6, Ta = -40 to +80°C.</td><td>D</td></tr>
<tr><td>CSA explosionproof for Class I, Division 1, Groups B, C, and D; dust-ignitionproof for Class II, Division 1, Groups E, F, and G; Class III, Division 1.</td><td>Maximum Ambient Temperature 85°C.</td><td rowspan="2">C</td></tr>
<tr><td>CSA for Class I, Division 2, Groups A, B, C, and D; Class II, Division 2, Groups F and G; Class III, Division 2.</td><td>Temperature Class T6 at 40°C and T4A at 85°C maximum ambient.</td></tr>
<tr><td>CSA field device zone certified flameproof Ex d IIC. Also, all certifications of Code C above.</td><td>Maximum Ambient Temperature 85°C.</td><td>B</td></tr>
<tr><td>FM explosionproof for Class I, Division 1, Groups B, C, and D; dust-ignitionproof for Class II, Division 1, Groups E, F, and G; Class III, Division 1.</td><td>Temperature Class T6 at 80°C and T5 at 85°C maximum ambient.</td><td rowspan="2">F</td></tr>
<tr><td>FM nonincendive for Class I, Division 2, Groups A, B, C, and D; Class II, Division 2, Groups F and G; Class III, Division 2.</td><td>Temperature Class T4A at 40°C and T4 at 85°C maximum ambient.</td></tr>
<tr><td>FM field device zone approved flameproof AEx d IIC. Also, all certifications of Code F above.</td><td>Temperature Class T6 at 80°C and T5 at 85°C maximum ambient.</td><td>G</td></tr>
<tr><td>IECEx flameproof: Ex d IIC.</td><td>T6, Ta = 80°C; T5, Ta = 85°C; Ambient Temperature -20 to +85°C.</td><td>V</td></tr>
</table>

MODEL CODE

Description	Model
Description	**Model**
I/A Series, Electronic d/p Cell Transmitter for Differential Pressure Measurement	IDP10
Electronics Versions and Output Signal	
Analog; 4 to 20 mA dc (Version -A)	-A
Structure Code - Select from one of the following six groups:	
1. **Transmitter with Traditional Structure**	

Covers	Sensor	Fill Fluid	Model
Steel	Co-Ni-Cr	Silicone	10
Steel	Co-Ni-Cr	Fluorinert	11
Steel	316L ss	Silicone	12
Steel	316L ss	Fluorinert	13
Steel	Hastelloy C	Silicone	16
Steel	Hastelloy C	Fluorinert	17
316 ss	Co-Ni-Cr	Silicone	20
316 ss	Co-Ni-Cr	Fluorinert	21
316 ss	316L ss	Silicone	22
316 ss	316L ss	Fluorinert	23
316 ss	316L ss, Gold Plated	Silicone	2G
316ss	Monel	Silicone	24
316 ss	Monel	Fluorinert	25
316 ss	Hastelloy C	Silicone	26
316 ss	Hastelloy C	Fluorinert	27
Monel	Monel	Silicone	34
Monel	Monel	Fluorinert	35
Hastelloy C	Hastelloy C	Silicone	46
Hastelloy C	Hastelloy C	Fluorinert	47
Hastelloy C	Tantalum	Silicone	48
Hastelloy C	Tantalum	Fluorinert	49
pvdf Insert (Kynar)	Tantalum	Silicone (Used w/Process Connector Type 7)	78 (a)
pvdf Insert (Kynar)	Tantalum	Fluorinert (Used w/Process Connector Type 7)	79 (a)

2. **Transmitter with Low Profile Structure LP1 (Not available with Pressure Seals)**

Covers	Sensor	Fill Fluid	Model
316 ss	316L ss	Silicone	LL
316 ss	316L ss	Fluorinert	LM
316 ss	Hastelloy C	Silicone	LC
316 ss	Hastelloy C	Fluorinert	LD

3. **Transmitter with Low Profile Structure LP2 (Not available with Pressure Seals)**

Covers	Sensor	Fill Fluid	Model
316 ss	316L ss	Silicone	52
316 ss	316L ss	Fluorinert	53
316 ss	Hastelloy C	Silicone	56
316 ss	Hastelloy C	Fluorinert	57

4. **Transmitter prepared for Foxboro Model Coded Remote Mount Seals (b)(c)**

Description	Model
Transmitter prepared for Remote Seals on Both HI and LO Sides, Silicone Fill in Sensor	S1
Transmitter prepared for Remote Seals on Both HI and LO Sides, Fluorinert Fill in Sensor	S2
Transmitter prepared for Remote Seal HI Side, 1/2 NPT Connector LO Side, Silicone Fill in Sensor	S3
Transmitter prepared for Remote Seal HI Side, 1/2 NPT Connector LO Side, Fluorinert Fill in Sensor	S4
Transmitter prepared for Remote Seal LO Side, 1/2 NPT Connector HI Side, Silicone Fill in Sensor	S5
Transmitter prepared for Remote Seal LO Side, 1/2 NPT Connector HI Side, Fluorinert Fill in Sensor	S6

Model Code continued on next page

IDP10 DIFFERENTIAL PRESSURE TRANSMITTERS (Cont.)

MODEL CODE (Cont.)

5. Transmitter Prepared for Foxboro Model Coded Direct Connect Seals (b)	
PSFLT, PSSCT, or PSSST Direct Connect Seal on HI Side; 1/2 NPT Process Connector LO Side; Silicone Fill	F1
PSFLT, PSSCT, or PSSST Direct Connect Seal on HI Side; 1/2 NPT Process Connector LO Side; Fluorinert Fill	F2
PSFLT, PSSCT, or PSSST Direct Connect Seal on HI Side; Remote Seal with Capillary LO Side; Silicone Fill	F3
PSFLT, PSSCT, or PSSST Direct Connect Seal on HI Side; Remote Seal with Capillary LO Side; Fluorinert Fill	F4
6. Transmitter Prepared for non-Foxboro Seals	
Remote Seals on High and Low Sides; Silicone Fill in Sensor	SA
Remote Seals on High and Low Sides; Inert Fill in Sensor	SB
Remote Seal on High Side and 1/2 NPT Connector on Low Side, Silicone Fill in Sensor	SC
Remote Seal on High Side and 1/2 NPT Connector on Low Side, Inert Fill in Sensor	SD
Remote Seal on Low Side and 1/2 NPT Connector on High Side, Silicone Fill in Sensor	SE
Remote Seal on Low Side and 1/2 NPT Connector on High Side, Inert Fill in Sensor	SF

Span Limits (Differential Pressure Units)

kPa	inH$_2$O	mbar	
0.12 and 7.5	0.5 and 30	1.2 and 75	A (e)
0.87 and 50	3.5 and 200	8.7 and 500	B
7 and 210	28 and 840	70 and 2100	C
MPa	**psi**	**bar or kg/cm^2**	
0.07 and 2.1	10 and 300	0.7 and 21	D
0.7 and 21	100 and 3000	7 and 210	E (f)

Process Connector Type (Material Same as Process Cover Material) (g)	
See below:	0
• For d/p: No connectors; both covers tapped for 1/4 NPT (316 ss only, no side vents)	
• Flange Mount Hi Side: 1/2 NPT, 316 ss Process Connector on Lo Side (F1 and F2 only)	
• Flange Mount Hi Side: No connectors; both sides prepared for seals (F3 and F4 only)	
• Two Remote Seals: No connectors; both covers tapped for capillary connection (S1, S2, SA, SB only)	
• One Remote Seal: 1/2 NPT, 316 ss Process Connector on side opposite seal (S3 to S6, SC to SF only)	
1/4 NPT, Not with Structure Codes 46 to 49, 78, 79; or pressure seals	1
1/2 NPT, Not with Structure Codes 78 or 79, or pressure seals	2
Rc 1/4, Not with Structure Codes 46 to 49, 78, 79; or pressure seals	3
Rc 1/2, Not with Structure Codes 78 or 79, or pressure seals	4
1/2 Schedule 80 Welding Neck, Not with Structure Codes 46 to 49, 78, 79; or pressure seals	6
None; pvdf Insert tapped for 1/2 NPT/Process Inlet on Side of 316 ss Process Covers (only with 78/79 above)	7
Conduit Connection and Housing Material	
1/2 NPT Conduit Connection, Aluminum Housing	1
PG 13.5 Conduit Connection, Aluminum Housing (With Electrical Safety Code D only)	2
1/2 NPT Conduit Connection, 316 ss Housing	3
PG 13.5 Conduit Connection, 316 ss Housing (With Electrical Safety Code D only)	4
M20 Conduit Connection, Both Sides, Aluminum Housing (With Electrical Safety Code D only)	5
M20 Conduit Connection, Both Sides, 316 ss Housing (With Electrical Safety Code D only)	6
Electrical Safety (Also see Electrical Safety Specifications section)	
ATEX II 2 GD, EEx d IIC, Zone 1 (d)	D
CSA Certified Division 1 explosionproof, dust-ignitionproof; and Division 2, Classes I, II, and III	C
CSA zone certified Ex d IIC; also all certifications of Code C above (d)	B
FM approved, Division 1 explosionproof, dust-ignitionproof; and Division 2 nonincendive	F
FM zone approved AEx d IIC; also all approvals of Code F above (d)	G
IECEx flameproof: Ex d IIC	V

Model Code continued on next page

IDP10 DIFFERENTIAL PRESSURE TRANSMITTERS (Cont.)

MODEL CODE (Cont.)

Optional Selections	
Refer to Optional Selections below.	
Mounting Bracket Set (h)	
Standard Style Painted Steel Bracket with Plated Steel Bolts	-M1
Standard Style Stainless Steel Bracket with Stainless Steel Bolts	-M2
Universal Style Stainless Steel Bracket with Stainless Steel Bolts (not with Structure Codes LL, LM, LC, or LD)	-M3
Blind (Solid) Cover over Standard LCD Indicator	
Blind (Solid) Cover replaces Window Cover	-L2
DIN 19213 Construction used with Process Connector Code 0 and 316 ss Covers with no side vents (not available when remote or direct connect seals are specified)	
Single Ended Process Cover with M10, B7 Steel Bolting (j)(s)	-D1
Double Ended Process Cover with M10, B7 Steel Bolting (Blind Kidney Flange on Back) (j)(k)(l)	-D2
Single Ended Process Cover with 7/16 in, B7 Steel Bolting; standard pressure rating 25 MPa (3625 psi) (s)	-D3
Double Ended Process Cover with 7/16 in, B7 Steel Bolting (Blind Kidney Flange on Back) (j)(k)(l)	-D4
Single Ended Process Cover with 7/16 in, 316 ss Bolting (j)(s)	-D5
Double Ended Process Cover with 7/16 in, 316 ss Bolting (Blind Kidney Flange on Back) (j)(k)(l)	-D6
Single Ended Process Cover with 7/16 in, 17-4 ss Bolting; standard pressure rating 25 MPa (3625 psi) (s)	-D7
Double Ended Process Cover with 7/16 in, 17-4 ss Bolting (Blind Kidney Flange on Back) (j)(k)(l)	-D8
Single Ended Process Cover with 7/16 in, 17-4 ss Bolting; pressure rating 40 MPa (5800 psi) (s) Not available with Span Codes A, D, or E; or Option Codes -V, -B1, -B2, -B3, or -Y	-D9
Cleaning and Preparation - Not Available with Gold-Plated Sensor, Structure 2G or Pressure Seals	
Unit Degreased - for Silicone Filled Sensors Only (Not for Oxygen/Chlorine/Other Fluids that may react with Silicone)	-X1
Cleaned and Prepared for Oxygen Service - for Fluorinert Filled Sensors Only (Not Available with Carbon Steel Covers or with Silicone Filled Sensors)	-X2
Cleaned and Prepared for Chlorine Service - for Fluorinert Filled Sensors Only (m) (Not Available with Carbon Steel Covers or with Silicone Filled Sensors)	-X3
Bolting for Process Covers/Connectors - Not with DIN 19213 Construction or Structure Codes 78 and 79 (n)	-B1
316 ss Bolts and Nuts (Pressure Derated; Not Available with -Y Option) (j)	-B2
17-4 ss Bolts and Nuts (m)	-B3
B7-M Bolts and Nuts (NACE)(Pressure Derated) (j)	
Conduit Thread Adapters (Not available with Conduit Connection Codes 5 and 6)	
Hawke-Type 1/2 NPT Cable Gland for use with Conduit Connection Codes 1 and 3 (p)	-A1
M20 Conduit Thread Adapter for use with Conduit Connection Codes 1 and 3 (p)	-A3
Electronics Housing Features	
External Zero Adjustment	-Z1
Custody Transfer Lock and Seal	-Z2
External Zero Adjustment and Custody Transfer Lock/Seal	-Z3
Custom Factory Configuration	
Full Factory Configuration (Requires Configuration Form to be Filled Out)	-C2
Tubing Connectors - Not available with Structure Codes 78 and 79; also not with Pressure Seals	
Steel, Connecting 6 mm Tubing to 1/4 NPT Process Connector Only with Structure Codes 10 to 13; and Process Connector Codes 0 and 1	-E1
Steel, Connecting 12 mm Tubing to 1/2 NPT Process Connector Only with Structure Codes 10 to 13; and Process Connector Code 2	-E2
316 ss, Connecting 6 mm Tubing to 1/4 NPT Process Connector Only with Structure Codes 10 to 13 and 20 to 23; and Process Connector Codes 0 and 1	-E3
316 ss, Connecting 12 mm Tubing to 1/2 NPT Process Connector Only with Structure Codes 10 to 13 and 20 to 23; and Process Connector Code 2	-E4
Vent Screw in Process Cover	
Supply Vent Screw in Side of Each Process Cover (Available only on Traditional Process Cover Structure Codes 22 to 47)	-V
Omit Vent Screw in Side of Each Process Cover (Available only on Type LP1 Low Profile Process Cover Structures Codes LL, LM, LC, and LD)	-V1

Model Code continued on next page

MODEL CODE (Cont.)

Adapter Plate, Bolts, and Gaskets for Direct Mount to Competitive Manifolds (t)	
See inside pages for manifold compatibility.	
Adapter Set for MC Coplanar Manifolds, B7 Bolts (not with options -B1, -B2, or -B3)	-P1
Adapter Set for MC Coplanar Manifolds, 316 ss Bolts (requires -B1 option)	-P2
Adapter Set for MC Coplanar Manifolds, 17-4 ss Bolts (requires -B2 option)	-P3
Adapter Set for MC Coplanar Manifolds, B7M Bolts (requires -B3 option)	-P4
Adapter Set for MT3 Coplanar Manifolds, Traditional Flange, B7 Bolts (not with options -B1, -B2, or -B3)	-P5
Adapter Set for MT3 Coplanar Manifolds, Traditional Flange, 316 ss Bolts (requires -B1 option)	-P6
Adapter Set for MT3 Coplanar Manifolds, Traditional Flange, 17-4 ss Bolts (requires -B2 option)	-P7
Adapter Set for MT3 Coplanar Manifolds, Traditional Flange, B7M Bolts (requires -B3 option)	-P8
Gaskets	
Gasket for Vacuum Service with Pressure Seals (r)	-G1
Instruction Books (Common MI, Brochure, and Full Documentation Set on CD-ROM is Standard)	
Without Instruction Book and CD; only “Getting Started” brochure is supplied.	-K1
Miscellaneous Optional Selections	
Low Temperature Operative Limit of Electronics Housing Extended Down to -50°C (-58°F) Not available with sensors and seals with fluorinert fill; Structure Codes 78 and 79; and DIN Options -D2, -D4, -D6, and -D8	-J
Supplemental Customer Tag (Stainless Steel Tag wired onto Transmitter)	-T
Static Pressure Rating to 40 MPa (5800 psi); Only with Span Codes B and C Not available with: – Options -B1, -B2, and -B3 (q) – Options -D1 to -D9 – Structure Codes 34, 35, 78, 79, S1 to S6, SA to SF, F1 to F4	-Y

(a) Maximum static pressure rating is 2.1 MPa (300 psi); temperature limits are -7 and +82°C (20 and 180°F).
(b) Both Transmitter and Pressure Seal Model Numbers are required. See PSS 2A-1Z11 A for the various pressure seal Model Codes.
(c) Remote Seal Models that may be specified are PSFPS, PSFES, PSFAR, PSTAR, PSISR, PSSCR, and PSSSR.
(d) Cover lock provided as standard with Electrical Safety Codes D, B, and G.
(e) Span Limit Code A is not available with pressure seals, except for Sanitary Spud Seals Models PSSSR-.4 and PSSST-.4.
(f) Span Limit Code E is not available with Structure Codes 78 and 79 above (pvdf insert in HI side cover).
(g) Select Code “0” if a pressure seal is specified. Otherwise select Codes 1 through 7.
(h) Mounting sets not offered with direct connect (flange mount) seals.
(j) See Functional Specifications section for pressure deratings when certain DIN 19213 versions and Bolting Options -B1 and -B3 are specified.
(k) Temperature limits derated to 0 and 60°C (32 and 140°F). Also not available with Structure Codes 52 to 57, and LL, LM, LC, and LD.
(l) Mounting Bracket Set options are not available with Options -D2, -D4, -D6, and -D8.
(m) When -X3 is specified, the standard bolting is replaced with 17-4 ss bolts and nuts. Therefore, there is no need to specify Option -B2 when selecting the Chlorine Service Option -X3.
(n) Not available with DIN construction options. For stainless steel bolts with DIN construction, specify -D5 to -D9, as required.
(p) Available with Electric Safety Code D only.
(q) -B2 Bolt Option (17-4 ss) is not available with the -Y option because 17-4 ss bolts and nuts are supplied as part of the -Y option.
(r) -G1 is a required option when pressure seal will be used in vacuum applications. This option substitutes vacuum service metal gasket for standard ptfe process cover gasket.
(s) Not available with Low Profile Structure Codes 52 to 67.
(t) Adapter plate options -P1 to -P8 are not available with:
– Pressure Seal Structure Codes.
– Process Connector Codes 1-7.
– DIN Construction Options -D1, -D2, -D4, -D5, -D6, -D7, -D8, -D9.

SUGGESTED RFQ SPECIFICATIONS

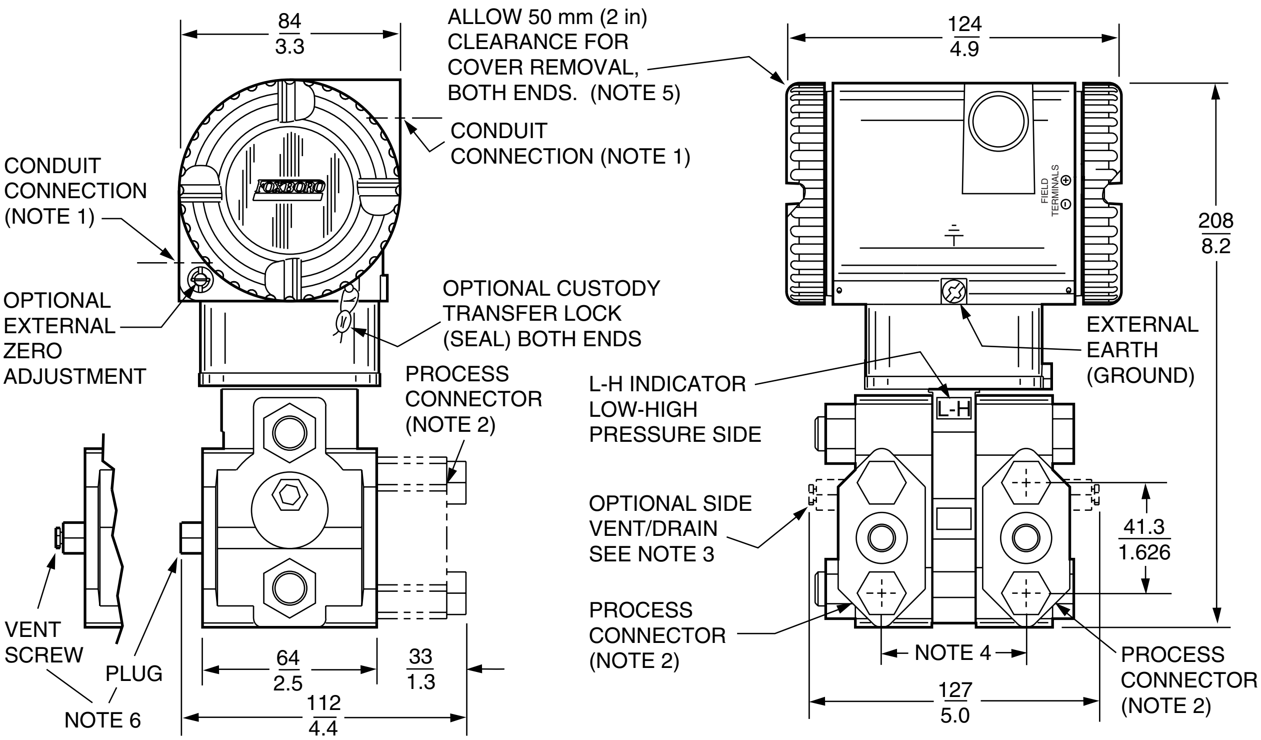
The manufacturer shall provide two-wire, 4 to 20 mA dc analog output, differential pressure transmitter(s) suitable for field mounting. They are offered with traditional or low profile structures. Transmitters with a traditional structure can also be provided (as required) with direct connect seals, or remote capillary connected seals. The specifications for these transmitters are:

Accuracy:	±0.20% of calibrated span.
Linear or Square Root Output:	Pushbutton configurable to set linear or square root output.
Static Pressure Rating:	25 MPa (3625 psi) for standard transmitter.
Ambient Temperature Effect:	For transmitter only (without pressure seals). Total effect for a 55°C (100°F) change within normal operating conditions is less than ±0.5% of calibrated span at maximum span (less than ±0.7% with 30 inH_2O URL sensor).
Damping:	Settable for a range of none to 8 seconds.
Proof Pressure:	14 500 psi for standard transmitter
Span Limits:	0.5 and 30 inH_2O, 3.5 and 200 inH_2O, 28 and 840 inH_2O, 10 and 300 psi, or 100 and 3000 psi, as specified; or SI and metric equivalents.
LCD Indicator:	Standard Liquid Crystal Display (LCD) Indicator with on-board pushbuttons for calibration and configuration.
Mounting:	On process piping, on a manifold, or optional mounting bracket
Input Connection:	With process connectors to accept 1/4 NPT, 1/2 NPT, Rc 1/4 or Rc 1/2, 1/2 Schedule 80 welding neck; or 1/2 NPT pvdf inserts installed in 316 ss covers; or prepared for a direct connect seal; or prepared for a single remote capillary connected seal, or two remote capillary connected seals.
Electronics Housing:	316 ss, or aluminum housing with epoxy finish
Modular Electronics:	Easily replaceable modular electronics in a NEMA 4X (IEC IP66) housing sealed with O-rings for protection against moisture or other contaminants.
Process Cover:	Traditional Structures: Steel, 316 ss, Monel, Hastelloy C, or pvdf insert Low Profile Structures: 316 ss
Sensor Materials:	Traditional Structure: 316L ss, Hastelloy C, Co-Ni-Cr, Monel, Tantalum, or Gold-Plated 316L ss Low Profile Structures: 316L ss or Hastelloy C
Approvals and Certifications:	Must be suitable for Division 1 hazardous locations, and conform to all applicable European Union Directives. Also versions available to meet Agency flameproof and zone requirements.
Approximate Mass: (with Process Connectors)	4.2 kg (9.2 lb), with Traditional Structures; Add 0.1 kg (0.2 lb) with Low Profile Structure LP1; Add 0.8 kg (1.8 lb) with Low Profile Structure LP2; Add 1.1 kg (2.4 lb) with 316 ss housing; Add 0.2 kg (0.4 lb) with optional LCD indicator.
Model Codes:	I/A Series IDP10-A Electronic d/p Cell Transmitter, with or without pressure seals, or equivalent.

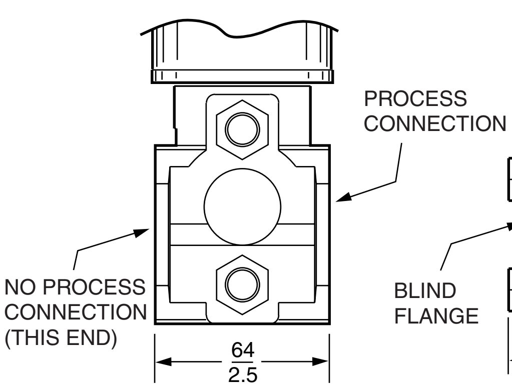
DIMENSIONS-NOMINAL

$\frac{\textbf{mm}}{\textbf{in}}$

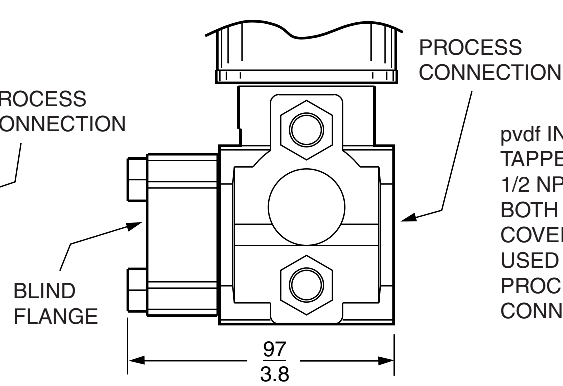
TRANSMITTER WITH TRADITIONAL STRUCTURE



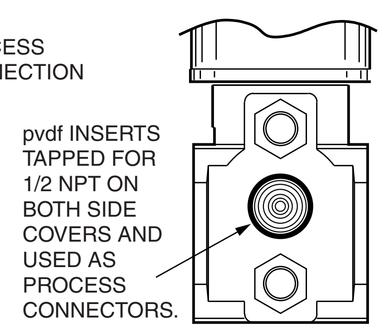
NOTES:
1. CONDUIT CONNECTION 1/2 NPT OR PG 13.5, BOTH SIDES: PLUG UNUSED CONNECTION WITH METAL PLUG (SUPPLIED).
2. PROCESS CONNECTORS MAY BE REMOVED AND TRANSMITTER MOUNTED DIRECTLY ON A MANIFOLD, OR CONNECTIONS MADE DIRECTLY TO PROCESS COVER USING 1/4 NPT INTERNAL THREAD IN PROCESS COVER.
3. PROCESS COVER CAN BE INVERTED MAKING OPTIONAL SIDE VENTS OR SIDE DRAINS
4. PROCESS CONNECTORS CAN BE INVERTED TO GIVE EITHER 51, 54, OR 57 mm (2.0, 2.125, OR 2.25 in) CENTER-TO-CENTER DISTANCE BETWEEN HIGH AND LOW PRESSURE CONNECTIONS.
5. TOPWORKS CAN BE ROTATED TO ANY POSITION WITHIN ONE TURN COUNTERCLOCKWISE OF THE FULLY TIGHTENED POSITION.
6. PROCESS COVER END PLUGS ARE SUBSTITUTED FOR VENT SCREWS WHEN OPTIONAL SIDE VENTS (NOTE 3) ARE SPECIFIED.



OPTIONAL DIN CONSTRUCTION
SINGLE ENDED PROCESS COVER
OPTIONS -D1, -D3, -D5, -D7, -D9



OPTIONAL DIN CONSTRUCTION
DOUBLE ENDED PROCESS COVER
OPTIONS -D2, -D4, -D6, -D8

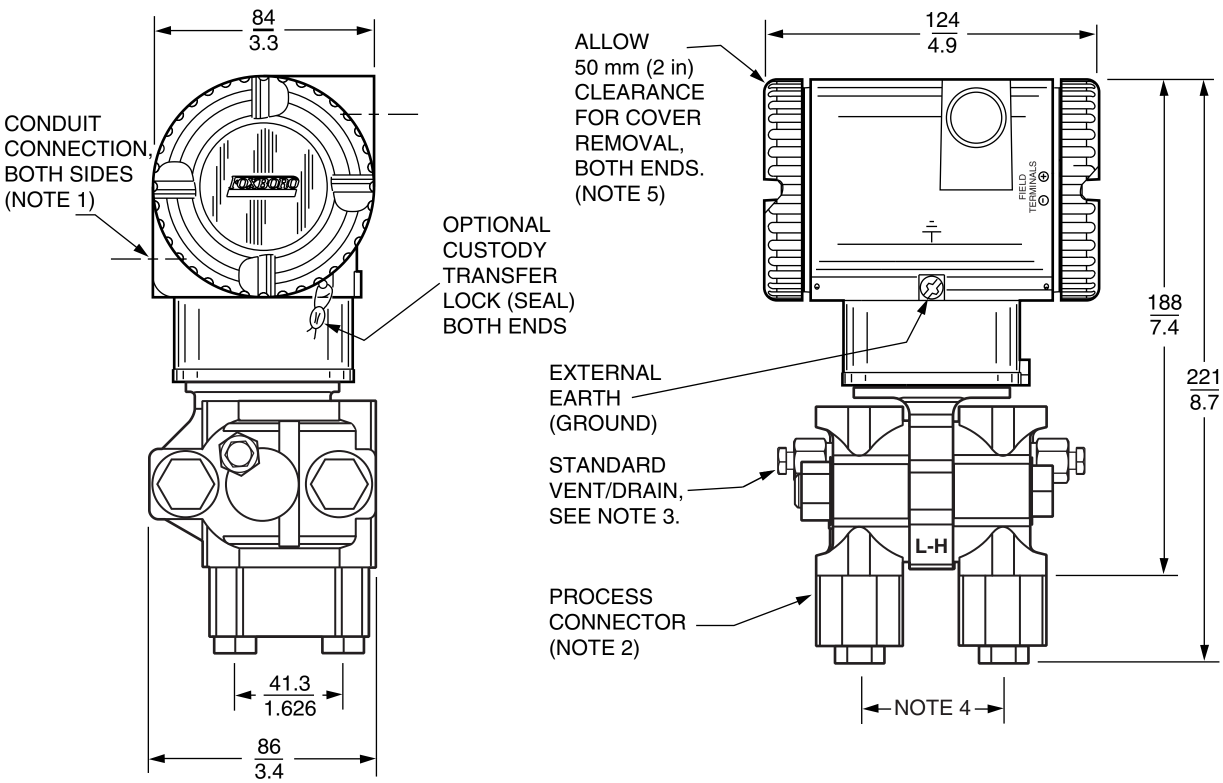


PROCESS CONNECTOR TYPE 7

DIMENSIONS-NOMINAL (Cont.)

$\frac{\textbf{mm}}{\textbf{in}}$

TRANSMITTER WITH LOW PROFILE STRUCTURE LP1

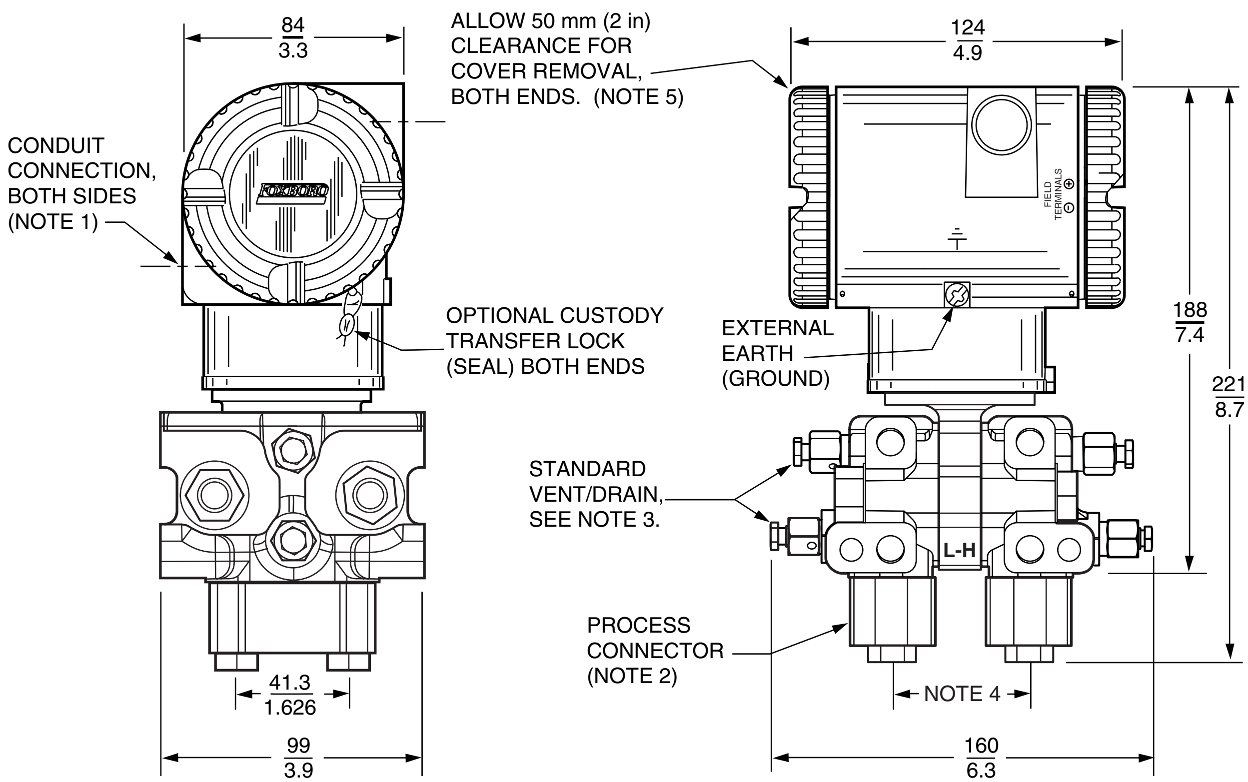


NOTES:
1. CONDUIT CONNECTION 1/2 NPT, PG 13.5, OR M20, BOTH SIDES: PLUG UNUSED CONNECTION WITH METAL PLUG (SUPPLIED).
2. PROCESS CONNECTORS MAY BE REMOVED AND TRANSMITTER MOUNTED DIRECTLY ON A MANIFOLD, OR CONNECTIONS MADE DIRECTLY TO PROCESS COVER USING 1/4 NPT INTERNAL THREAD IN PROCESS COVER.
3. THE TRANSMITTER'S LOW PROFILE STRUCTURE LP1 IS SHOWN IN THE VERTICALLY UPRIGHT POSITION. NOTE THE LOCATION OF THE STANDARD VENT/DRAIN SCREW. IN THIS CONFIGURATION THE TRANSMITTER CAN BE VENTED OR IS SELF-DRAINING. ALSO RECOMMENDED IS A HORIZONTAL INSTALLATION WHERE THE INSTALLED ORIENTATION CAN BE SET TO ALLOW FOR VENTING OR DRAINING.
4. PROCESS CONNECTORS CAN BE INVERTED TO GIVE EITHER 51, 54, OR 57 mm (2.0, 2.125, OR 2.25 in) CENTER-TO-CENTER DISTANCE BETWEEN HIGH AND LOW PRESSURE CONNECTIONS.
5. TOPWORKS CAN BE ROTATED TO ANY POSITION WITHIN ONE TURN COUNTERCLOCKWISE OF THE FULLY TIGHTENED POSITION.

DIMENSIONS-NOMINAL (Cont.)

mm / in

TRANSMITTER WITH LOW PROFILE STRUCTURE LP2

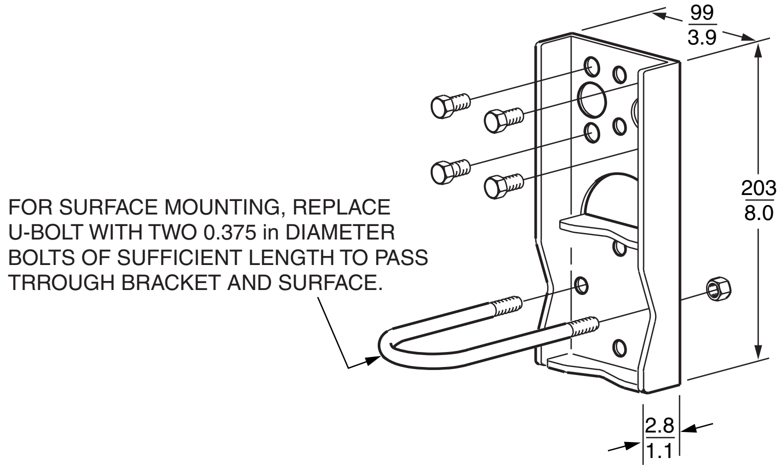


NOTES:
1. CONDUIT CONNECTION 1/2 NPT, PG 13.5, OR M20, BOTH SIDES: PLUG UNUSED CONNECTION WITH METAL PLUG (SUPPLIED).
2. PROCESS CONNECTORS MAY BE REMOVED AND TRANSMITTER MOUNTED DIRECTLY ON A MANIFOLD, OR CONNECTIONS MADE DIRECTLY TO PROCESS COVER USING 1/4 NPT INTERNAL THREAD IN PROCESS COVER.
3. THE TRANSMITTER'S LOW PROFILE STRUCTURE LP2 IS SHOWN IN THE RECOMMENDED VERTICAL UPRIGHT POSITION. NOTE THE STANDARD VENT OR DRAIN SCREWS. HORIZONTAL INSTALLATIONS ARE NOT RECOMMENDED.
4. PROCESS CONNECTORS CAN BE INVERTED TO GIVE EITHER 51, 54, OR 57 mm (2.0, 2.125, OR 2.25 in) CENTER-TO-CENTER DISTANCE BETWEEN HIGH AND LOW PRESSURE CONNECTIONS.
5. TOPWORKS CAN BE ROTATED TO ANY POSITION WITHIN ONE TURN COUNTERCLOCKWISE OF THE FULLY TIGHTENED POSITION.

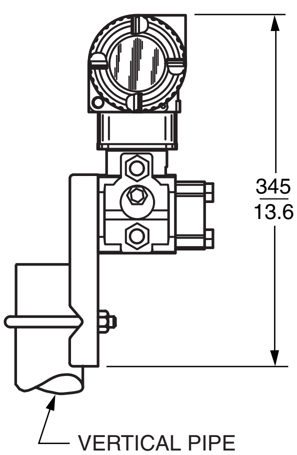
DIMENSIONS-NOMINAL (Cont.)

$\frac{\textbf{mm}}{\textbf{in}}$

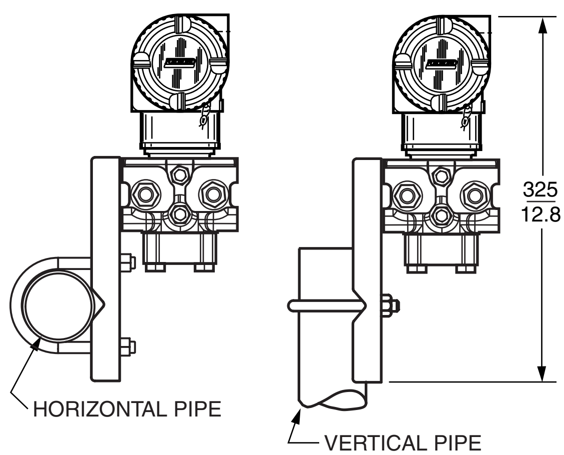
TRANSMITTER WITH STANDARD STYLE MOUNTING BRACKET KIT (Options -M1 and -M2)



TRANSMITTER WITH TRADITIONAL STRUCTURE



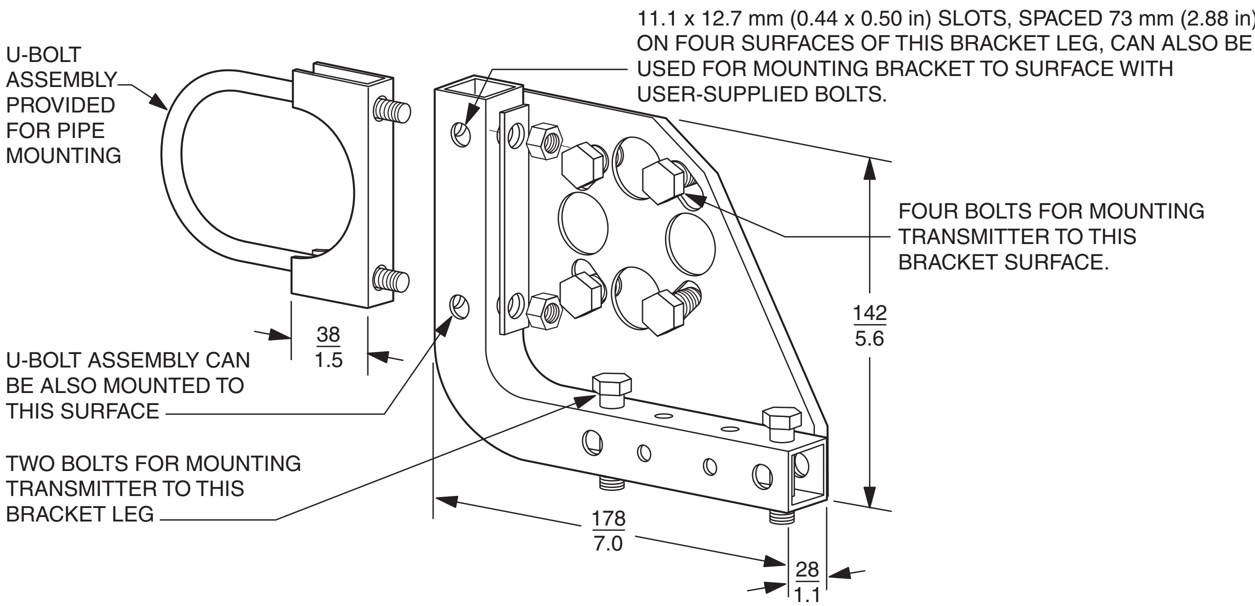
TRANSMITTER WITH LOW PROFILE STRUCTURE LP2



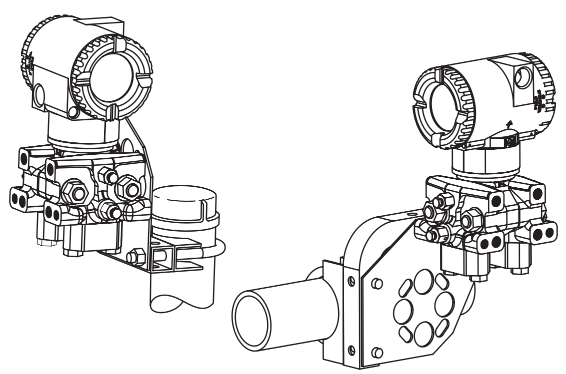
DIMENSIONS-NOMINAL (Cont.)

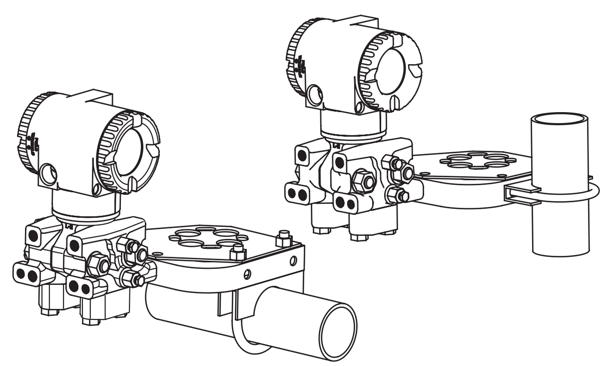
mm / in

TRANSMITTER WITH UNIVERSAL STYLE MOUNTING BRACKET KIT (Option -M3)



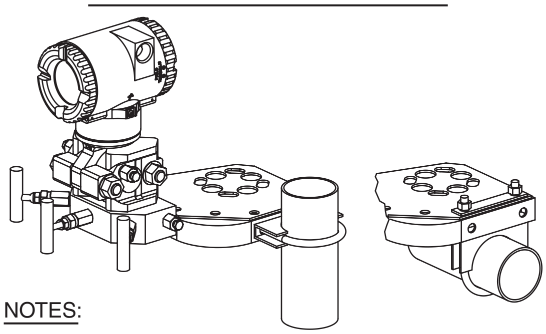
TYPICAL PIPE MOUNTING WITH LOW PROFILE STRUCTURE LP2

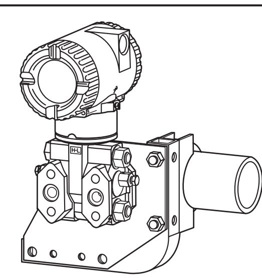




TYPICAL PIPE MOUNTING
LOW PROFILE STRUCTURE LP1

TYPICAL PIPE MOUNTING
WITH TRADITIONAL STRUCTURE





NOTES:

1. FOR SURFACE MOUNTING CONFIGURATIONS, USE THE U-BOLT MOUNTING HOLES FOR ATTACHING THE BRACKET TO A SURFACE RATHER THAN TO THE U-BOLT ASSEMBLY. SURFACE MOUNTING BOLTS FOR ATTACHING THE BRACKET TO A SURFACE ARE USER SUPPLIED.
2. REFER TO DIMENSIONAL PRINT DP 020-446 FOR FURTHER IPD10 MOUNTING CONFIGURATIONS, INCLUDING MOUNTING WITH -P OPTIONAL MOUNTING PLATES.

ORDERING INSTRUCTIONS

1. Model Number(s) as follows:
   - Transmitter only if pressure seals are not selected
   - Both transmitter and pressure seals if pressure seals are selected with traditional structure. See PSS 2A-1Z11 A.
2. Calibrated Pressure Range (using Allowable Pressure Units from the table below).
3. Configuration Data Form when Factory Calibration Option -C2 is specified.
4. Options and Accessories not in Model Code (see PSS 2A-1Z9 E).
5. User Tag Data - Data Plate; 32 characters maximum. For additional tag data, specify Optional Supplemental Tag -T.

Allowable Pressure Units for Calibrated Range (a)

inH_2O	psi	Pa	atm	g/cm^2
ftH_2O	inHg	kPa	bar	kg/cm^2
mmH_2O	mmHg	MPa	mbar	torr

(a) Displayed in upper case only on transmitter.

OTHER M&I PRODUCTS

Invensys Foxboro provides a broad range of measurement and instrument products, including solutions for pressure, flow, analytical, positioners, temperature, controlling and recording. For a listing of these offerings, visit the Invensys Foxboro web site at:

www.foxboro.com/instrumentation

33 Commercial Street
Foxboro, MA 02035-2099
United States of America
www.foxboro.com
Inside U.S.: 1-866-746-6477
Outside U.S.: 1-508-549-2424
or contact your local Foxboro representative.
Facsimile: 1-508-549-4999

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MB 010 Printed in U.S.A. 0507

IGP10, IGP20 Intelligent Gauge Pressure Transmitters
IAP10 Intelligent Absolute Pressure Transmitter

- IGP10 for compact light weight and direct-to-process mounting (bracket optionally available)
- IGP20, bracket mounted, for lower ranges, more material options, and vacuum service
- Field-proven silicon strain gauge technology
- Corrosion-resistant epoxy finish
- Accuracy to ± 0.07 % of span
- Ambient temperature effects to ± 0.2 % URL per 55 °C (100 °F) change
- Intelligent FOXCOM & HART / 4 to 20 mA version or economical 4 to 20 mA version
- LCD Indicator / Pushbutton Configurator to set zero, span, display units, etc. Optional on Digital / 4 to 20 mA version, Standard on 4 to 20 mA version

These Intelligent, two-wire transmitters provide precise, reliable, measurement of gauge or absolute pressure, and transmit a 4 to 20 mA output signal with a superimposed HART/ FOXCOM digital signal for remote configuration and monitoring.

IGP10 Span, Range and Overrange Limits
IAP10 Span, Range and Overrange Limits

Span Limits Code	Span Limits			Range Limits			Maximum Overrange		
	kPa	psi	bar (kg/cm²)	kPa	psi	bar (kg/cm²)	kPa	psi	bar (kg/cm²)
C	7 & 210	1 & 30	0.07 & 2.1	0 & 210	0 & 30	0 & 2.1	310	45	3.15
D	70 & 2100	10 & 300	0.7 & 21	0 & 2100	0 & 300	0 & 21	3100	450	31.5
E	700 & 21000	100 & 3000	7 & 210	0 & 21000	0 & 3000	0 & 210	31000	4500	315

IGP20 Span, Range and Overrange Limits

Span Limits Code	Span Limits			Range Limits			Maximum Overrange		
	kPa	psi	bar (kg/cm²)	kPa	psi	bar (kg/cm²)	kPa	psi	bar (kg/cm²)
B	0.87 & 50	0.125 & 7	0.0087 & 0.5	–50 & 50	–7 & 7	–0.5 & 0.5	25000	3625	250
C	7 & 210	1 & 30	0.07 & 2.1	–100 & 210	–14.7 & 30	–1 & 2.1	25000	3625	250
D	70 & 2100	10 & 300	0.7 & 21	–100 & 2100	–14.7 & 300	–1 & 21	25000	3625	250
E	700 & 21000	100 & 3000	7 & 210	–100 & 21000	–14.7 & 3000	–1 & 210	25000	3625	250

Temperature Limits

	Fill fluid Flourinert	Fill fluid Silicone
Ambient:	–29 to 85 °C (–20 to 185 °F)	–40 to 85 °C (–40 to 185 °F)
Sensor:	–29 to 121 °C (–20 to 250 °F)	–46 to 121 °C (–50 to 250 °F)

Accuracy (Includes Linearity, Hystersis, and Repeatability)

Electronics Version	Configured Output Signal	Accuracy in % of Calib. Span
-D & -T	Digital 4 to 20 mA	± 0.07 ± 0.1
-I	4 to 20 mA	± 0.2

Ambient Temperature Effect

Total effect for a 55 °C (100 °F) change within Normal Operating Conditions limit is:

Electronics -D, -T: ± 0.2 % of URL

Electronics -I: ± (0.2 % of URL + 0.1 % of span)

For complete specifications, refer to Product Specification Sheet PSS 2A-1C13 B

Model Codes IGP10

Intelligent Direct Connected Gauge Pressure Transmitter . . . **IGP10**

Electronics Versions and Output Signal

- Intelligent; Digital FoxCom and/or 4 to 20 mA dc, Configurable . . . -D
- Intelligent; Digital HART and 4 to 20 mA . . . -T
- 4 to 20 mA Analog Output, Explosionproof and Intrinsically Safe . . . -I

Structure Code - Process Connection, Sensor, and Fill Fluid

Process Connection Mat'l	Sensor	Fill Fluid	Code
316L ss	Co-Ni-Cr	Silicone	20
316L ss	Co-Ni-Cr	Fluorinert	21
316L ss	316L ss	Silicone	22
316L ss	316L ss	Fluorinert	23

Span Limits - Absolute or Gauge Pressure Units, as Applicable

MPa	psi	bar or kg/cm²	Code
0.007 and 0.21	1 and 30	0.07 and 2.1	C
0.07 and 2.1	10 and 300	0.7 and 21	D
0.7 and 21	100 and 3000	7 and 210	E

Conduit Connection

- 1/2 NPT Conduit Connection, Both Sides . . . 1
- PG 13.5 Conduit Connection, Both Sides (available only with Electrical Safety Codes E & N . . . 2

Electrical Safety (See Electrical Safety Specifications Section)

- **CENELEC** Certified Intrinsically Safe, ia . . . E
- **CSA** Certified . . . N
- **EUROPEAN** Ex, N, IIC. Nonsparking . . . C
- **FM** Approved . . . F
- **SAA** Certified, EEx, d, IIC . . . A

Options

Mounting Bracket Set

- Painted Steel Bracket with Plated Steel Bolts . . . M1
- Stainless Steel Bracket with Stainless Steel Bolts . . . M2

Digital Indicator with Pushbuttons (standard equipment on IGP10-I)

- Digital Indicator, Pushbuttons, and Window Cover (for Electr Version D & T only) . . . -L1

Vent Screw and Block & Bleed Valve

- Vent Screw in Process Connection for IGP10/IAP10; or in High Side Process Cover for IGP20 . . . V1
- Block and Bleed Valve, Carbon Steel . . . V2
- Block and Bleed Valve, 316 ss . . . V3
- Block and Bleed Valve, 316 ss Body w/Monel Trim (NACE Approved) . . . V4

Conduit Thread Adapters

- Hawke-Type 1/2 NPT Cable Gland for use with Conduit Connection Code "1" . . . A1
- Plastic PG 13.5 Connector for use with Conduit Connection Code "2" (available only with Electrical Safety Codes E & N) . A2
- M20 Connector for use with Conduit Connection Code "1" . . . A3

Electronics Housing Features

- External Zero Adjustment . . . Z1
- Custody Transfer Lock and Seal . . . Z2
- External Zero Adjustment and Custody Transfer Lock and Seal . . . Z3

Factory Configuration

- Digital Output (4 to 20 mA Default if not selected) . . . C1
- Full Factory Configuration (Requires Configuration Form to be filled out) . . . C2

Miscellaneous Optional Selections

- G 1/2 B Manometer Process Connection (Not Available with Option "-V1") . . . G
- R 1/2 Process Connection (1/2 NPT to R 1/2 Adapter) . . . R
- Five Year Warranty . . . W
- Supplemental Customer Tag (Stainless Steel Tag wired onto Transmitter) . . . T

FOXBORO ECKARDT
An Invensys company

Model Codes IGP20

Intelligent Bracket-Mounted Gauge Pressure Transmitter **IGP20**

Electronics Versions and Output Signal

Digital, FOXCOM, or 4 to 20 mA dc, Software Selectable	D
Digital, HART/4 to 20 mA	T
4 to 20 mA	I

Structure Code - Process Cover, Sensor Material, and Sensor Fill Fluid

Hi-Side Cover	Sensor Material	Fill Fluid		
Steel	Co-Ni-Cr	Silicone		10
Steel	Co-Ni-Cr	Fluorinert		11
Steel	316L ss	Silicone		12
Steel	316L ss	Fluorinert		13
Steel	Hastelloy C	Silicone		16
Steel	Hastelloy C	Fluorinert		17
316 ss	Co-Ni-Cr	Silicone	Value Package	20
316 ss	Co-Ni-Cr	Fluorinert		21
316 ss	316L ss	Silicone		22
316 ss	316L ss	Fluorinert		23
316 ss	Hastelloy C	Silicone		26
316 ss	Hastelloy C	Fluorinert		27
Hastelloy C	Hastelloy C	Silicone		46
Hastelloy C	Hastelloy C	Fluorinert		47

Span Limits (Differential Pressure Units)

kPa	psi	mbar	inH_2O	mmHg	
0.87 and 50	0.125 and 7	8.7 and 500	3.5 and 200	6.5 and 375	B
MPa	**psi**	**bar or kg/cm²**	**inH_2O**	**mmHg**	
0.007 and 0.21	1 and 30	0.07 and 2.1	28 and 840	52 and 1550	C
0.07 and 2.1	10 and 300	0.7 and 21			D
0.7 and 21	100 and 3000	7 and 210			E

Process Connector Type (Material Same as Process Cover Material)

None, Cover tapped for 1/4 NPT	0
1/4 NPT	1
1/2 NPT	2
Rc 1/4	3
Rc 1/2	4
1/2 Schedule 80 Welding Neck	6

Conduit Connection

1/2 NPT Conduit Connection, Both Sides	1
PG 13.5 Conduit Connection, Both Sides (available only with Electrical Safety Codes E & N)	2

Electrical Safety (See Electrical Safety Specifications Section for Description)

CENELEC Certified Intrinsically Safe, ia	E
CENELEC Certified Flameproof, d	D
CSA Certified, ia, d, and n	C
EUROPEAN Ex, N, IIC. Nonsparking	N
FM Approved, ia, d, and n	F
SAA Certified, EEx, d, IIC	A

Options

Mounting Bracket Set	
Painted Steel Bracket with Plated Steel Bolts	M1
Stainless Steel Bracket with Stainless Steel Bolts	M2
Indicator with Internal Pushbuttons (Standard equipment on Electr. Version I)	
Digital Indicator, Pushbuttons, and Window Cover, for Electr. Version D & T only.	L1
DIN 19213 Construction, used with Process Connector Code 0 and 316 ss Covers Only(b)	
Single Ended Process Cover with M10, B7 Steel Bolting	D1
Double Ended Process Cover with M10, B7 Steel Bolting (Blind Kidney Flange on Back)(c)(d)	D2
Single Ended Process Cover with 7/16 in, B7 Steel Bolting.	D3
Double Ended Process Cover with 7/16 in, B7 Steel Bolting (Blind Kidney Flange on Back)(c)(d)	D4
Cleaning and Preparation	
Unit Degreased - (Not for Oxygen/Chlorine) (Available only with Structu-re Codes having Silicone)	X1
Cleaned and Prepared for Oxygen Service (Available only withStructure Codes having Flourinert and not available with carbon steel process covers)	X2
Cleaned and Prepared for Chlorine Service (Available only with Structure Codes having Flourinert and not available with carbon steel process covers) (Includes 17-4 ss bolts; do not specify option B2.	X3
Bolting for Process Covers and Process Connectors	
316 ss Bolts and Nuts (Maximum upper range limit pressure 150 bar or 2175 psi)	B1
17-4 ss Bolts and Nuts	B2

(continued on next page)

Model Codes IGP20 (continued)

Options (continued)	
Conduit Thread Adapters	
Hawke-Type 1/2 NPT Cable Gland (for use with 1/2 NPT Conduit Connection Code 1)	A1
Plastic PG 13.5 Connector (for use with PG 13.5 Conduit Connection Code 2) (available only with Electrical Safety Codes E & N)	A2
M20 Connector (for use with 1/2 NPT Conduit Connection Code 1)	A3
Electronics Housing Features	
External Zero Adjustment	Z1
Custody Transfer Lock and Seal	Z2
External Zero Adjustment and Custody Transfer Lock and Seal	Z3
Factory Configuration	
Digital Output (4 to 20 mA Default if not selected) (Electr. Version D only)	C1
Full Factory Configuration (Requires Configuration Form)	C2
Ermeto Connectors	
Steel, Connecting 6 mm Tubing to 1/4 NPT Process Connector	E1
Steel, Connecting 12 mm Tubing to 1/2 NPT Process Connector	E2
316 ss, Connecting 6 mm Tubing to 1/4 NPT Process Connector	E3
316 ss, Connecting 12 mm Tubing to 1/2 NPT Process Connector	E4
Miscellaneous Optional Selections	
Vent Screw In Side of Process Cover	V
Five Year Warranty	W
Supplemental Customer Tag	T

(a) Refer to PSS 2A-1Z9 E for option descriptions, and for additional optional features and accessories not listed in Model Code.
(b) See Functional Specifications section for pressure deratings when certain DIN 19213 versions are specified.
(c) Temperature limits derated to 0 and 60°C (32 and 140°F).
(d) Mounting Set option is not available.

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Model Codes IAP10

Description	Model Code
Intelligent Direct Connected Absolute Pressure Transmitter	**IAP10**
Electronics Versions and Output Signal	
Digital FOXCOM or 4 to 20 mA dc, Software Selectable	-D
Digital HART and 4 to 20 mA	-T
4 to 20 mA Analog Output	-I
Structure Code - Process Connection, Sensor, and Fill Fluid	
Process Connection Mat'l — Sensor — Fill Fluid	
316L ss — Co-Ni-Cr — Silicone. Val. Pkg.	20
316L ss — Co-Ni-Cr — Fluorinert	21
316L ss — 316L ss — Silicone	22
316L ss — 316L ss — Fluorinert	23
Span Limits - Absolute or Gauge Pressure Units, as Applicable	
MPa — psi — bar or kg/cm²	
0.007 and 0.21 — 1 and 30 — 0.07 and 2.1	C
0.07 and 2.1 — 10 and 300 — 0.7 and 21	D
0.7 and 21 — 100 and 3000 — 7 and 210	E
Conduit Connection	
1/2 NPT Conduit Connection, Both Sides	1
PG 13.5 Conduit Connection, Both Sides (available only with Electrical Safety Codes E & N	2
Electrical Safety (See Electrical Safety Specifications Section)	
CENELEC Certified Intrinsically Safe, ia	E
CSA Certified	C
EUROPEAN Ex, N, IIC. Nonsparking	N
FM Approved	F
SAA Certified, EEx, d, IIC	A
Options	
Mounting Bracket Set	
Painted Steel Bracket with Plated Steel Bolts	M1
Stainless Steel Bracket with 316 ss Bolts	M2
Indicator with Pushbuttons (standard equipment on IGP10-I)	
Digital Indicator, Pushbuttons, and Window Cover (for Electr Version D & T only)	-L1
Vent Screw and Block & Bleed Valve	
Vent Screw in Process Connection for IGP10/IAP10; or in High Side Process Cover for IGP20	V1
Block and Bleed Valve, Carbon Steel	V2
Block and Bleed Valve, 316 ss	V3
Block and Bleed Valve, 316 ss Body w/Monel Trim (NACE Approved)	V4
Conduit Thread Adapters	
Hawke-Type 1/2 NPT Cable Gland for use with Conduit Connection Code "1"	A1
Plastic PG 13.5 Connector for use with Conduit Connection Code "2" (available only with Electrical Safety Codes E & N)	A2
M20 Connector for use with Conduit Connection Code "1"	A3
Electronics Housing Features	
External Zero Adjustment	Z1
Custody Transfer Lock and Seal	Z2
External Zero Adjustment and Custody Transfer Lock and Seal	Z3
Factory Configuration	
Digital Output (4 to 20 mA Default if not selected)	C1
Full Factory Configuration (Requires Configuration Form to be filled out)	C2
Miscellaneous Optional Selections	
G 1/2 B Manometer Process Connection (Not Available with Option "-V1")	G
R 1/2 Process Connection (1/2 NPT to R 1/2 Adapter)	R
Five Year Warranty	W
Supplemental Customer Tag (Stainless Steel Tag wired onto Transmitter)	T

PRESSURE SYSTEMS

Industrial Submersible Pressure Transducer

ISO-9001 Certified

KPSI™

Series 700

FEATURES

- High Static Accuracy & Repeatability
- Welded 316 SS Construction
- Small Rugged Package
- User-Specified Pressure Ranges Available
- 100% Computer-Tested, Calibrated and Serialized
- Unique Cable Seal System
- Fully Temperature Compensated
- Datalogger Compatible

APPLICATIONS

- Well Monitoring
- Slug Tests
- Pump Control
- Ground Water Monitoring
- Soil Remediation
- Oceanographic Research
- Lift Stations
- Level Control
- Surface Water Monitoring

The Series 700 family of submersible pressure transducers is specifically designed to meet the rigorous environments encountered in liquid level measurement and control. It can be configured to perform to specifications under the most adverse, reactive conditions.

These transducers incorporate the latest advancements in piezoresistive pressure sensing technology. A stability-enhancing charged "Field Shield" is vapor deposited directly to the pressure cell. A welded 316 Stainless Steel diaphragm, with a spring rate ratio of 1000:1 with the piezoresistive pressure cell, is used for contact with the media. The transducer housing is an all-welded design, constructed of corrosion resistant 316 SS. A titanium housing with hastelloy/platinum sensor combination is also offered for extremely corrosive media.

The Series 700 also features state-of-the-art, surface mount internal signal conditioning which provides a power supply rejection of 0.001% and either a 4-20 mAdc, 0-5 Vdc, or mVdc process signal. Approvals to FM, CSA, and UL are available for Class I, Div 1, Groups A, B, C and D, and Class II, Div 1, Groups E, F and G, and Class III, Div 1 hazardous locations. These instruments also meet CE approval according to EN-50081-2 and EN-50082-2. Hazardous locations installation must be to local and national electrical codes and installed with an approved electrical barrier, such as manufactured by R.G. Stahl, Inc.

Each transducer is shipped with a vent filter that prevents moisture from entering the cable vent tube and with traceable calibration data. This data specifies input/output conditions and actual data recorded at zero and full scale during manufacture. Optional calibration is available when additional performance characteristics are required. All units are repairable and have low power requirements.

Pressure Systems, Inc.
A Roxboro Group Company
34 Research Drive
Hampton, VA 23666
USA
Phone: (757) 865-1243
Toll Free: 800-328-3665
Fax: (757) 865-8744
E-mail: sales@psih.com

Visit us on the Web:
www.psih.com
or
www.kpsi.com

For product literature updates visit:
www.kpsi.com/levelupdate.html

PSI Ltd.
124, Victoria Road
Farnborough, Hants
GU14 7PW United Kingdom
Phone: +44 1252 510000
Fax: +44 1252 510099
E-mail: dcopley@westonaero.com

Parameter	730	720	710	700	Units	Comments
PRESSURE RANGES						
Pressure Ranges[1]	0 - 2 through 0 - 300 0-14 through 0-21000				psig kPa	any intermediate ranges available
Proof Pressure	1.5				x F.S.	
Burst Pressure	2.0				x F.S.	
STATIC PERFORMANCE						
Static Accuracy[2]	±0.10	±0.25	±0.50	±1.00	%FSO BFSL	
Thermal Error[3]	±0.05			±0.10	%FSO/ºC	worst case
Resolution	Infinitesimal					
ENVIRONMENTAL						
Wetted Materials[1]	316 SS, Fluorocarbon					options available
Compensated Temp Range[1]	0 to 50				ºC	options available
Operating Temp Range	-20 to 60				ºC	options available
ELECTRICAL						
Excitation	2.5 - 10 5 9 - 30				VDC	mVdc output (ratiometric) mVdc output (non-ratiometric) mAdc, Vdc output
Input Current	3.5 20				mA max	mVdc, Vdc output mAdc output
Output	2.5 - 10 0 - 100[4] 0 - 5 4 - 20				mV/V mV VDC mA	ratiometric, depending on range non-ratiometric 3 wire 2 wire
Zero Offset	±5 ±60 ±0.12				mV mV mA	mVdc output Vdc output mAdc output
Output Impedance	< 10				ohms	
Insulation Resistance	100				megaohms	at 50 VDC
Circuit Protection	Polarity, surge/shorted output					
PHYSICAL						
Weight	198				grams	excluding cable
Cable	Polyurethane jacketed shielded cable with polyethylene vent tube. 90 kilograms pull strength. Conductors are 22 AWG. Tefzel jacket optional.				70 g/m	specify cable length as separate line item
Mounting Provisions	Suspended by cable. For turbulent conditions, specify optional mount bracket or conduit fitting.					

Notes:

1 Consult factory for highly corrosive media, tighter tolerances on environmental specifications and special low/high pressure applications.

2 Static accuracy includes the combined errors due to nonlinearity, hysteresis and nonrepeatability on a Best Fit Straight Line (BFSL) basis, at 25ºC per ISA S51.1.

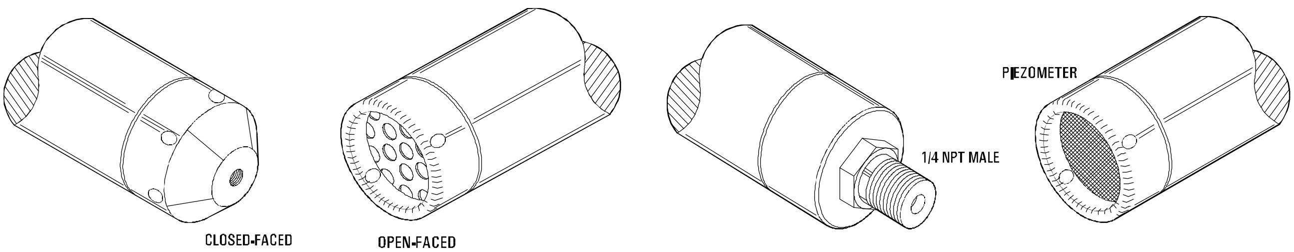
3 Thermal error is the maximum allowable deviation from the Best Fit Straight Line due to a change in temperature, per ISA S51.1.

4 0-50 mV FSO for ranges <10 psi.

Specifications subject to change without notice.

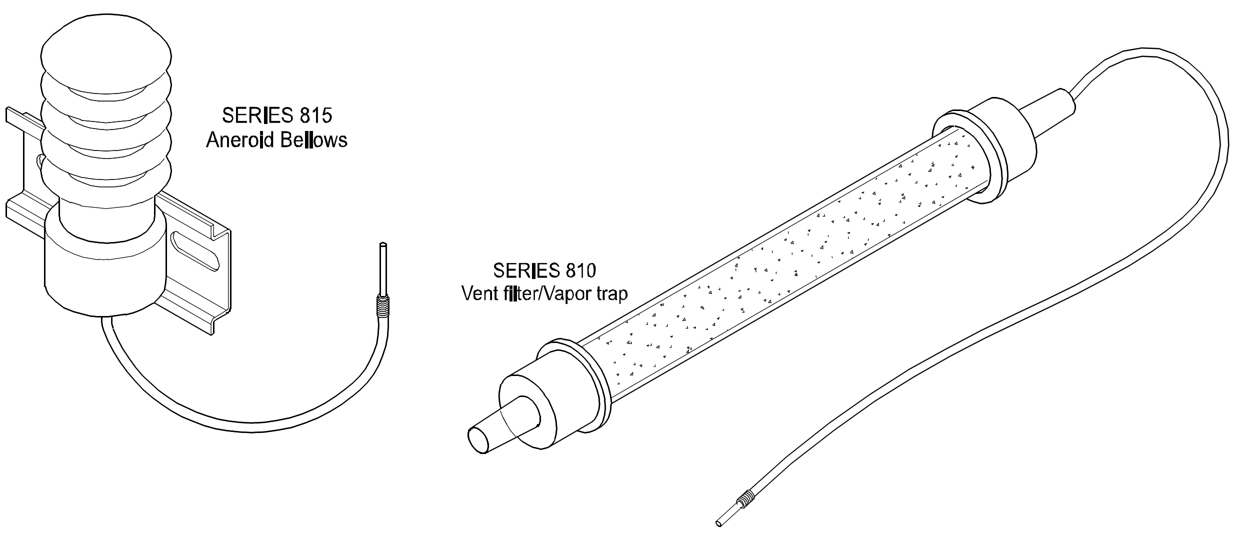
Field Installable Nose Caps

Several different user-installable nose caps are available for the Series 700, 710, 720, 730 submersible pressure transducers. The closed-faced port end cap (PN# 42-01-1314) with #8-32UNC-2B threaded hole is best used where weights are required and for those installations where users may encounter sharp, protruding objects. The open-faced port end cap (PN# 42-01-6481) which allows maximum contact with the liquid media is ideal for wastewater and “greasy” applications where clogging of the sensor is a concern. The ¼” male NPT pressure port end cap (PN# OPTION-017) is not only useful for calibration purposes but also allows the device to be used as a submersible or above ground pressure transducer. The piezometer port end cap (PN# OPTION-006) allows the unit to be buried in the ground without damage to the sensor diaphragm.



Moisture Protection

Our submersible transducers are equipped with custom, vented cable. The vent provides an atmospheric reference for the sensor, which is necessary for insuring the highest possible accuracy when making a level measurement. The downside to the vent is that, if left unprotected, it provides a pathway for water vapor to enter the level transducer. This vapor will condense into liquid water and, at the least, create an offset in the transducer output and at worst, cause damage. For these reasons, a Series 810 desiccant-filled vent filter is provided free of charge with each Series 700 that we ship. These filters must be periodically replaced as the desiccant becomes spent, which is obvious because the desiccant changes from blue to pink. Replacement filters are available from the factory. For those applications where periodic maintenance is not practical, our Series 815 Aneroid Bellows is a direct replacement for the vent filter. This sensitive bellows responds to and transmits changes in atmospheric pressure to the sensor while remaining a maintenance-free, closed system. It should be noted, however, that the Bellows may not be a suitable replacement for the desiccant cartridge in applications where extremely high accuracy is required, usually 0.1% or better. The user is cautioned to evaluate a Bellows in the specific application intended.



Surge/Lightning Protection

Surge protection is offered for 0-5 VDC (PN# OPTION-012) and 4-20 mA (PN# OPTION-009) output for our 700 family of submersible pressure transducers. This is achieved through the use of 2 protectors. One is located in a 6.5 inch long, 1 inch OD 316 SS housing extension attached directly to the non-pressure sensing end of the transducer while the other is located at the surface and grounded via DIN-rail or ground wire. Whether lightning protection is employed or not, the cable shield is left exposed so that the shield can be attached to an earth ground.

Submersible Cable

Our submersible transducers utilize two different types of custom cable made just for submersible applications. The most common is our polyurethane-jacketed cable, or poly cable for short. Our unique design includes Kevlar strength members to prevent errors due to cable elongation and a water block liner to “self-seal” the cable in the event of accidental cuts to the cable jacket. This is the cable of choice for most applications, including potable water, sewage, rivers, streams and even leachate.

The other choice is our Tefzel-jacketed cable. DuPont Tefzel is a derivative of Teflon, providing the chemical resistance and toughness but at a lower price than Teflon. Tefzel is the better choice when media are expected that are not compatible with polyurethane or when a high degree of abrasion is anticipated. While more expensive than poly cable, it can save money in the long term due to lower maintenance costs. Some applications where Tefzel is utilized include remediation wells, drinking water tanks that are periodically sanitized with chemicals such as sodium hypochlorite and where it is not possible or practical to remove the transducer during the sanitization process. Installations where it is expected that the cable will be subjected to sharp objects and/or abrasion would also be a good candidate for Tefzel. In the case where the user is not sure which material is best, contact the KPSI applications department for assistance. In all installations, care should be taken to ensure no damage occurs to the cable as cable damage represents on of the most frequent causes of transducer failure.

Display Meter

The PD690 is a high performance, easy-to-use, industrial grade digital process meter with many useful features. They include:

- single button scaling
- NEMA 4X front panel
- linearization with square root extraction
- 4-20 mA output option
- 2 or 4 control relay options
- isolated 24 VDC transmitter power supply
- steady 4½ digit + extra zero display
- 4 visual alarm points
- UL approval

Single-button and stand-alone scaling make setups a snap and the internal 24 VDC power supply simplifies your 4-20 mA current loop setups by eliminating the need for an external power supply.

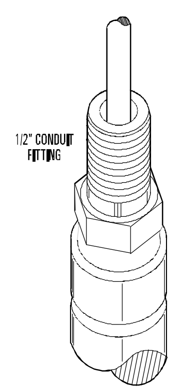
The NEMA 4X front panel allows installation of the PD690 in almost any panel in your plant, including wet, dirty and dusty environments. The PD690's 4½ digit plus extra zero is great for displaying large numbers, like the volume in a 100,000 gallon tank. Even when displaying large numbers, the PD690's display is accurate and steady.

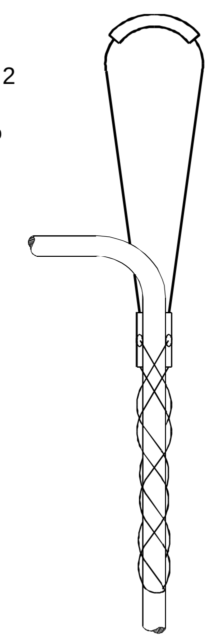
Optional 4-20 mA isolated output provides signal to independent RTU or data logger, while the options for either 2 or 4 control relays means the PD690 can function as a controller. These SPDT relays are rated at 2 amps at 240 VDC and can be programmed for automatic or automatic+manual reset. They can also be programmed for 0-100% deadband.

Installation Tips

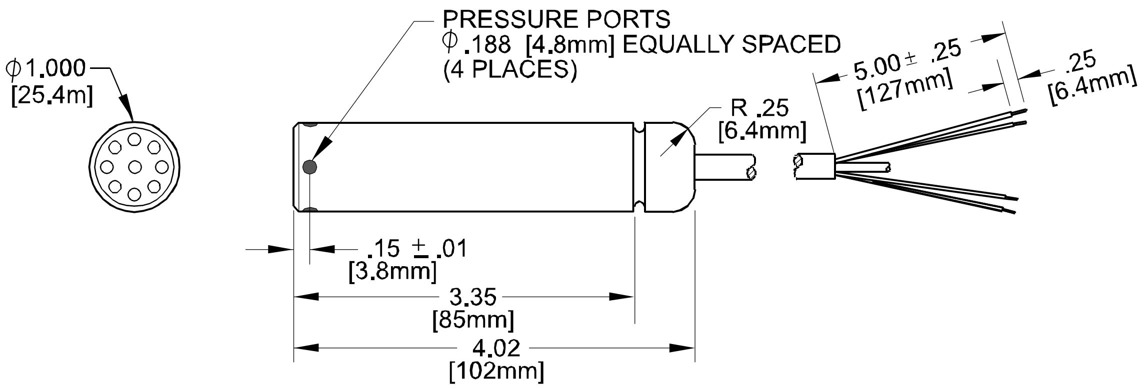
Most users either suspend our submersible transducer in a 1" or 2" PVC instrumentation still well or attach the transducer using our optional ½” M NPT fitting to a rigid conduit.

When suspending the cable, users often utilize our cable hanger (PN# 12-90-0931). This device slides onto the cable from the bare-wire end. The cable hanger can be positioned anywhere on the cable by pushing the ends together. Once positioned, the cable hanger contracts to provide a snug grip.



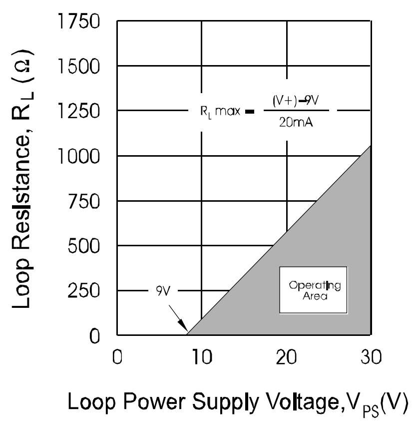


CABLE HANGER



ELECTRICAL TERMINATION		
(2,3 or 4) 22AWG CONDUCTORS IN A SHIELDED CABLE WITH SENSOR BREATHER AND POLYURETHANE JACKET		
(4) 4-20 mA	RED BLACK	+ EXCITATION - EXCITATION
(3) 0-5 VDC	RED BLACK WHITE	+ EXCITATION - EXCITATION + SIGNAL
(2,5,6) mV	RED BLACK WHITE GREEN	+ OUTPUT + EXCITATION - EXCITATION - OUTPUT
ALL	BLUE	CABLE SHIELD

LOOP RESISTANCE vs.
LOOP POWER SUPPLY



Series 700 Order Information

Standard shipment is 10 working days upon receipt of order. Expedited 2 and 5 working day shipment is available. All orders are shipped FOB from our factory in Hampton, Virginia.

Ordering Information

Model No.

7	0	0	±1.0% FSO Static Accuracy Submersible Pressure Transducer
7	1	0	±0.50% FSO Static Accuracy Submersible Pressure Transducer
7	2	0	±0.25% FSO Static Accuracy Submersible Pressure Transducer
7	3	0	±0.10% FSO Static Accuracy Submersible Pressure Transducer

Pressure Format

1	Gage, vented reference
3	Sealed gage
4	Absolute

Excitation/Signal

2	9-30 VDC Input, mV Output (Non-Ratiometric)
3	VDC Input, VDC Output
4	VDC Input, mA Output
5	VDC Input, mV Output (Ratiometric)
6	5 VDC Input, mV Output (Non-Ratiometric)

Pressure Connection

0	Standard submersible screen (open faced)
2	¼" - 18 NPT male

Electrical Connections

0	Standard submersible cable exit
4	½" - 14 NPT Male conduit connection
6	Submersible cable exit (non-vented)

Pressure Range

0 - 2 psi through 0 - 300 psi

Examples: 0-2 psi = 0002; 0-10 psi = 0010; 0-100 psi = 0100

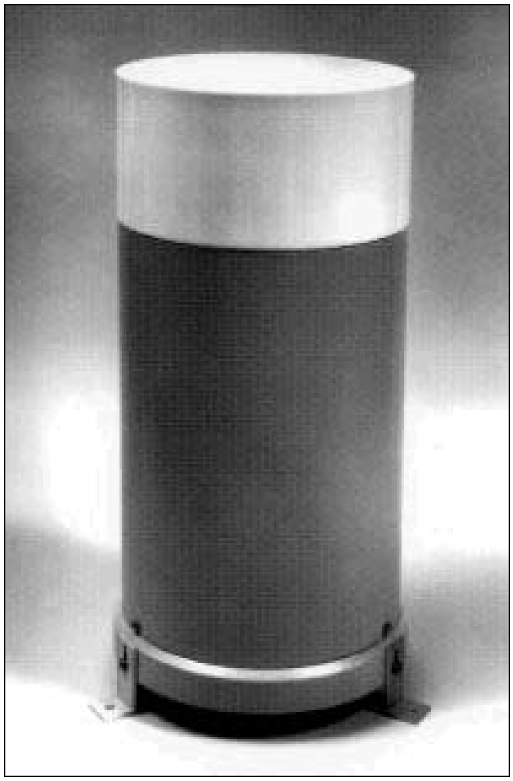
☐☐☐ - ☐☐☐ - ☐☐☐☐☐

Warranty: The Series 700 family of products is warranteed against defects in material and workmanship for 12 months from date of shipment. Products not subjected to misuse will be repaired or replaced. THE FOREGOING IS IN LIEU OF ANY OTHER EXPRESSED OR IMPLIED WARRANTIES. We reserve the right to make changes to any product herein assume no liability arising out of applications or use of any product or circuit described. Products described in this Specification are not intended for life support applications.

Precipitation Gauges

300 Series

The accurate measurement of rain and snow precipitation remains one of the most basic elements of meteorology. To enable accurate measurement of precipitation in all environments, Met One Instruments provides a series of instruments incorporating a tipping bucket mechanism. The tipping bucket design allows accurate, repeatable measurements, requires no regular operator maintenance, and is economical and proven in operation.



The Model 370 Rain Gauge

Features

- Jeweled bearings
- Teflon coated bucket
- Reed switch
- Self-emptying
- Corrosion resistant materials
- Quality construction

Each model in the series is optimized to meet a particular site and sampling requirement.

Operation

A dual-chambered tipping bucket assembly is located below the collection funnel. When a precise amount of precipitation has been collected in one side of the bucket, gravity tips the assembly and activates a reed switch. A momentary electrical contact closure through the switch is provided for each increment of rainfall. The sample is discharged through the base of the gauge. For environments that can typically expect a significant amount of frozen precipitation, internal sensor heaters are available. The heating elements are thermostatically controlled to melt and measure the water content of snow and frozen rain, but to avoid evaporative loss.

Construction

The heavy machined aluminum base provides a stable platform for the tipping assembly. The bucket is made from stainless steel and is Teflon coated to prevent retention of the sample. The bucket pivots are precision machined and fitted with jeweled bearings to reduce wear and friction. The funnel is powder coated aluminum and has two screens for preventing leaves and other debris from entering or clogging the gauge. A circular bubble-level and adjustable feet facilitate proper mounting of the unit. Major components are finished in catalyzed polyurethane paint, with a color and texture chosen to allow the sensor to blend into the environment.

Met One Instruments, Inc.

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Specifications

Rain Gauges

Model Number	Funnel Diameter	Standard Calibration	Optional Calibration
370	8 in (20.3 cm)	0.01 in	0.2 or 0.25 mm
372	8 in (20.3 cm)	0.5 mm	N/A
380	12 in (30.5 cm)	0.01 in	0.2 or 0.25 mm
382	12 in (30.5 cm)	0.1 mm	N/A

Rain and Snow Gauges

Model Number	Funnel Diameter	Standard Calibration	Optional Calibration	Heater Voltage
375	8 in (20.3 cm)	0.01 in	0.2 or 0.25 mm	115 VAC, 315 watts
376	8 in (20.3 cm)	0.01 in	0.2 or 0.25 mm	220 VAC, 315 watts
377	8 in (20.3 cm)	0.5 mm	N/A	115 VAC, 315 watts
379	8 in (20.3 cm)	0.5 mm	N/A	220 VAC, 315 watts
385	12 in (30.5 cm)	0.01 in	0.2 or 0.25 mm	115 VAC, 315 watts
386	12 in (30.5 cm)	0.01 in	0.2 or 0.25 mm	220 VAC, 315 watts
387	12 in (30.5 cm)	0.1 mm	N/A	115 VAC, 315 watts
389	12 in (30.5 cm)	0.1 mm	N/A	220 VAC, 315 watts

Thermostat Set Point:	Funnel Heater	40°F (4.4°C)
	Base Heater	40°F (4.4°C)
Heaters:	Funnel	240 watts, composite with built-in thermostat
	Base	75 watts, composite with built-in thermostat
Operating Temperature:	-50°C to +50°C	
Accuracy:	at 0.5"/hr	±0.5%
	at 1" to 3"/hr	±1.0%
Switch:	Type	Reed
	Rating	10 mA, 28 VDC
Height:	8 in Gauges	18 in (46 cm)
	12 in Gauges	20.5 in (52 cm)
Weight:	8 in Rain Gauges	6 lbs (2.7 kg)
(not including cabling)	12 in Rain Gauges	7.5 lbs (3.4 kg)
	8 in Rain/Snow	6.5 lbs (3 kg)
	12 in Rain/Snow	11.5 lbs (5.2 kg)
Shipping Weight:	8 in Rain Gauges	8.5 lbs (3.9 kg)
(not including cabling)	12 in Rain Gauges	10 lbs (4.5 kg)
	8 in Rain/Snow	9 lbs (4 kg)
	12 in Rain/Snow	14 lbs (6.4 kg)

Finish: White gloss/beige textured powder coat and clear anodized aluminum

Ordering Information

Specify Model Number, calibration factor, cable length(s), and accessories

Cable:	Signal	PN 1566-xx (xx=length in feet)
	Power (as required)	PN 2517-xx (xx=length in feet)

Accessories

Model 820440 Wind Screen: The improved Alter-design screen is constructed of 32 free-swinging, separated leaves. It can greatly improve the accuracy of the precipitation catch by reducing local turbulence.

MODEL 375C
8" RAIN GAUGE

OPERATION MANUAL
Document No. 375-9801

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MODEL 375C
ELECTRIC RAIN/SNOW SENSOR
OPERATION MANUAL

1.0 GENERAL INFORMATION

1.1 Model 375C Electric Heated Tipping Bucket Rain/Snow Gauge is an accurate, sensitive and low-maintenance sensor designed to measure rainfall on a continuous basis. Water does not collect in the sensor, but is drained each time an internal bucket fills with 0.01 inch of rainfall (standard calibration). At this time, a switch closure pulse is also sent to the translator module for counting. The sensor is calibrated prior to shipment and requires no adjustments after mounting.

1.2 Sensor Cable is a vinyl-jacketed 2-conductor shielded cable connecting to the sensor via an internal terminal strip. Cable length is designated in -xx feet on each cable part number label.

1.3 Power Cable is a vinyl-jacketed 3-conductor shielded cable connecting to the sensor heaters with wire nuts in an externally mounted J-Box. Cable length is designated in -xx feet on each cable part number label.

Table 1-1
Model 375C Rainfall Sensor Specifications

Orifice	8" Diameter
Calibration (standard) Calibration (options)	.01" Rain per switch closure 0.2mm, 0.25mm
Accuracy	±1% at 1" to 3" per hour at 70° F
Switch Type	Magnet & Reed
Mounting	3 Pads for 1/4 bolts on 9-21/32" (9.66") circle diameter
Dimensions	17-3/4" high, 8" diameter not including mounting pads
Power Requirement	110VAC, 50/60 Hz, 315W
Weight, less cables	7.5 lbs/3.4 kg (10 lbs shipping w/cables)

2.0 INSTALLATION

2.1 Choose a site where the height of any nearby trees or other objects above the sensor is no more than about twice their distance from the sensor. (Sample: 50 ft tree at least 100' away from gauge). A uniform surrounding of objects (such as an orchard) is beneficial as a wind break. Nonuniform surroundings (such as a nearby building) creates turbulence which affects accuracy.

2.2 Mount the sensor level on a platform, using the built in level as an aid. The three legs can be adjusted for leveling. Three 1/4" diameter bolts are used to mount the sensor on a 9-21/32" (9.66") bolt circle.

2.3 Remove shipping restraint (This may be tape, rubber band, or similar item) from sensor bucket and verify that bucket moves freely and that all adjusting screws are tight.

2.4 Connect the signal cable lugs to the terminal strip if not connected already. See diagram. Polarity is not important. See FIGURE 2-1.

2.5 Connect the power cable to the leads inside the condulet (see FIGURE 2-2) if not connected already.

2.6 Replace cover on sensor, tightening screws at base.

NOTE: If snowfall is anticipated, remove primary screen from funnel.

2.7 Route signal cable to the translator or datalogger and connect. Refer to the System Interconnect Diagram in your system manual for terminal identification.

2.8 Route the power cable to a 110VAC power source protected with a 15A GFI circuit. Connect (Ref. FIGURE 2-2). This wiring must conform to local and state wiring codes. If you are not familiar with these codes, an electrical contractor should be used.

Warning:
As with any AC power wiring, improper safety procedures can cause fatal injuries. If you are not qualified to do this work, call an electrical contractor to do it for you.

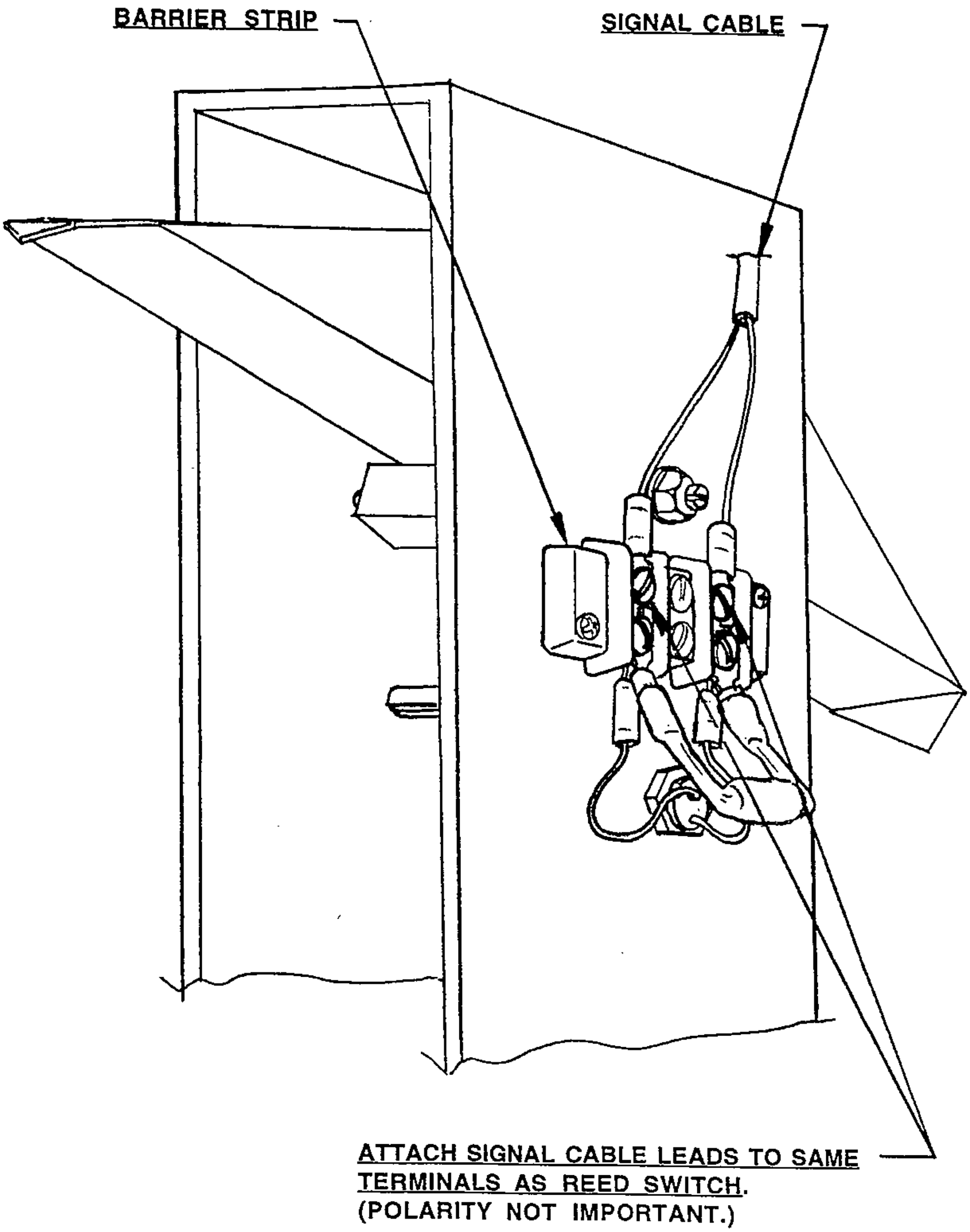
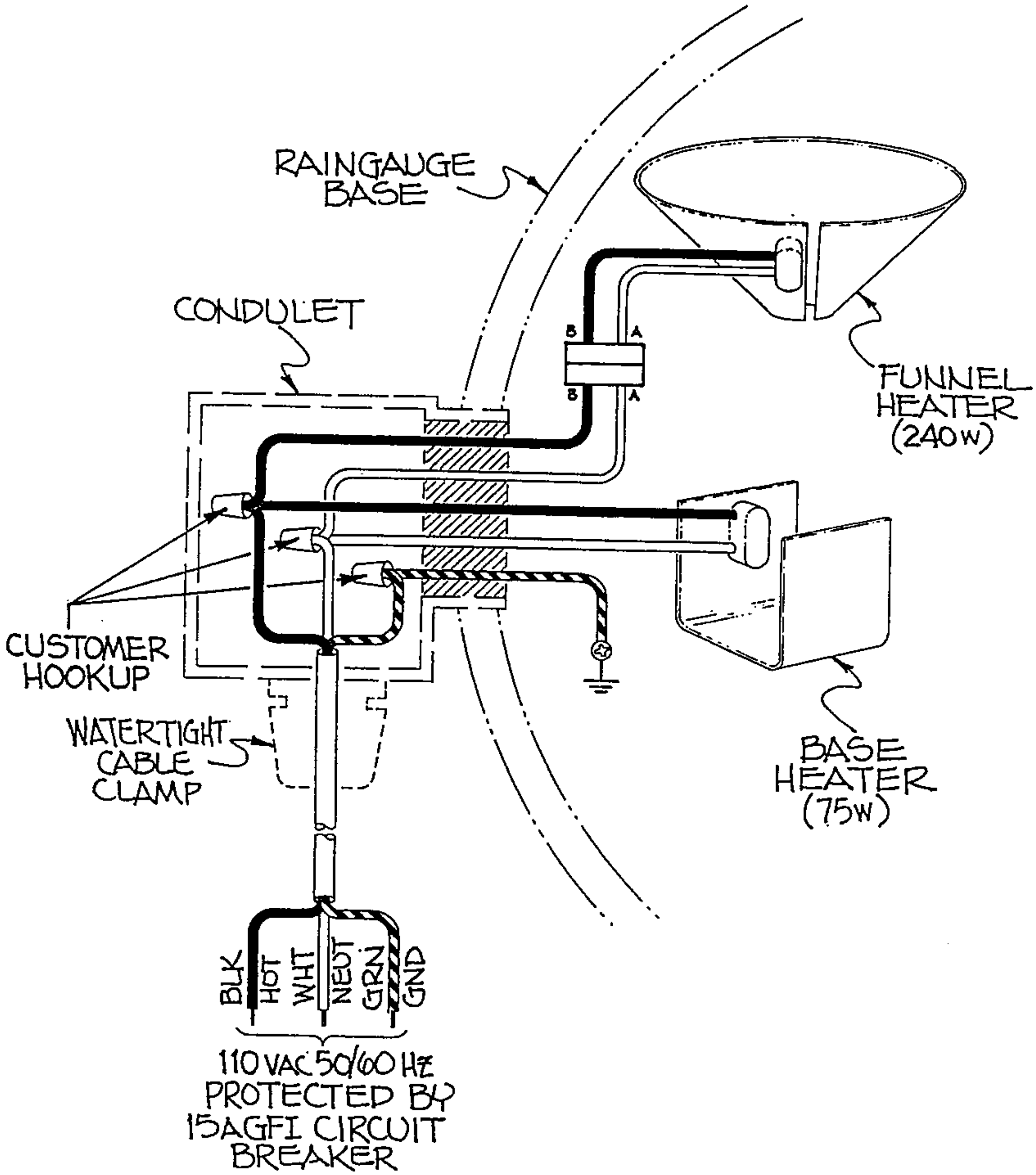

BARRIER STRIP
SIGNAL CABLE
ATTACH SIGNAL CABLE LEADS TO SAME TERMINALS AS REED SWITCH.
(POLARITY NOT IMPORTANT.)

FIGURE 2-1



HEATER POWER HOOKUP

FIG. 2-2

3.0 OPERATIONAL CHECK-OUT

3.1 Manually actuate tip bucket mechanism (stop-to-stop) three (3) times. Confirm that 3 tips have registered on the recording equipment. If not, refer to Troubleshooting Guide, Section 4-3.

4.0 MAINTENANCE AND TROUBLESHOOTING

4.1 General Maintenance Schedule*:
At six month intervals, perform the following steps:

a. Clean sensor funnel and buckets.
b. Do NOT lubricate the pivots, as any lubricant may attract dust and dirt and cause wear of the jewel bearings.
c. Verify that buckets move freely and that translator card or datalogger registers 0.01" or as calibrated for each bucket tip.

*Based on <u>average</u> to <u>adverse</u> environments.

4.2 <u>Calibration</u>. The sensor is factory calibrated; recalibration is not required unless damage has occurred or the adjustment screws have loosened. To check or recalibrate, perform the following steps:

a. Check to be sure the sensor is level.

b. Wet the mechanism and tipping bucket assembly. Using a graduated cylinder, slowly pour the measured quantity of water through the inner funnel to the tipping bucket, which should then tip. Repeat for the alternate bucket. If both buckets tip when filled with the measured quantity of water, the sensor is properly calibrated. If they do not, recalibrate as follows:

1. Release the lock nuts on the cup adjustments.
2. Move the adjustment screws down to a position that would place the bucket far out of calibration.
3. Allow the measured quantity of water to enter the bucket. (Refer to Table 4.1)
4. Turn the cup adjustment screw up until the bucket assembly tips. Tighten the lock nut.
5. Repeat steps 3 and 4 for the opposite bucket.
6. Measure the quantity of water necessary to tip each bucket several times to ensure proper calibration.
7. Replace the cover on the gauge.

Table 4.1
Calibration Quantities

Tip Calibration	Water Quantity
0.01" (standard)	8.24 milliliters
0.2mm	6.49 milliliters
0.25mm	8.11 milliliters

4.3 TROUBLESHOOTING

SYMPTOM	PROBABLE CAUSE	REMEDY
No sensor output	Faulty Reed Switch	Replace Reed Switch
	Signal Cable Connection	Check Connections
	Lightning Strike	Replace Reed Switch & Diode
	Debris in Funnel	Clean (See 4.1)
Erroneous Reading	Sensor not level	Re-level
	Sensor out of Calibration	Recalibrate (see 4.2)
	Site too near trees or other objects	Relocate (See 2.1)
Snow Not Melting	Heaters not getting power	Check circuit protector (customer provided)
	Heater Failure	Return unit to factory for repair.
	Primary Screen Installed	Remove Screen

Master Calibration Procedure For MMP Sites

Isco

1. Verify Telog is receiving the information properly from the Transmitter.
2. Verify that the Isco flow meter is working properly.
   a. Verify Pipe information
      i. Pipe OD
      ii. Wall thickness
      iii. Verify probe insertion depth
   b. Run Self test

KPSI

1. Verify Teloger is receiving pressure value being sent by Transmitter
   a. While performing calibration verify Telog is reading transmitter at all calibration points
2. Follow Red Valve Procedure
3. KPSI cannot be calibrated by us. If calibration is necessary they need to be sent back to factory.

Fuji

1. Verify pipe parameters are correct in meter head.
   a. Press function key
   b. Press pipe key
   c. Scroll through list to verify parameters
2. Verify 4-20mA is calibrated.
3. Verify Teloger is receiving flow value being sent by Transmitter
   a. While performing calibration verify Telog is reading transmitter at all calibration points

Druck

1. Verify Teloger is receiving pressure value being sent by Transmitter
   a. While performing calibration verify Telog is reading transmitter at all calibration points
2. Follow Red Valve Procedure
3. Follow Druke Procedure

Foxboro

1. Verify Teloger is receiving pressure value being sent by Transmitter
   a. While performing calibration verify Telog is reading transmitter at all calibration points
2. Follow Red Valve Procedure
3. Follow Foxboro Procedure

ABB Mag Master

1. Verify Teloger is receiving flow value being sent by Transmitter
   a. While performing calibration verify Telog is reading transmitter at all calibration points
2. Verify pipe parameters are correct in meter head.
3. Follow ABB Mag Master quick reference guide

ISCO Procedure

Chapter
5

ADFM Test Procedures

5-1 Introduction

This chapter explains how to test the ADFM using *BBTALK* and the *WinADFM* program. These tests thoroughly check the ADFM in a laboratory environment, but are no substitute for a practice deployment. You should test the ADFM:

- When you first receive the ADFM.
- Before each deployment or every six months.
- When you suspect instrument problems.
- After each deployment.

These test procedures assume all equipment is working. The tests can help you isolate problems to a major functional area of the ADFM. For trouble-shooting information, see Chapter 6.

NOTE. The built-in tests require you to immerse the transducer faces in water. If you do not, some of the tests may fail. Running the tests in air will not harm the ADFM.

5-2 Test Setup

Use the following steps to connect the ADFM system and to place the ADFM in a known state.

a. Connect a laptop computer to the RS-232 communication port.

b. Connect and apply power to the system as described in Chapter 2.

c. Place the ADFM transducer in approximately one foot of water.

5-3 Built-In Diagnostic Tests

The following describes how to execute an automatic self-test. In general, if the automatic self-test is successful, no further testing is required. However, if the automatic self-test is not successful, further fault isolation, utilizing individual Built-In Tests is necessary.

5-3.1 Automatic Built-In Test Test

The automatic Built-In Test (BIT) runs whenever the power is applied to the electronic housing or the reset button is cycled.

a. Switch power to the ADFM off.

b. Switch the power on again; however, make sure that at least one minute has passed since power was switched off. The computer screen will display [COLD Wakeup], and the ADFM's LCD display will show the "wake up message":

```
RD Instruments
-------------------
Acoustic Doppler
Flow Meter
```

c. The ADFM's LCD display will begin displaying the results of BIT as these tests are executed. The BIT tests will take approximately one or two minutes to perform after which the computer screen will display the wake up message:

```
Broadband ADFM Version 6.xx
RD Instruments © 1991-94
All rights reserved.
```

d. To repeat the BIT tests you may turn and release the Reset key switch, located at the front panel of the Electronics Unit.

e. To wake up the ADFM without performing the BIT, send a BREAK from *BBTALK*, by pressing the <END> key. The above wake up message will appear on the computer screen in approximately one second; the LCD will not display this message.

5-4 Using BBTALK to Test the ADFM

BBTALK allows you to send direct commands to the ADFM. You may use the following commands to further test the system.

5-4.1 Diagnostic Tests

The diagnostic test checks the major ADFM modules and signal paths. We recommend you run this test before a deployment. If any test fails, call MGD for further troubleshooting information.

a. Start *BBTALK*. Press the `End` key to wake the ADFM.

b. Type `CP` to clear the fault log.

c. Type `PC`. A message similar to the following should appear.

```
>pc
Transducer Communications:                  PASS
Recorder BIT (RT ):                         PASS
Modem (MO ):                                PASS
System Voltages (PT2):                      PASS
CPU RAM (PI ):                              PASS
Timing Card RAM (PI ):                      PASS
Demodulator RAM (PI ):                      PASS
Checksum Code/Tables (PT8):                 PASS
Receive Test (PT3):                         PASS
Transmit Test (PT4):                        PASS
Electronics Wrap Test (PT5):                PASS
LPF Bandwidth Test (PT6):                   PASS
Clock Interrupt (PI ):                      PASS
Error Log:
 Power Loss
 Auto Restart Occurred
 Transducer Communications Error
Self Tests Complete
```

Many users tell us their ADFM reports a FAIL condition during the self-tests that check the ADFM's "electronics wrap test." In most cases, the cause of the failure is external interference. A "noisy" environment, such as in a lab usually causes this external interference. You can take a few simple steps to find out if the FAIL condition is being caused by external interference or by a problem with the ADFM.

The following procedure explains how to conduct the PC test to reduce the likelihood of a false failure.

a. Turn off any nearby equipment (monitors, radios, etc.) that is not needed to conduct the test.

b. The electronic housing case should be closed to help shield the circuit boards from external electronic "noise."

c. The ADFM transducer head must be immersed in water. Ensure there are no air bubbles on the transducer faces.

d. If the transducer is immersed in a bucket of water that is resting on the floor, noise can be coupled into the ADFM. As such, you should shield the bucket from the floor by inserting a piece of hard foam between the bucket and the floor.

e. If possible, you may also want to move the ADFM to a different room, or at least to a different part of the lab to see if the fail condition goes away.

f. If after following the above procedure, your ADFM still fails the receive tests, contact MGD for assistance.

5-4.2 Receive Path Test

This test runs a through test on the ADFM's receive path electronic circuits.

a. Start *BBTALK*. Press the `End` key to wake the ADFM.

b. Type `CP` to clear the fault log.

c. Type `PT3`. A message similar to the following should appear.

```
>pt3

Correlation Magnitude:

               Lag  Bm1  Bm2  Bm3  Bm4  Bm5
                 0  255  255  255  255  255
                 1  206  212  207  206  212
                 2  103  118  107  105  119
                 3   31   47   33   33   49
                 4    4   15    9    6   16
                 5    2    3    7    3    7
                 6    2    2    9    1    5
                 7    2    2    6    1    4

  High Gain RSSI:    45   47   44   42   47

  DAC Sin:   182
  DAC Cos:   183
  Duty:       50   50,    LPF:  0

Receive Test Results = $00000000 ... PASS
```

d. Observe the High Gain RSSI values. They should be between 40 to 57 counts with the transducer connected.

e. Disconnect the transducer from the electronic housing by disconnecting the transducer cable.

f. Type `PT3`. A message similar to the following should appear.

```
>pt3

Correlation Magnitude:

               Lag   Bm1   Bm2   Bm3   Bm4   Bm5
                 0   255   255   255   255   255
                 1   192   196   198   192   194
                 2    70    75    88    76    73
                 3     9    11    27    26    11
                 4    16    15    10    26    17
                 5    12    15     6     9    13
                 6    10    11    10    15     8
                 7     9     8    10    19     7

  High Gain RSSI:     21    21    20    21    21

  DAC Sin:   186
  DAC Cos:   187
  Duty:       59   50,    LPF:  0

Receive Test Results = $00000000 ... PASS
```

g. Observe the High Gain RSSI values. They should be between 20 to 25 counts with the transducer disconnected.

h. Leave the transducer cable disconnected if you want to run the next test.

5-4.3 Transmit Test

This test runs a through test on the ADFM's transmit path electronic circuits.

a. Start *BBTALK*. Press the `End` key to wake the ADFM.

b. Type `CP` to clear the fault log.

c. Type `PT4`. A message similar to the following should appear.

```
>pt4

----------- BEAM 1 -----------
IXMT    =      3.1 Ml Amps peak
VXMT    =      4.1 Volts peak
RXMT    =   1335.6 Ohms
Transmit Test Results = $40 ... PASS
----------- BEAM 2 -----------
IXMT    =      3.1 Ml Amps peak
VXMT    =      4.1 Volts peak
RXMT    =   1335.6 Ohms
Transmit Test Results = $40 ... PASS
----------- BEAM 3 -----------
IXMT    =      3.1 Ml Amps peak
VXMT    =      4.1 Volts peak
RXMT    =   1335.6 Ohms
Transmit Test Results = $40 ... PASS
----------- BEAM 4 -----------
IXMT    =      3.1 Ml Amps peak
VXMT    =      4.1 Volts peak
```

```
RXMT    =   1335.6 Ohms
Transmit Test Results = $40 ... PASS
```

d. Observe the RXMT values. They should be above 1300 ohms with the transducer disconnected.

e. Re-connect the transducer to the electronic housing by connecting the transducer cable.

f. Type `PT4`. A message similar to the following should appear.

```
>pt4

----------- BEAM 1 -----------
IXMT    =     30.9 Ml Amps peak
VXMT    =      3.4 Volts peak
RXMT    =    109.7 Ohms
Transmit Test Results = $0 ... PASS
----------- BEAM 2 -----------
IXMT    =     30.6 Ml Amps peak
VXMT    =      3.4 Volts peak
RXMT    =    111.3 Ohms
Transmit Test Results = $0 ... PASS
----------- BEAM 3 -----------
IXMT    =     30.9 Ml Amps peak
VXMT    =      3.4 Volts peak
RXMT    =    109.7 Ohms
Transmit Test Results = $0 ... PASS
----------- BEAM 4 -----------
IXMT    =     30.9 Ml Amps peak
VXMT    =      3.4 Volts peak
RXMT    =    109.7 Ohms
Transmit Test Results = $0 ... PASS
>
```

g. Observe the RXMT values. They should be approximately 109 ohms with the transducer connected.

5-4.4 Sensor Test

This test checks the internal ADFM sensors (temperature and depth).

a. Start *BBTALK*. Press the `End` key to wake the ADFM.

b. Type `CP` to clear the fault log.

c. Type `PA1`) This command lets you view sensor data and scale factor calculations while the ADFM is operating.

```
>pa1

Press any key to quit sensor display ...

Transducer Temp   Depth(mm)
  21.47øC           0
  21.47øC           0
```

d. Verify these readings are present and correct.

5-4.5 Modem Test

This test checks the modem operation.

a. Start *BBTALK*. Press the `End` key to wake the ADFM.

b. Type `CP` to clear the fault log.

c. Type `MP1` to turn the modem power on.

d. Type `MO`.

e. Verify these readings are present and correct.

```
>mp1
>mo
Modem is OK
Modem state/connect status = COMMAND/NOT CONNECTED
Primary Port = RS-232
```

f. Type `MP0` to turn the modem power off.

g. Type `MO`.

h. Verify these readings are present and correct.

```
>mp0
>mo
Modem is NOT OK
Modem state/connect status = OFF/NOT CONNECTED
Primary Port = RS-232
>
```

5-4.6 Recorder Test

This tests the recorder — it does not destroy any data.

a. Start *BBTALK*. Press the `End` key to wake the ADFM.

b. Type `CP` to clear the fault log.

c. Type `RT`.

d. Verify these readings are present and correct for your system.

```
>rt

Recorder Message...  0  1 14  0  0

RAM --------------PASS
Cards Found ------   1
Memory Found -----  20 MB
Write/Read -------PASS
Block Copy -------PASS
Recorder NOT Erased

Recorder BIT...PASS
>
```

5-5 Using WinADFM to Test the ADFM

WinADFM can be used to test the ADFM. Figure 5-18 shows the Operate dialog window. The ADFM can be tested for proper communication, bench test the system to ensure the system electronics are operating properly, and field-test the system after it has been installed.

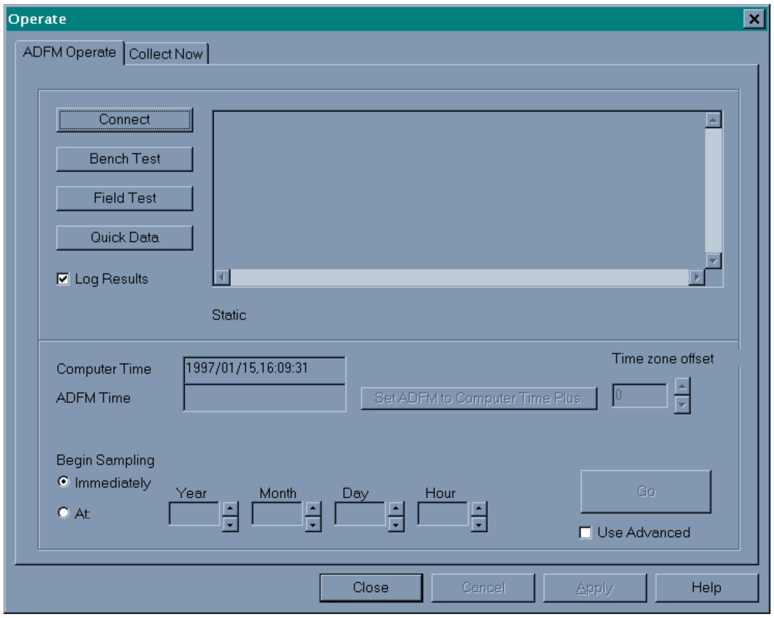


Figure 5-1. WinADFM Operate Dialog Window

The tests are listed in the top half of the window next to the output display. Results of each test are displayed in the terminal screen to the right of the buttons. Test results are recorded in the station's Log File. If checked, the log file keeps a record of all communication between the computer and the ADFM once communications have been established.

5-5.1 Connect

This test establishes communications and determines if the ADFM wake-up message contains any errors. Determines if the system is "ready". This test is for either serial (RS-232) or modem communications between the ADFM and a laptop. The system will return an error declaration (Communication Error) if communications are not obtained.

5-5.2 Bench Test

This test determines if all the required ADFM systems are present and functioning. The bench test does the following.

- Establishes communications and determines if the ADFM wake-up message contains any errors. Determines if the system is "ready".

- Lists the ADFM's serial number and the transducer and electronics firmware versions.
- Determines if an internal recorder is present. Performs a "Recorder Test" and returns an "OK" or an error declaration.
- Determines if a modem is present. Performs a "Modem Test" and returns an "OK" or an error declaration.
- Performs a "Systems Test" and returns an "OK" or an error declaration.
- Performs a Look-up Table "Checksum Test" and returns an "OK" or an error declaration.
- Determines the value of three operating voltages in the ADFM.
    - Battery Voltage,
    - VDD1 Voltage (logic),
    - Transducer Voltage.

5-5.3 Field Test

This test performs internal ADFM system checks that should be performed after installation. This test does the following.

- Establishes communications and determines if the ADFM wake-up message contains any errors. ADFM is "ready".
- Determines if the receive path is operating properly and returns a Pass or Fail with an error. This test will fail if the transducer is not connected to the electronics case.
- Determines if the transmit path is operating properly and returns a Pass or Fail with an error.
- Determines if the electronics signal-processing path is operating properly and returns a Pass or Fail with an error. This test will fail if the transducer is not underwater.

NOTES

Foxboro Procedure

4. Calibration

NOTE

1. For best results in applications where high accuracy is required, rezero the transmitter output once it has stabilized at the final operating temperature.

2. Zero shifts resulting from position effects and/or static pressure effects can be eliminated by rezeroing the transmitter output.

3. After calibrating transmitters operating with a 4 to 20 mA (or 1 to 5 V dc) output signal, check the underrange and overrange output values to ensure that they extend beyond 4 and 20 mA (or 1 and 5 V dc) respectively.

General Calibration Notes

1. Each transmitter is factory characterized over its full rated pressure range. One benefit of this process is that every transmitter can measure any applied pressure within its range limits regardless of the calibrated range. The applied pressure is measured and converted into an internal digital value of pressure. This digital value of pressure is always available whether the transmitter is calibrated or not. Calibration assures that the transmitter rated accuracy is achieved over the calibrated range.

2. The internal digital value of pressure can be displayed on the local display, and converted to a 4 to 20 mA analog output signal.

3. Each transmitter is factory calibrated to either a specified or a default calibrated range. This calibration optimizes the accuracy of the internal digital value of pressure over that range. If no range is specified, the default range is zero to the sensor upper range limit (URL).

4. There is an independent trim on the digital-to-analog conversion stage. This trim allows for slight adjustment of the 4 and 20 mA outputs. This compensates for any slight difference that exists between the transmitter mA output and an external reference device which is measuring the current.

- The mA trim does not affect the calibration or the reranging of the transmitter and does not affect the internal digital value of pressure or the transmission or display of measured pressure.
- The mA trim can be done with or without pressure applied to the transmitter.

5. The transmitter database has configurable values for both lower range value (LRV) and upper range value (URV). These stored values are used for two functions: defining the calibrated range and reranging without pressure.

a. Defining the Calibrated Range:

- When either **CAL LRV** or **CAL URV** is initiated from the pushbuttons, the transmitter expects that the pressure applied at the time the button is pressed is equal to the LRV or URV value respectively.
- This function trims the internal digital value of pressure; that is, it performs a calibration based on the application of accurate pressures equal to the values entered for LRV and URV in the transmitter database.
- This function also sets the 4 and 20 mA output points; that is, the 4 and 20 mA points correspond to the values of LRV and URV in the database.
- If the transmitter is configured for reverse range, the 20 and 4 mA points correspond to the LRV and URV respectively.

b. Reranging Without the Application of Pressure:

- Since the transmitter continually determines an internal digital value of the measured pressure from the lower range limit (LRL) to the upper range limit (URL), the 4 and 20 mA output points can be assigned to any pressure values (within the span and range limits) without application of pressure.

- The reranging function is accomplished by entering new database values for LRV and URV.
- Reranging does not affect the calibration of the transmitter; that is, it does not affect the optimization of the internal digital value of pressure over a specific calibrated range.
- If the reranged LRV and URV are not within the calibrated range, the measured values may not be as accurate as when they are within the calibrated range.

6. LCD Indicator

- The display can show any measured pressure in selected units regardless of the calibrated range and the values of LRV and URV (within the limits of the transmitter and display). The display can also be 0 to 100 percent.
- If the measured pressure is outside the range established by the LRV and URV values in the database, the display shows the measurement but also continually blinks to indicate that the measurement is out of range. The current signal is saturated at either the low or high overrange limit respectively but the display continually shows the pressure.

7. Zeroing the Transmitter

- Zeroing does not affect the span.
- When the transmitter is zeroed to compensate for installed position effect, the transmitter may have either LRV pressure applied (**CAL LRV**) or zero pressure applied (**CAL AT0**). If the range is zero-based, either method produces the same result. However, if the range is not zero-based, it is advantageous to have both methods available.

  For example, consider a pressure transmitter having a range of 50 to 100 psig. If it is not feasible to vent the transmitter to atmosphere for zeroing, it may be zeroed while the LRV pressure of 50 psi is applied by using the **CAL LRV** function. On the other hand, if the transmitter has been installed but there is no pressure in the process line yet, it can be zeroed while open to atmosphere by using the **CAL AT0** function.

a. Zeroing with LRV Pressure Applied (**CAL LRV**):

- Before using this zeroing function, apply a pressure to the transmitter equal to the value of LRV stored in the transmitter database.
- When you zero the transmitter, the internal digital value of the pressure is trimmed to be equal to the value of LRV stored in the database and the mA output set to 4 mA.
- If zeroing is done when the applied pressure is different from the LRV pressure value in the database, the internal digital value of pressure is biased by the difference in the values but the output is still set at 4 mA.
- The **CAL LRV** (and **CAL URV**) function should be used when calibrating a transmitter for a specific range with known input pressures applied for the LRV and URV.

b. Zeroing a Gauge Pressure Transmitter with Zero Pressure Applied (**CAL AT0**):

NOTE

Do **not** use the **CAL AT0** function with an absolute pressure transmitter. If an absolute pressure transmitter is vented to atmosphere, it does **not** have zero pressure applied but instead has the barometric pressure (approximately 14.7 psia) applied.

- Make sure that the applied pressure is at zero. This means venting the transmitter to atmosphere.

- When you zero the transmitter, the internal digital value of the pressure is trimmed to be equal to zero and the mA output set to an appropriate value such that the mA output is a normal 4 mA when the LRV pressure is applied later.

c. Zeroing an Absolute Pressure Transmitter

To zero an absolute pressure transmiter, the LRV can be temporarily set to the barometric pressure and a CAL LRV function performed with the transmitter vented to atmosphere. Then, the LRV can be set back to the proper value.

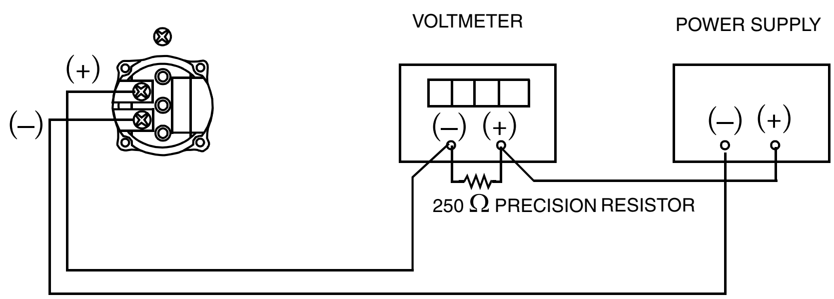
Calibration Setup

The following sections show setups for field or bench calibration. Use test equipment that is at least three times as accurate as the desired accuracy of the transmitter.

NOTE

It is not necessary to set up calibration equipment to rerange the transmitter to a different range. The transmitter can be accurately reranged by simply changing the lower range value and the upper range value, which are stored in the transmitter database.

Setup of Electronic Equipment

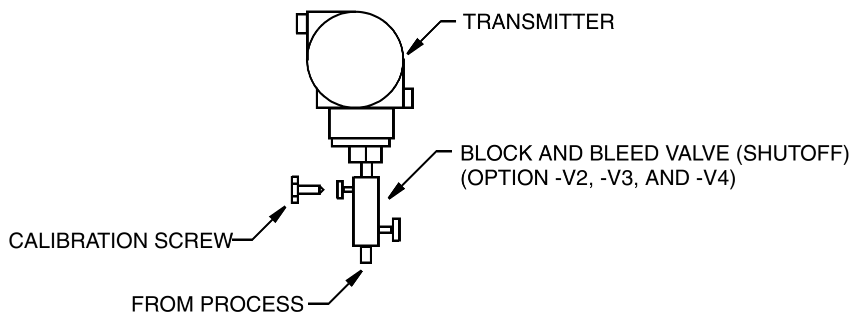


Resistor: 250 Ω, ±0.01%, 1 W minimum (Part No. E0309GY)
Power Supply: Refer to Figure 17
Digital Voltmeter: readings from 1.000 to 5.000 V dc

Figure 23. 4 to 20 mA Output Calibration Setup of Electronic Equipment

Field Calibration Setup

Field calibration is performed without disconnecting the process piping. This is only possible if the transmitter is piped as shown in Figure 24.



NOTE: Block and Bleed Valve Maximum Pressure
40 MPa (6000 psi at 38°C (100°F)
25 MPa (4000 psi at 250°C (400°F)
Calibration Screw Maximum Pressure
0.7 MPa (100 psi with Poly-Flo Fitting (F0101ES)

Figure 24. Transmitter Piping

If the transmitter is to be removed from the process for calibration, refer to the "Bench Calibration" procedure.

An adjustable air supply and a pressure measuring device are required. For example, a dead weight tester or an adjustable clean air supply and pressure gauge can be used.

Bench Calibration Setup

The bench calibration setup requires disconnecting the process piping. For calibration setup without disconnecting the process piping, refer to the "Field Calibration" procedure.

The input setup is shown in Figure 25. If calibrating the output signal, also connect equipment as shown in “Setup of Electronic Equipment” on page 27.

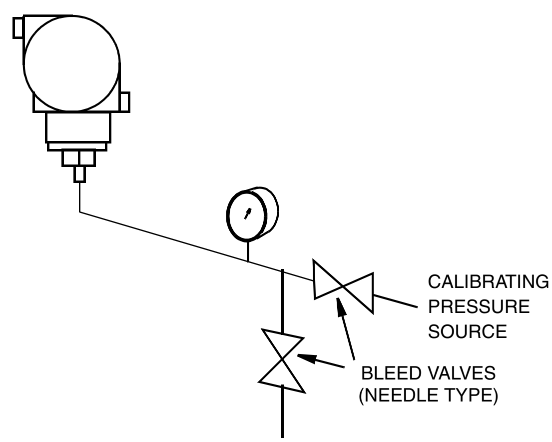


Figure 25. Bench Calibration Setup

Calibration Using the Local Display

To access the Calibration mode (from normal operating mode), press the **Next** button. The display reads **CALIB**, the first item on the menu. Acknowledge your choice of this selection by pressing the **Enter** button. The display shows the first item in the Calibration menu.

NOTE

During calibration, a single change could affect several parameters. For this reason, if an entry is entered in error, re-examine the entire database or use the **Cancel** feature to restore the transmitter to its starting configuration and begin again.

Table 4. Calibration Menu

Item	Description
CAL AT0	Calibrate with zero pressure.
CAL LRV	Calibrate with pressure at 0% of transmitter range (LRV).
CAL URV	Calibrate with pressure at 100% of transmitter range (URV).
ADJ 4MA	Adjust nominal 4 mA output.
ADJ20MA	Adjust nominal 20 mA output
ADJ 4MA causes the following four submenus.	
A 4mAΔΔ	Increase 4 mA output by large step.
A 4mA∇∇	Decrease 4 mA output by large step.
A 4mAΔ	Increase 4 mA output by small step.
A 4mA∇	Decrease 4 mA output by small step.
ADJ 20MA causes the following four submenus.	
A 20mAΔΔ	Increase 20 mA output by large step.
A 20mA∇∇	Decrease 20 mA output by large step.
A 20mAΔ	Increase 20 mA output by small step.
A 20mA∇	Decrease 20 mA output by small step.

NOTE

1. It is not necessary to use the **ADJ4MA** or **ADJ20MA** menu selections unless there is a plant requirement to make the 4 and 20 mA output values exactly match readings on certain plant calibration equipment and the “zero” and “span” operations done result in a small but unacceptable difference between the transmitter mA output and the test equipment mA readout values.
2. The transmitter can be reranged without the application of pressure.

Proceed to calibrate your transmitter by using the **Next** key to select your item and the **Enter** key to specify your selection per Figure 26. At any point in the calibration you may **Cancel**, restore your prior calibration and return to the on-line mode or **Save** your new calibration.

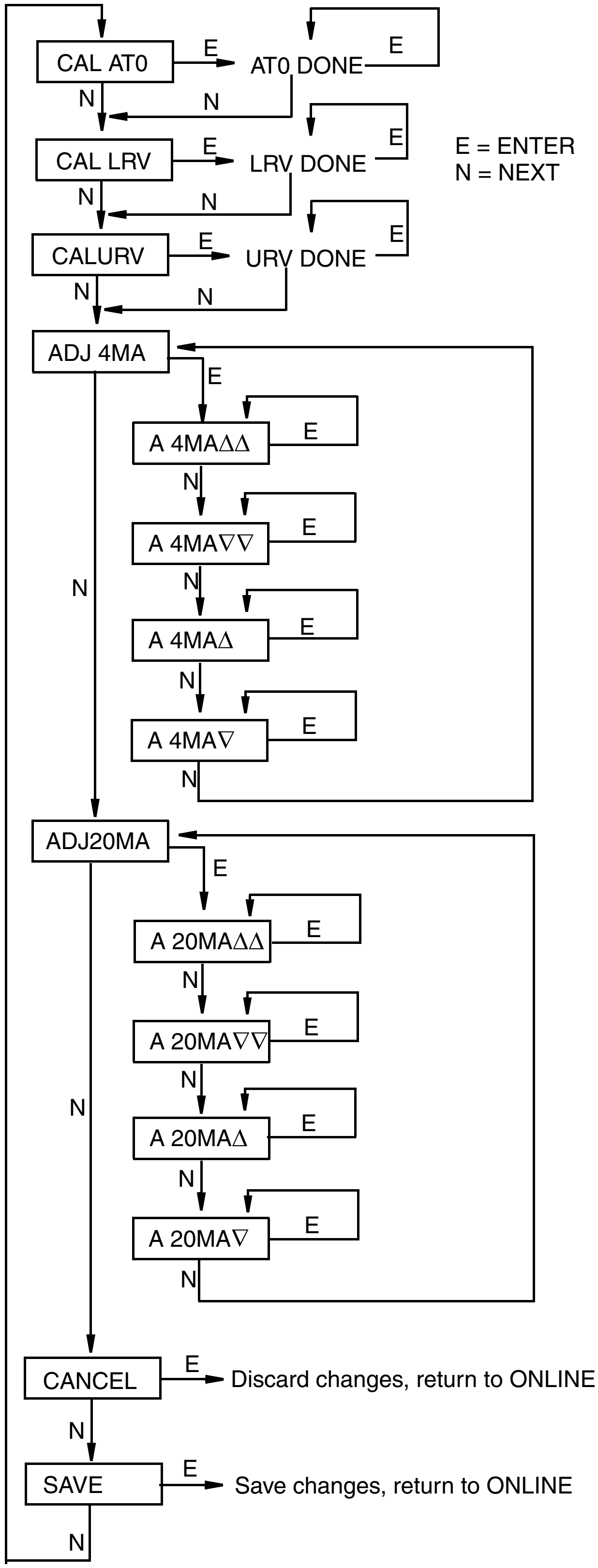


Figure 26. Calibration Structure Diagram

CAL AT0: To set or reset the zero point at zero pressure, apply zero pressure to the transmitter and, at display of **CAL AT0**, press **Enter**. This can be done whether LRV is zero or not. Completion is indicated by the display **AT0 Done**.

CAL LRV: To set or reset 0% of range input, apply pressure to the transmitter equal to the lower range value (LRV) in the transmitter database and, at display of **CAL LRV**, press **Enter**. Completion is indicated by the display **LRV Done**.

CAL URV: To set or reset 100% of range input, apply pressure to the transmitter equal to the upper range value (URV) in the transmitter database and, at display of **CAL URV**, press **Enter**. Completion is indicated by the display **URV Done**.

ADJ4mA: If you configured your transmitter operating mode as 4 to 20 mA, you can adjust the 4 mA output by going to **ADJ4mA** using the **Next** button and press **Enter**. This menu item is bypassed if you configured your transmitter operating mode as digital.

To increase the 4 mA output by a large (0.025 mA) step, press **Enter** at the display **A 4mAΔΔ**. To decrease it by a large step, go to the display **A 4mA∇∇** by pressing the **Next** button and then **Enter**. To increase it by a small (0.001 mA) step, go to the display **A 4mAΔ** with the **Next** button and then press **Enter**. To decrease it by a small step, go to the display **A 4mA∇** with the **Next** button and then press **Enter**.

ADJ20mA: Similar to **ADJ4mA**.

Zero Adjustment Using External Zero Button

An optional external zero adjustment mechanism in the electronics housing allows local "rezeroing" of the transmitter output without removing the electronics compartment cover. The mechanism is magnetically activated through the housing wall to prevent moisture from entering the enclosure. Zeroing is accomplished when the external zero button is depressed. The external zero button does a **CAL AT0** calibration (at zero pressure).

To use this feature:

1. Unlatch the external zero button by turning it 90° in a counterclockwise direction so that the screwdriver slot lines up with the two holes in the face of the adjacent part. Do **not** push the button in with the screwdriver while doing this.
2. Press the button with zero pressure applied to the transmitter.
3. The display indicates **ZEROED**. If **EX ZERO** is disabled, or the transmitter is not on-line, the display reads **Bad Key**.
4. If additional rezeroing is required, wait 20 seconds and repeat Step 2.
5. Relatch the external zero button by turning it 90° in a clockwise direction to prevent accidental pressing of the button. Do **not** push the button in with the screwdriver while doing this.

Error Messages

Table 5. Error Messages

Message	Interpretation
BAD KEY	Pressing **External Zero** button with **EX ZERO** disabled or transmitter not on-line.
LOLIMIT	4 mA or 20 mA calibration adjustment has reached lower limit. a. Improper calibration setup; correct setup. b. Bad D/A converter; replace electronics module.
HILIMIT	4 mA or 20 mA calibration adjustment has reached upper limit. a. Improper calibration setup; correct setup. b. Bad D/A converter; replace electronics module.
BADZERO	Recalculation of offset during **CAL AT0**, **CAL LRV**, or **EX ZERO** resulted in out of range value. a. Applied pressure too high during operation. b. Improper calibration setup.
BADSPAN	Recalculation of slope during **CAL URV** operation resulted in out of range value. a. Applied pressure too low during **CAL URV** operation. b. Improper calibration setup.

5. Configuration

You can access the Configuration mode by the same multi-level menu system that was used to enter Calibration mode. Entry to the Mode Select menu is made (from normal operating mode) by pressing the **Next** button. The display reads **CALIB**, the first item on the menu. Press the **Next** button again to get to the second item on the menu, **CONFIG**. Acknowledge your choice of this selection by pressing the **Enter** button. The display shows the first item in the Configuration menu. You can then configure items shown in Table 6. The initial factory configuration is also given in this table.

— **NOTE**

During configuration, a single change may affect several parameters. For this reason, if an entry is entered in error, re-examine the entire database or use the **Cancel** feature to restore the transmitter to its starting configuration and begin again.

Table 6. Configuration Menu

Item	Description	Initial Factory Configuration[(a)]
EX ZERO	External zero: enable or disable	Disable
OUT DIR	Output direction: forward or reverse	Forward
OUTMODE	Output: linear[(b)]	Linear
OUTFAIL	Fail mode output: low or high	High
DAMPING	Damping: none, 2-, 4-, or 8-seconds	None
DISPEGU	Display measurement in EGU or in percent of span	Use EGU
EGU SEL	Engineering units for calibrated range and display: select from list.	Per Sales Order
EGU LRV	Set Lower Range Value (LRV)	Per Sales Order
EGU URV	Set Upper Range Value (URV)	Per Sales Order

(a) Default settings. If optional feature "–C2" is specified, the initial factory configuration is custom per order.

(b) Square root is not applicable to absolute pressure, gauge pressure, or level measurement.

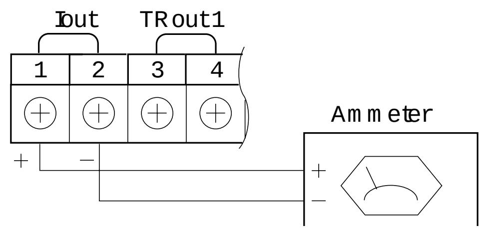
Proceed to configure your transmitter by using the **Next** key to select your item and the **Enter** key to specify your selection per Figure 27. At any point in the configuration you may **Cancel** your changes and return to the on-line mode or **Save** your changes.

Fuji Procedure

5.4 (18) Analog output check

Description

Check the analog output circuit.
Check to make sure that the output values at –20% to 120% are 0.8mA to 23.2mA.
Connect an ammeter to the Iout terminal as shown below.



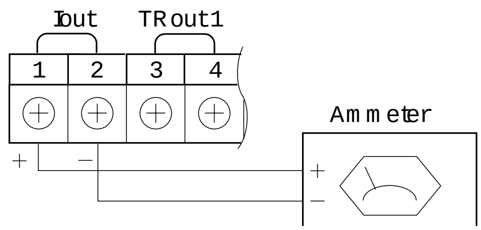
Operation (example)	Check of analog output of 4mA, 8mA, 12mA, 16mA, 20mA	
Key operation	**Description**	**Display**
FUNC SYSTEM		
▲ or ▼	Select "Analog output check".	OUTPUT CHECK 0 %
0, ENTER	Enter "0" with ten keys. [0% (4mA) check]	OUTPUT CHECK 0 %
2 5, ENTER	Enter "25" with ten keys. [25% (8mA) check]	OUTPUT CHECK 25 %
5 0, ENTER	Enter "50" with ten keys. [50% (12mA) check]	OUTPUT CHECK 50 %
7 5, ENTER	Enter "75" with ten keys. [75% (16mA) check]	OUTPUT CHECK 75 %
1 0 0, ENTER	Enter "100" with ten keys. [100% (20mA) check]	OUTPUT CHECK 100 %
ESC ESC	Press the key twice.	(Measurement display)

5.4 (19) Analog output calibration

Description

The analog output circuit is calibrated so that the measured flow rate is set to provide an output of 4mA in the base scale and 20mA in the full scale.

Calibration should be performed by connecting an ammeter to Iout terminal as shown below.



Operation (example)	Calibration of output of 4mA, 20mA	
Key operation	**Description**	**Display**
FUNC SYSTEM		
▲ or ▼	Select "Analog output calibration".	OUTPUT ADJUST SKIP
◀ or ▶, ENTER	Select "Setting".	OUTPUT ADJUST SETTING
▲ (up) or ▼ (down) ◀ (down) or ▶ (up) , ENTER	Fine calibration Coarse calibration } Ammeter should indicate 4mA.	OUTPUT ADJUST 4mA
▲ (up) or ▼ (down) ◀ (down) or ▶ (up) , ENTER	Fine calibration Coarse calibration } Ammeter should indicate 20mA.	OUTPUT ADJUST 20mA
ESC ESC	Press the key twice.	(Measurement display)

Note: After calibration is completed, set the calibration mode to Skip.

Red Valve Procedure

Red Valve Calibration for PRS stations

Footnote: To operate Manual Pressure Producing device: Use Black Knob clockwise to hold pressure while pumping. Use Brass colored knob starting in the center or null position as a fine adjustment for pressure. The black knob can also be used to release overall pressure.

Overall Objective: To Calibrate Pressure Units connected to a Red Valve.

1) On site you will see a sewage purge hose and a valve that controls flow to manual PSI Gauge and a Red Valve cutoff valve.
2) Shut off Valve that supplies raw sewage to red valve tightly.
3) Open Sewage Purge Hose valve and release contents.
4) Open Valve that supplies sewage pressure to PSI gauge.
5) Remove Suction side Red Valve by removing all bolts in any order.
6) Clean all components inside and around red valve with a hose.
7) Wash sewage from deck into pump station well areas. (a Courtesy)
8) Clean with rag the area within the Red Valve. Use no sharp instruments while doing this.
9) Fasten 4 Bolts in a rectangular pattern while cross tightening evenly around the station suction side Red Valve while attaching gaskets and plastic calibration covers to produce an airtight result.
10) Use Checkmate pressure calibrator. Connect pressure hose from pressure producing device to High side of Checkmate Pressure Calibrator. Turn power on and always Zero pressure calibrator before doing measurements.
11) Attach the other hose from the pressure producing device to the center of the plastic calibration cover. Tighten only applying minimal force to this fitting as it is Brass.
12) Pre-Calibration checks will be performed at 0%, 25%, 50%, 75% and 100% of Span as directed from Calibration sheet. (manually pump air to these specified values) Read the current (ma) values from the Clamp on ammeter and from display device for the three above values respectively. Write on Calibration sheet.
13) If instrument is out of calibration then follow calibration procedure in instruments manual. If pressure transmitter is KPSI then calibration is not possible. The transmitter and Red Valve will have to be separated and the KPSI will then have to be checked separately. If KPSI is still off then replace.
14) Reinstall Suction side Foxboro in reverse order ensuring to replace gaskets and cross tighten bolts with even torque. Shut valves on Gauge and purge hose after gear reconnected.
15) Open main valve that leads into Red Valve fully open.
16) Open Purge hose valve and Gauge valve to release sewage and air out of Red valve then shut.
17) Wash sewage from deck into pump station well areas. (a Courtesy)

Author:
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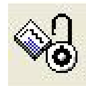
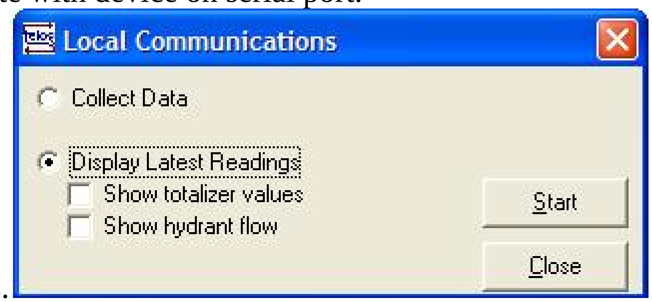
South Side Instrumentation
5 March 2008

Telog Procedure

Procedure for connecting PC to Teloger for Teloger verification.

1. Connect Teloger cable from pc serial port to Teloger serial port.
2. Start TCC or Telogers for windows.
3. Insure padlock icon is locked  not .
4. Click  to communicate with device on serial port.
5. Click Display local readings. 

6. Click start to display new readings. Updates will occur every few seconds while this window is open.
7. To exit click close.

Druck Procedure

Druck Calibration Procedure

1. Set pressure zero and span
    a. Setup Druck with a Red Valve (See included Red Valve Instructions)
    b. Vent the center of the Red Valve to atmosphere.
    c. Set zero by
        i. applying 0 psi to instrument
        ii. Go to Range tab
        iii. Adjust current until output is 4.00 mA
            1. Adjust low current by entering the mA reading the fluke is showing @ 0 psi into the Offset box {A}
    d. Apply span pressure to Red Valve
        i. applying Span psi to instrument
        ii. Go to Range tab
        iii. Adjust current until output is 20.00 mA
            1. Adjust current by entering the mA reading the fluke is showing @ 100 psi into the Full Scale {B} box and 4 in the Offset box {A}
        iv.
    e. Exit application

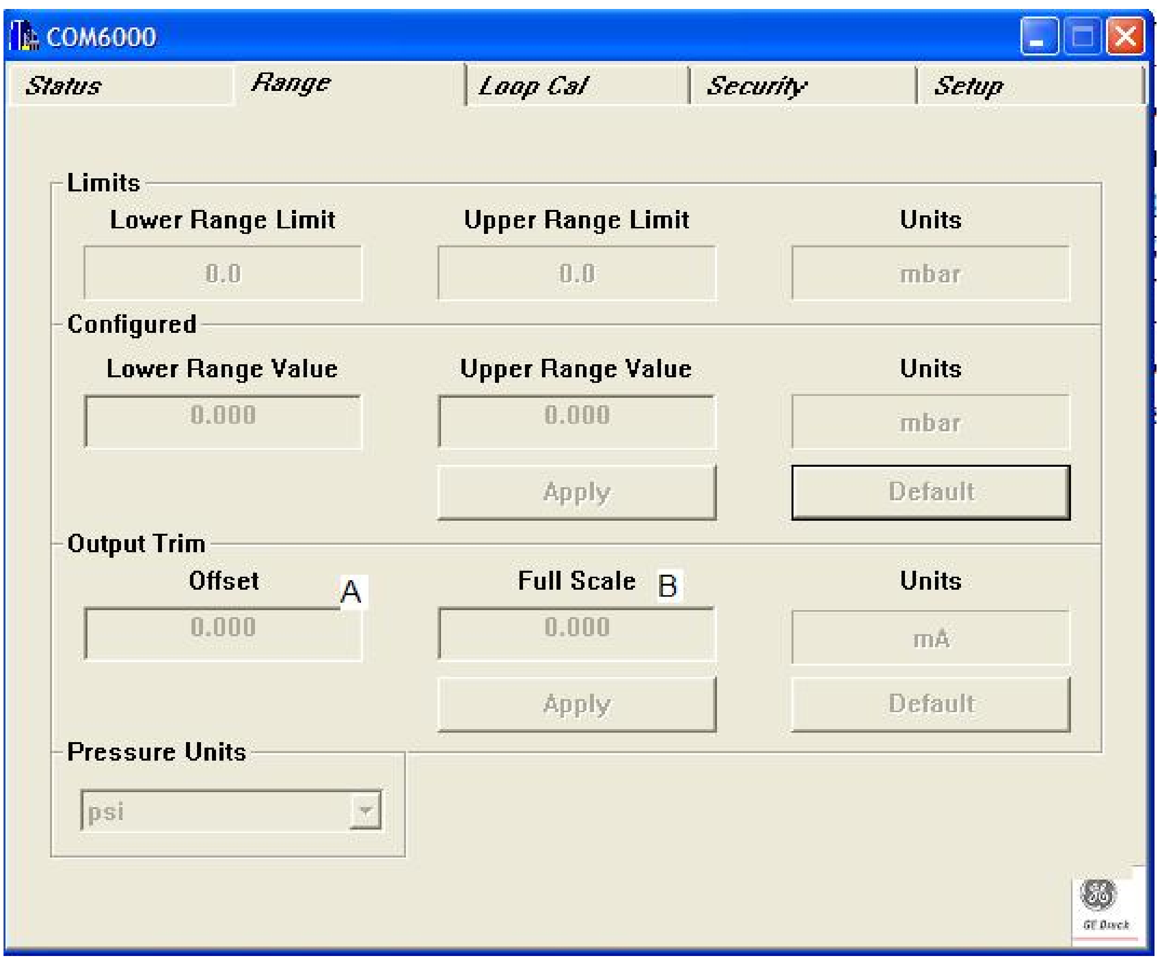


ABB Magmaster Procedure

FUNCTIONS OF KEYS

↵ *RETURNS (or ENTER, EXE, etc.)*

- Scrolls through main menu or submenu

Read 1> + ↵ → Disp 2>

Flow Rng 1> + ↵ → Flow Unit 2>

- Enters default or confirms existing value.

Login En 1> 0? + ↵ → Login En 1> 0

1 ↵ *ALPHANUMERIC plus RETURN*

- Selects menu (or submenu) item and advances to its first submenu

Read 1> + 5 ↵ → Anlg Fsd 1>

Anlg Fsd 1> + 3 ↵ → Anlg Dir Fwd 1>

- Keystrokes can be combined as a shortcut

Read 1> 5 3 ↵ → Anlg Dir Fwd 1>

- Selects submenu and displays current value
A '?' indicates current value is configurable

Anlg Fsd 1> + 1 ↵ → Anlg Fsd 1> 20?

- Enters selected value at '?' prompt

Anlg Fsd 1> 20? + 9 ↵ → Anlg Fsd 1> 9

- Note. In some submenus, 1 = select, 0 = deselect

Q ↵ *QUIT plus RETURN*

- In main menu, exits system
(Security access reverts to Level 0)

Read 1> + Q ↵ → Bye

- In submenu, returns to top of main menu, or parent submenu

Flow Rng 1> + Q ↵ → Read 1>

Flow Unit Ltr 1> Q ↵ Flow Rng 1>

ESC *ESCAPE*

- In any menu or submenu, returns to top of main menu

Flow Unit Ltr 1 + ESC → >

CONFIGURATION PROCEDURE

Main Menu	Submenus	Description
ABB Process ‡ MagMaster V 1.10 17/05/93		*Indicates model variant* *software version, date* *‡ or 'Slurry'*
READ		
Read 1>	Read Flow 1>	*Flow rate in selected units*
	Read % 2>	*Flow rate in % of range*
	Read Fwd 3>	*Total in forward totalizer‡*
	Read Rev 4>	*Total in reverse totalizer‡*
	Read Net 5>	*Net total (fwd minus rev)*
	Read Alm 6>	*Current active alarms*
	** Read Vel 7>	*True flow velocity in m/sec, or ft/sec if flow units are in UGal or ft^3*
	‡ Resettable to 0 if Tot ClrEn is set.	
DISPLAY OPTIONS		
Disp 2>	Disp Mode 1>	*0 = Single line display* *1 = Double line display* *2 = New line for each update (for printers, etc.)*
	Disp Res 2>	*Resolution of flow display* *Enter number of decimal places required (max. = 6)*
PASSWORDS *See information in Security Access section for detailed description*		
Login 3>	Login En 1>	*Current Security level* *0 = default* *For default passwords Enter 'user' for Level 1, 'engineer' for Level 2.* ***Note**: enter these passwords in ALL lower case*
	** Login Key 2>	*Changes Level 1 password*
	** Login Key 3>	*Changes Level 2 password*
FLOW MEASUREMENT*		
Flow 4>	# Flow Rng 1>	*Enter 100% primary range in selected units*
	Flow Unit 2>	*Enter '1' ONE place only* *Ltr 1> Litres* *m^3 2> Cubic meters* *IGal 3> Imperial gal* *UGal 4> US gallons* *ft^3 5> Cubic feet*

Main Menu	Submenus	Description
Flow 4>	Flow Mult 3>	*Enter '1' ONE place only* *m 1> Thousandths* *c 2> Hundredths* *3> Unity* *h 4> Hundreds* *k 5> Thousands* *M 6> Millions*
	Flow Time 4>	*Enter '1' ONE place only* *s 1> Seconds* *Min 2> Minutes* *Hr 3> Hours* *Dy 4> Days* *Wk 5> Weeks*
	Flow Rspns 5>	*Nominal time constant for output in seconds.* *Enter display setting value.* *Display Setting / Seconds* *0 0.6* *1 1* *2 2* *3 3* *4 4* *5 8* *6 15* *7 30* *8 60* *9 120*
	Flow Probe 6>	*# Ins 1> Insertion factor* *# Prof 2> Profile correction factor*
Note. The two factors above must be set to 1.0 if not used.		
	Flow % 7>	*Present flow as % of primary range.*
	** Flow Cutoff 8>	*Minimum flow velocity in mm/sec, below which all outputs set to zero.*
ANALOG OUTPUT*		
Anlg 5>	Anlg Fsd 1>	*Enter 0 to 21. Output current in mA for 100% flow*
	Anlg Zero 2>	*Enter 0 to 21. Output current in mA for 0% flow*
	Anlg Dir 3>	*Enter '1' to select* *Select both parameters for bidirectional flow* *Fwd 1> Current responds to forward flow* *Rev 2> Current responds to reverse flow*
	Anlg No2 4>	*Secondary range as % of primary range*
	Anlg mA 5>	*Present output current, mA*
	Anlg HART**	*HART Variant only, see full manual*

Main Menu	Submenus	Description
PULSE OUTPUT*		
Pls 6>	# Pls Fact 1>	*Enter output pulses per flow volume unit*
	Pls Cutoff 2>	*Flow rate in % of primary range, below which pulse output and totalizer stop*
	Pls Max 3>	*Maximum output freq. in Hz*
	Pls Hz 4>	*Frequency in Hz*
	** Pls Idle 5>	*Pulse output in idle (off)*
	** Pls Size 6>	*Enter pulse width in msec (will round up to nearest 10msec)* *0 = square wave*
TOTALIZER*		
Tot 7>	Tot Unit 1>	*See Flow Unit 2> for parameters*
	Tot Mult 2>	*See Flow Mult 3> for parameters*
	Tot ClrEn 3>	*Enables totalizer reset function from terminal, transmitter display or input contact*
ALARMS*		
Alm 8>	Alm No1 1>	*Any combination of alarms* *1 = Select 0 = Deselect* *Idle 1> Idle state* *En 2> 0 = Disabled, 1 = Enabled* *Fault 3> Measurement fault* *Fwd 4> Forward flow* *Rev 5> Reverse flow* *Cutoff 6> Pulse output cutoff* *Mtsnsr 7> Empty sensor* *Hi 8> High flow* *Lo 9> Low flow* *Anlg A> Analog output overrange* *Pls B> Pulse output overrange*
	Alm No2 2>	*Same parameters as No.1* *Factory default – Rev flow enabled, required for dual current option*
	Alm Trip 3>	*Hi 1> High flow trip-point, % range* *Lo 2> Low flow trip-point % range* *Hyst 3> Hysteresis* *Disp 4> Enables display of Hi and Lo Alarms*

Main Menu	Submenus	Description
INPUT CONTACT*		
Input 9>	Input Analg 1>	*Enter '1' to select. Active level selects second analog range*
	Input Clr 2>	*Active level resets all totalizers*
	Inpt Hld 3>	*Active level holds flowmeter flow value*
	Inpt Zero 4>	*Active level selects downscale drive*
	** Inpt Idle 5>	*Enter inactive state of input contact* *1 = Hi normal, 0 = Lo normal*
EMPTY PIPE DETECTION**		
Mtsnsr A>	Mtsnsr Trip 1>	*Enter empty pipe detector trip threshfold* ***Note**. Set to zero for a 'slurry' MagMaster*
	Mtsnsr mV 2>	*Measured indication used for empty pipe trip. When valve below 'trip' threshold then all outputs driven to zero*
SENSOR DATA AND CALIBRATION**		
Snsr B>	Snsr No 1>	*Serial number of sensor*
	Snsr Tag 2>	*Tag number of sensor*
	Snsr Size 3>	*Calibrated bore (mm)*
	Snsr Vel 4>	*Present velocity in sensor*
	Snsr Fact 5>	*1>, 2>, 3>, 4> = calibration data. Same as on sensor data label*
SYSTEM TEST**		
Test C>	Test Mode 1>	*If '1', transmitter is in test mode. Self-cancels after 30min. if no entry made*
	# Test Flow 2>	*Present flow rate. In test mode, any value may be entered manually*
	Test % 3>	*Flow rate in %‡*
	Test Hz 4>	*Output frequency in Hz‡*
	Test mA 5>	*Output current in mA‡*
	Test Vel 6>	*Flow velocity in sensor ‡*
	Test Alm 7>	*Current active alarms‡* *Clr = none*
	Test Txv 8>	*Flow velocity, uncorrected for sensor calibration*
	‡ Calculated from Test Flow 2	

**Requires Level 1 access* ***Requires Level 2 access*

 # The maximum no. must not exceed 21000. The value entered may display with a small error, e.g. 1.900 may display as 1.899. 1.900 is used in calculation

INTRODUCTION

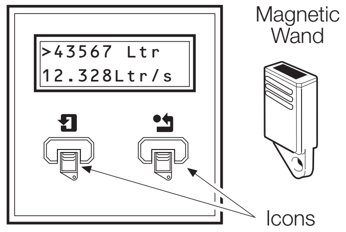
The Magmaster™ provides high-precision electromagnetic flow metering for conductive fluids of >5µS/cm, in sizes of 2.5 to 2200mm (0.1 to 86 in.). It has state-of-the-art accuracy, repeatability and rangeability.

The MagMaster offers a choice of liners and electrodes, flange or wafer tubes, integral or remote electronics and an optional keypad display.

Standard outputs include fully-programmable analog output (0 to 21mA), dual pulse (forward and reverse), dual alarm (flow rate, fault conditions, etc) and a RS232 connection. Optional outputs include dual analog and RS422/423.

The MagMaster has been designed to eliminate traditional noisy signals in slurry applications. It has multiple self-monitoring and diagnostic functions , and a comprehensive test mode to test the system without interrrupting the process or power.

SIMPLE READ AND RESET



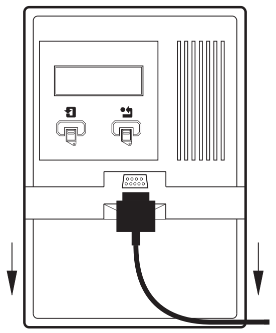
- Top line of display indicates flow totals, velocity, % of range and alarm status. Second line shows flow rate.
- Applying wand to the left icon steps the top line display through this sequence:

>	Forward flow total
<	Reverse flow total
*	Net flow total
Alm	Alarms in sequence ('Alm Clr' when no alarms are activated)
Vel	Flow velocity
%	Flow rate as % of full scale range

- Applying wand to right icon resets the flow total displayed on the top line if parameter 73 (Tot Clr En) is enabled
- For keypad/display version, see separate Quick Reference Guide.

CONFIGURATION

1. Set up serial communications* on terminal or PC
2. For PC use a laplink/null modem cable. A cable is available from ABB .
3. Connect terminal cable to transmitter's D-connector as shown
4. Press RETURN or equivalent (ENTER, EXE, etc).



*Serial communications setup	
Baud rate	4800
Data bits	8
Stop bits	1
Parity	None
Handshake	None

RELATIONSHIP OF MENUS

Main Menu
Startup
↓

Main Menu	Submenus	
Read 1>	Read 1–7, Q	
Disp 2>	Disp 1, 2, Q	
Login 3>	Login 1–3, Q	
Flow 4>	Flow 1–8, Q	Flow 2 1-5, Q Flow 3 1-6, Q Flow 4 1-5, Q Flow 6 1, 2, Q
Anlg 5>	Anlg 1–5, Q	Anlg 3 1, 2, Q
Pls 6>	Pls 1–6, Q	
Tot 7>	Tot 1–3, Q	Tot 1 1–5, Q Tot 2 1–6, Q
Alm 8>	Alm 1–3, Q	Alm 1 1–9, A, B, Q Alm 2 1–9, A, B, Q Alm 3 1–4, Q
Inpt 9>	Inpt 1–5, Q	
MtsnsrA>	Mtsnsr 1, 2, Q	
Snsr B>	Snsr 1–5, Q	Snsr 5 1–4, Q
Test C>	Test 1–8, Q	
Quit Q>		

↓
Exit

SECURITY ACCESS

Any of three security levels can be selected. In Levels 0 and 1, the operator is restricted to certain menus as listed below. In Level 2, the operator has full access to all menus and can change passwords.

1>	Read flow parameters, etc.	Level 0 (1>–3>)
2>	Set display options	
3>	Security access, passwords	
4>	Set flow parameters	Level 1 (1>–9>)
5>	Analog output	
6>	Pulse output	
7>	Set totalizer parameters	
8>	Alarm operation	
9>	Input contact	
A>	Empty pipe detection	Level 2 (1>–C>)
B>	Sensor data and calibration	
C>	Test operation	

IM/MM/QRG2 Issue 5

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Quick Reference Programming Guide

MagMaster™
Electromagnetic Flowmeters