Catalog Number 3314

Sigma 950 Flow Meter

USER MANUAL

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Section 1 Safety Precautions

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.

Do not use or install this equipment in any manner other than that which is specified in this manual.

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.

1.1.1 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 that the marked item can be hot and should not be touched without care.
	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).

1.2 Hazardous Locations

The Sigma 950 Flow Meter is 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.

DANGER

Bien que certains produits Sigma soient conçus et certifiés pour être installés dans des endroits dangereux tels que définis par le National Electric Code, de nombreux produits Sigma ne conviennent pas pour de tels endroits. Il relève de la responsabilité des personnes qui placent les produits dans des endroits dangereux de déterminer s'ils sont adaptés à cet environnement. En outre, à des fins de sécurité, le placement de machines dans des endroits dangereux doit s'effectuer dans le respect des consignes des schémas de contrôle du fabricant. Toute modification apportée aux machines ou tout déplacement de celles-ci est déconseillé, car susceptible de provoquer des accidents matériels et/ou corporels.

1.3 Confined Space Entry

The following information is provided to guide users of Sigma 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.

DANGER
Pour éviter les accidents mortels dans les espaces confinés, il faut organiser des formations supplémentaires dans les matières suivantes: Contrôle avant entrée, Ventilation, Procédures d'entrée, Procédures d'évacuation et de secours et Méthodes de travail sûres.

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.

1.4 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.

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.

DANGER
Les utilisateurs ne doivent pas essayer d'établir eux-mêmes de telles connexions, mais doivent contacter l'électricien ou l'organisme de vérification électrique appropriée, selon le cas.

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.

1.5 Service Requirements

In the event of equipment malfunction, all repairs should be performed by the manufacturer or an authorized agent. It is the responsibility of users requiring service to report the need for service to the manufacturer, or to one of our authorized agents. Service can be facilitated throughout our office (Section 10 on page 85).

Section 2 Specifications

Specifications are subject to change without notice.

General	
Dimensions	34.3 H x 25.4 W x 24.1 cm D (13.5 x 10.0 x 9.5 in.)
Weight	5 kg (11 lb) not including power source
Enclosure	NEMA 4X, 6 with front cover open or closed ABS, UV resistant
Temperature	Storage: -40 to 80°C (-40 to 176°F) Operating: -10 to 65.5°C (14 to 150°F)
Power Options	12Vdc supplied from one of: 7 A-Hr rechargeable gel lead-acid battery 4 A-Hr rechargeable Ni-Cad battery Non-rechargeable alkaline lantern batteries (2 x 6VDC) 15Vdc supplied from one of: 100-120VAC input power supply 230VAC input power supply
Graphics Display	Back-lit liquid crystal display (LCD), auto-off when not in use (under battery operation). 8 line x 40 character in text mode, 60 x 240 pixels in graphics mode.
Keypad	21-position sealed-membrane switch with blinking green LED to indicate power on. Four “soft keys,” functions defined by display.
Totalizers	8-digit resettable and 8-digit non-resettable software
Time Base Accuracy	± 0.007% per day
Measurement Modes	Flumes: Parshall, Palmer Bowlus, Leopold-Lagco, H, HL, HS, Trapezoidal Weirs: V-notch (22.5 to 120 degrees), Compound V-Notch, Contracted/Non-Contracted rectangular, ThelMar, Cipolletti Manning Equation: Round, U, Rectangular and Trapezoidal Channels Flow Nozzle: California Pipe Head vs. Flow: Custom programmable curve of up to 99 points. Level only: Inches, feet, centimeters, meters Area Velocity: Level-area table, Circular pipe, U-shaped channel, Trapezoidal channel, Rectangular channel Power Equation: $Q = K_1 H^{n_1} + K_2 H^{n_2}$
Data Logging	"Smart" dynamic memory allocation automatically partitions memory to provide the maximum logging time. No manual memory partitioning required. Memory Mode: Either slate or wrap-around may be selected. Data Points: Approximately 20,000 standard. Expandable up to 116,000 data points. Daily statistics: Available for up to 32 days. Recording Intervals: 1, 2, 3, 5, 6, 10, 12, 15, 20, 30, 60 minutes
Sampler Output	12 to 17 VDC pulse, 100 mA max at 500 ms duration
Communications	RS232 - up to 19,200 baud Modem - 14400 bps., V.32 bis. V.42, MNP2-4 error correction. V.42 bis MNP5 data compression. MNP 10-EC Cellular Protocol Pager SCADA - Modbus communication protocol (standard) through RS232 or optional modem
CE Mark	CE - some 950 models (such as, 3248, 3522 and 2672) when used as detailed in manual Section 2.8 CE - 230V AC-DC power adaptor and cETLus 115V AC-DC power adaptor (UL/CSA 61010-1 Safety Std.)

2.1 Factory Installed Options

Integral pH/Temperature Meter (pH and ORP cannot be simultaneously measured)	
Control/Logging	Field selectable to log pH/temperature independent of flow or in conjunction with flow; also controls sample collection in response to value of low/high setpoints.
pH/Temperature Sensor	pH combo, 3/4" NPT-in-line, ryton, ASG V Flat 100 ohm KTD/GND in glass, DJ with porous gel Ag/AgCI gel in Dynagan out, CE cable
pH Range	0 to 3 pH
Operating Temperature	0 to 80°C (0 to 176°F)
Dimensions	1.9 D x 15.24 cm L (0.75 x 6 in.) with 1.9 cm (0.75 in.) mpt cable end
Totalizers	6-digit non-resettable mechanical Units: ft^3, gal, m^3, liter, acre-ft
Pressure Rating	100 psi maximum
pH Response Time	5 seconds to 95% of full response

ORP Meter	
Reading	86 ± 15 mV (25°C) (in pH 7.00 - saturated with Quinhydrone)
Slope	170 mV (25°C) (pH 4-7) (saturated with Quinhydrone)
Temperature Range	0 to 80°C (0 to 176°F)

Integral Dissolved Oxygen 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 of low/high set points.
Measurement Method	Polargraphic
Sensor	Temperature compensated; impact resistant polypropylene body
Measurement Range	0 to 20 mg/L dissolved oxygen
Resolution	0.01 mg/L
Accuracy	±0.02 mg/L
Operating Temperature	0 to 50°C (32 to 122°F)
Dimensions	1.65 x 12.7 cm (0.65 x 5 in.) with 1.95 cm (0.75 in.) mpt cable end
Integral Conductivity Meter	
Control/Logging	Field selectable to log conductivity independent of flow or in conjunction with flow. It also controls sample collection in response to value of low/high set points.
Sensor	Temperature compensated; impact resistant polypropylene body
Measurement Range	0 to 100 mS/cm
Resolution	0.01 mS/cm or 1 mS/cm (user selectable)
Accuracy	±1% of reading + 0.05 mS/cm
Operating Temperature	0 to 50°C (32 to 122°F)
Dimensions	1.7 x 12.7 cm (0.67 x 5 in.) with 1.9 cm (0.75 in.) mpt cable end

Rain Gauge Input	
General Information	For use with Hach Tipping Bucket Rain Gauge. Flow meter records rainfall data in 0.01 in. increments.
Analog Input Channels	
General Information	Up to 7 additional data logging channels record data from external source(s) Field assignable units -4.5 to + 4.5 VDC, ± 0.5% full scale voltage accuracy and 0 to 20 mA, ± 0.2% full scale 4-20 mA accuracy with 200 ohm impedence
Alarm Relays	
General Information	(4) 10 amp/120 Vac or 5 amp/250 Vac form C relays User assignable for any internal or external data channel or event.
4–20 mA Output	
General Information	2 output signals available User assignable Optically isolated 0.1 FS error
Maximum Resistive Load	600 ohms
Output Voltage	24 VDC–no load
Insulation Voltage	Between flow meter and 4–20 mA output - 2500 Vac Between the two 4–20 mA outputs - 1500 Vac
Communications	
General Information	RS232 - up to 19,200 baud Modem - 14400 bps., V.32 bis, V.42, MNP2-4 error correction. V.42 bis MNP5 data compression. MNP 10-EC Cellular Protocol
Sensor Specifications	Pager SCADA-Modbus® communication protocol (standard) via RS232 or optional modem
Bubbler Sensor	
Accuracy	±0.003 m (0.011 ft) linearity and hysteresis at 22 °C (72 °F), from 0.01 to 11.75 ft
Range	0.003 to 3.6 m (0.01 to 11.75 ft)
Ambient Operating Temperature	–18 to 63 °C (0 to 145 °F)
Compensated Temperature	0 to 59 degrees C (32 to 138 degrees 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
Line Lengths	160 m (500 ft) maximum

Submerged Depth Only Sensor	
Accuracy	+0.1% full scale (Non-linearity and dysteresis)
Range	2.5 psi; 0.01 to 1.75 m (0.04 to 5.75 ft)
Ambient Operating Temperature	0 to 71 °C (32 to 160 °F)
Temperature Error	2.5 psi: 0.04 to 5.75 ft. +/-0.006 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
Cable 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. (squared)
Weight	0.7 kg (1.5 lbs)
Downlooking Ultrasonic Depth Sensor–50 kHz	
Accuracy	1 to 10 ft. ± 0.01 ft. (± 0.003 m) (at 22 °C (72 °F), still air, 40 to 70% relative humidity)
Range	Maximum distance from sensor to liquid 9.1 m (30 ft)
	Minimum distance from sensor to liquid 38.1 cm (15 in.)
Span	0 to 8.84 m (0 to 29 ft.)
Sensor Certification	USA: Class I, Zone I, Groups A, B, C, D Canada: Class I, Division I, Groups A, B, C, D, Class II, Division I, Groups E, F, G
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 with Buna-N acoustic window
Cable	4-conductor with integral stainless steel support cable
Cable Length	7.6 m (25 ft.) standard (custom lengths are available)
Crystal Specification	50 kHz, 11.5° included beam angle
Dimensions (transducer only)	9.5 cm H x 7 cm D (3.75 in. H x 2.75 in. D)
Weight	0.7 kg (1.5 lbs)

Downlooking Ultrasonic Depth Sensor–75 kHz	
Accuracy	1 to 10 ft ±0.01 ft (±0.003 m) at 22°C (72 °F), still air, 40–70% relative humidity.
Range	Maximum distance from sensor to liquid 3.3 m (10.8 ft)
	Minimum distance from sensor to liquid 23 cm (9 in.)
Span	0 to 4.57 m (0 to 15 ft)
Sensor Certification	USA: Class I, Zone I, Groups A, B, C, D Canada: Class I, Division I, Groups A, B, C, D, Class II, Division I, Groups E, F, G
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 with Buna-N acoustical window
Cable	4-conductor with integral stainless steel support cable
Cable Length	7.6 m (25 ft) standard (custom lengths are available)
Crystal Specification	5° beam angle with horn
Dimensions	12.7 (H) x 5.7 cm (D) (5.0 x 2.25 in.)
Weight	0.7 kg (1.5 lb)
In-Pipe Zero Deadband Ultrasonic Depth Sensor –75 kHz	
Accuracy	0.038 to 2.4 m ±0.003 m (0.125 to 8 ft. ± 0.01 ft.) (at 22°C (72°F), still air, 40 to 70% relative humidity)
Range	Distance from sensor to liquid: 0 to 2.4 m (0 to 8 ft)
Span	0.038 to 4.57 m (0.125 to 15 ft)
Sensor Certification	USA: Class I, Zone I, Groups A, B, C, D Canada: Class I, Division I, Groups A, B, C, D, Class II, Division I, Groups E, F, G
Resolution	0.019 cm (0.0075 in.)
Ambient Operating Temperature	-18 to 60°C (0.04 to 140°F)
Temperature Error	±0.00005 m/°C (±0.0001 ft./°F) (maximum error within compensated temperature range per degree of change)
Material	Stat-Kon A-E ABS Plastic
Cable	4-conductor
Cable Length	7.6 m (25 ft) standard, custom lengths up to 305 m (1000 feet) using RS485 two wire remote sensor option
Crystal Specification	7° beam angle
Dimensions (transducer only)	4.44 cm (1.75 in.) maximum diameter, 31.5 cm (12.4 in.) long
Mounting	Dedicated Mounting Rings, Permanent Mounting Bracket (installs directly to pipe wall), Adjustable Mounting Band Kit.
Connection	Bare lead connection through 3658 junction box or quick connect.

Low-Profile Velocity-Only Sensor	
Accuracy	±2% of reading; Zero Stability: <0.52 cm/s (± 0.05 ft/s)
Range	-1.52 to 6.1 ms (-5 to +20 ft/s)
Resolution	0.3 cms (0.01 ft/s)
Response Time	4.8 seconds
Profile Time	4.8 seconds
Dimensions	Length: 6.86 cm (2.7 in.) Width: 3.81 cm (1.5 in.) Height: 1.12 cm (0.44 in.)
Cable	Urethane Jacket, (2x) RG174U Coax Cables, (4x) #22 AWG Copper Stranded
Cable Length	7.6 m (25 ft) standard (custom cable lengths to 76 m (250 ft) are available)
Submerged Area/Velocity Sensor	
Velocity Measurement	
Method	Doppler Ultrasound Twin 1 MHz piezoelectric crystals
Accuracy	±2% of reading
Recommended Range	–1.52 to 6.1 m/s (-5 to +20 ft/s)
Zero Stability	<0.015 m/s (<0.05 ft/s)
Typical Minimum Depth	2 cm (0.8 in.)
Depth Measurement	
Method	Pressure Transducer with stainless steel diaphragm
Material	Polyurethane body, 316 series stainless steel diaphragm
Accuracy (static[1])	±0.16% full scale ±1.5% of reading at constant temp (±2.5°C) ±0.20% full scale ±1.75% of reading from 0 to 30°C (32 to 86°F) ±0.25% full scale ±2.1% of reading from 0 to 70°C (32 to 158°F)
Standard Depth Range	0 to 3 m (0 to 10 ft.)
Extended Range	0 to 9 m (0 to 30 ft.)
Maximum Allowable Depth	Standard: 10.5 m (34.5 ft.) Extended: 31.5 m (103.5 ft.)
Operating Temperature Range	32 to 160°F (0 to 71°C)
Compensated Temperature Range	32 to 86°F (0 to 30°C)
Temperature Error	0.005 to 3.5 m ±0.0022 m/°C (0.018 to 11.5 ft ±0.004 ft/°F) 0.005 to 10.5 m ±0.006 m/°C (0.018 to 34.6 ft ±0.012 ft/°F) (maximum error w/in compensated temperature range - per degree of change)
Velocity Induced Error on Depth	Compensated based on pipe geometry and flow velocity
Air Intake	Atmospheric pressure reference is desiccant protected

Bubbler Area / Velocity Sensor	
Depth 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 Range	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 ft/s)
Zero Stability	< 0.015 m/s (0.05 ft/s)
Accuracy	±2% of reading
Typical Minimum Depth	2 cm (0.8 in.)
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.)

[1] For temperatures above 40°C (104°F) add ± 0.3 cm/°C (0.03 in./°F)

Section 3 Introduction

3.1 Measurement Capabilities

The 950 Flow Meter is a portable flow meter that is completely self-contained. With its rugged construction, the meter is completely sealed—even with the door open. Conforming to NEMA 4X, 6 standards, the meter also withstands submersion and corrosive gases—again, with its door open. As a result, access to the meter's keypad is no problem in manholes, rain, and other harsh weather conditions.

The 950 Flow Meter is suitable for measuring and recording flow in open channels, full pipes, and surcharged lines. The 950 Flow Meter is most often used to measure flow in conjunction with a primary measuring device (flume, weir, pipe, etc.) that has a known level-to-flow relationship. The 950 Flow Meter directly measures the level of liquid in a channel that is contributing to flow (referred to as "head") and calculates the flow rate based on the head-to-flow relationship of the primary device.

The flow meter can also measure the average velocity of the flow stream using a submerged Doppler sensor and calculate flow based on the current depth and the Continuity Equation: *Wetted Area* $\times$ *Velocity* = *Flow*.

In addition to its extensive data logging capabilities, the 950 Flow Meter is capable of enabling a sampler, pacing a sampler, controlling external devices with four Normally Open/Normally Closed relays, and controlling external devices with two 4–20 mA current outputs.

Communication capabilities include a standard RS232 port and an optional on-board modem used for remote data transfer, remote programming, and updating internal embedded programs using Flash Memory technology (RS232 only). The 950 Flow Meter also provides SCADA Communication Interface functionality using the Modbus® ASCII protocol. This software protocol communicates with the instrument via an RS232 connection.

Using Hach's integrated sewer system management software, users can download, remotely program, and conduct other data manipulation via RS232 connection or the optional modem.

3.2 Front Panel Features and Controls

The 950 Flow Meter case has several unique features, all designed to simplify installation, operation, and maintenance.

The instrument front cover protects the panel controls and display window while providing a clear view of the flow meter status on the display. The cover also contains two lockable latches which can be secured with a padlock(s) for security. While a software lock can be programmed to keep unauthorized personnel from operating the keypad, the front cover locking ability provides added security against tampering.

The cover perimeter contains a gasket seal to keep moisture and dirt from entering the front panel area. This seal is not required to maintain the NEMA 4X,6 rating of the case.

Figure 1 950 Flow Meter Front Panel

Item #	Description	Function
1	Menu bar	The menu bar appears in a black band on the top edge of the display. The upper left corner of the menu bar shows the time and date. The upper right corner shows the name of the current menu.
2	Display	The 950 Flow Meter liquid crystal display (LCD) works in conjunction with the four soft keys as a guide through all programming steps. The display also provides other useful information as described below.
3	Soft keys	The soft keys are the blank, white keys located to the left and right of the display. The function of each key is according to the appearance of the display. If no function is shown for a specific key, that key is not currently needed. The soft key labels appear on the display and point (with a straight line) to the proper soft key to push for that action. In some cases during a programming step you will be asked to pick an item from a list. The soft keys on the right side of the display will change to display “up” and “down” arrows. This allows you to scroll up and down the list of choices. When the desired choice is highlighted, press the SELECT soft key to choose that item.
4	Status bar	The appearance of the status bar changes depending upon the function being performed. The lower left corner of the status bar indicates whether a program is Complete, Running, Halted, or Ready To Start. It will disappear if it is not needed during a programming step. The lower right corner displays system alarm conditions, such as low memory battery, clogged bubbler line, etc. For a list of possible alarms see Alarm Relays on page 72. The status bar also lists valid choices when entering certain programming information. For example, when selecting level measurement units in the Level Units menu, the status bar indicates the valid choices: cm, ft, in., or m.
5	Humidity Indicator	The Internal Humidity Indicator changes from blue to pink when the humidity inside the case exceeds 60 percent. An internal desiccant module absorbs any humidity that may have been trapped in the case during final assembly. Under normal operating conditions, this desiccant provides long-term protection against condensed moisture inside the case. Replace the internal desiccant module only if the indicator turns pink. (See Replacing the Internal Desiccant Module on page 82).

6	Mechanical Totalizer Option	An optional six-digit non-resettable mechanical totalizer is available for the flow meter. Located below the Humidity Indicator, the totalizer indicates total flow and supplements the internal software totalizers (one resettable and one non-resettable) that are configured during programming. The totalizer can be configured for all conditions and installations because flow units and scaling are selectable. To select flow and scaling factors for the mechanical and internal software totalizers see Flow Totalizer on page 103. To obtain the total flow for any period of time, record the number at the start of the time period, subtract it from the number at the end of the period, and then multiply the difference by the scaling factor.
7	Display Button	The Display push-button is located on the upper right side of the case. It allows you to read the display without opening the cover. The 950 Flow Meter is optimized for portable (battery-powered) use. Its unique power saving modes conserve battery resources by putting the meter to “sleep” during any period of inactivity. During battery operation or ac power with the screen saver enabled, pressing the Display push-button will “wake up” the flow meter and cause it to turn on the display. The Status Screen is the first screen displayed. Another press of the button causes the display to show additional status information, if necessary. Continuing to press the Display push-button will return you to the initial Status Screen after all information has been shown. After three minutes of inactivity, the display goes blank to conserve battery power.
8	Soft Keys	See item #3.
9	Function Keys	The white keys located just above the numeric keys are function keys that are used often while operating the flow meter. These functions are dedicated keys to allow quick access. **Main Menu**: This is the program starting point. Press the Main Menu key at any time during programming to return to the Main Menu Screen. The current action is cancelled if changes are not yet accepted. **Level Adjust**: Adjust the flow meter to match the current head (or level contributing flow) in the channel. **Run/Stop**: Run (or resume) a program. Stops a currently running program.
10	Numeric Keypad	The numeric keypad is located below the function keys. It consists of the digits 0 through 9, a +/- key, and a decimal key.
11	Power On/Off	To turn the flow meter power on/off use the **ON** and **OFF** keys.

3.2.1 Power Indicator Light

When the unit is turned on, a green light located next to the **ON** key flashes. This does not indicate that a program is running but indicates that the unit has power because under some conditions (battery operation or Screen Saver mode), the display may automatically turn off to conserve battery power.

See Screen Saver Mode on page 105 for details on battery operation and the Screen Saver feature.

DANGER
Some of the following manual sections contain information in the form of warnings, cautions and notes that require special attention. Read and follow these instructions carefully to avoid personal injury and damage to the instrument. Only personnel qualified to do so, should conduct the installation/maintenance tasks described in this portion of the manual.

DANGER
Certains des chapitres suivants de ce mode d'emploi contiennent des informations sous la forme d'avertissements, messages de prudence et notes qui demandent une attention particulière. Lire et suivre ces instructions attentivement pour éviter les risques de blessures des personnes et de détérioration de l'appareil. Les tâches d'installation et d'entretien décrites dans cette partie du mode d'emploi doivent être seulement effectuées par le personnel qualifié pour le faire.

PELIGRO
Algunos de los capítulos del manual que presentamos contienen información muy importante en forma de alertas, notas y precauciones a tomar. Lea y siga cuidadosamente estas instrucciones a fin de evitar accidentes personales y daños al instrumento. Las tareas de instalación y mantenimiento descritas en la presente sección deberán ser efectuadas únicamente por personas debidamente cualificadas.

GEFAHR
Einige der folgenden Abschnitte dieses Handbuchs enthalten Informationen in Form von Warnungen, Vorsichtsmaßnahmen oder Anmerkungen, die besonders beachtet werden müssen. Lesen und befolgen Sie diese Instruktionen aufmerksam, um Verletzungen von Personen oder Schäden am Gerät zu vermeiden. In diesem Abschnitt beschriebene Installations- und Wartungsaufgaben dürfen nur von qualifiziertem Personal durchgeführt werden.

PERICOLO
Alcune parti di questo manuale contengono informazioni sotto forma d'avvertimenti, di precauzioni e di osservazioni le quali richiedono una particolare attenzione. La preghiamo di leggere attentivamente e di rispettare quelle istruzioni per evitare ogni ferita corporale e danneggiamento della macchina. Solo gli operatori qualificati per l'uso di questa macchina sono autorizzati ad effettuare le operazioni di manutenzione descritte in questa parte del manuale.

DANGER
This instrument should be installed by qualified technical personnel to ensure adherence to all applicable electrical codes.

DANGER
Cet appareil doit être installé par du personnel technique qualifié, afin d'assurer le respect de toutes les normes applicables d'électricité.

Capped, watertight connectors for external devices are located along the left side of the case. Level sensor inputs and accessories are located along the right side of the case.

A recessed pocket for installing the flow meter power supply is located at the top rear of the case.

4.1 Unpacking the Instrument

Remove the 950 Flow Meter from its shipping carton and inspect it for any visible damage. Contact Hach Customer Service at 1-800-368-2723 if any items are missing or damaged.

4.2 Choosing the Proper Site

The accuracy of your flow measurements greatly depends on the suitability of your 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

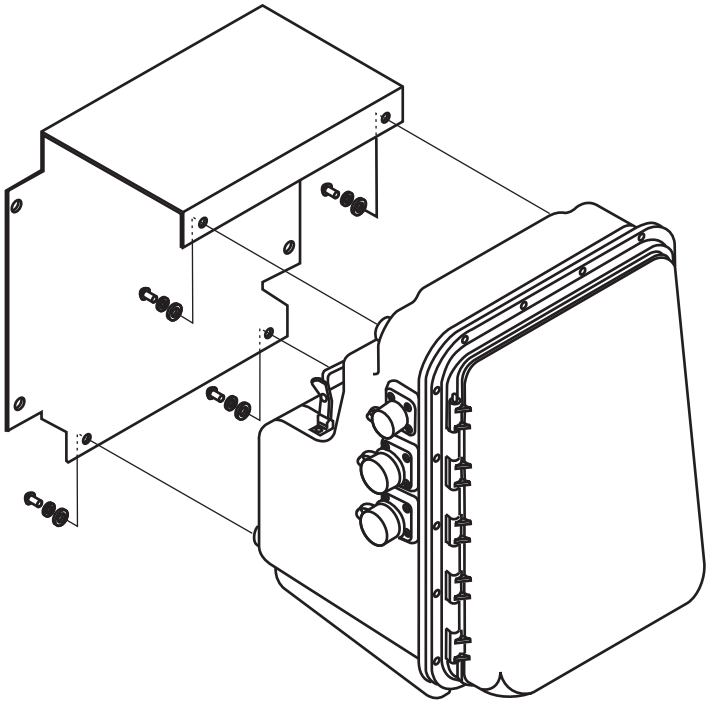
Site Condition	Suggested Remedy
Outfalls	Place the sensor in at least ten times the maximum expected level upstream of the outfall.
Vertical drops in the channel floor	Place the sensor in at least ten times the maximum expected level upstream of the vertical drop.
	Place the sensor in at least ten times the maximum expected level downstream of the vertical drop.
Elbows, sharp turns, and “Y” connections	Place the sensor in at least ten times the maximum expected level upstream of the impediment.
	Place the sensor in at least ten times the maximum expected level downstream of the impediment.

4.3 Mounting Options

4.3.1 Wall Mounting (Optional)

Wall mounting the 950 Flow Meter requires the optional Wall Mounting Bracket (P/N. 2743). This bracket provides stable, secure mounting for the flow meter and provides clearance for removing the power supply while the unit is installed. Connect the flow meter with four ¼-20 screws (provided) using the four threaded inserts on the back of the case. (See Figure 2).

Figure 2 Wall Mounting Bracket



4.3.2 Suspension Harness Installation (Optional)

Use the optional Suspension Harness (P/N 2889) to suspend the flow meter in a manhole or similar site. The suspension harness has two captive ¼-20 S.S. mounting screws attached to the top of two threaded inserts on the back of the flow meter.

A stainless steel clip is also provided on top of the harness for mounting to an Instrument Support Bracket (P/N 5713000) or similar support.

When suspending the flow meter, the Suspension Harness utilizes only the top two threaded mounting inserts, leaving the bottom two free. **Do not use the bottom inserts for suspending any additional equipment.** The inserts are designed to support only the weight of a 950 Flow Meter and will not adequately support additional weight.

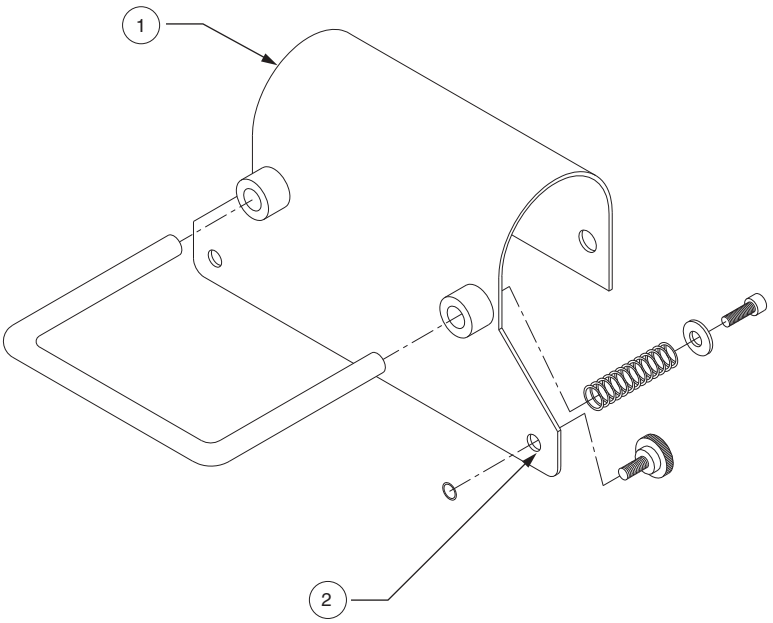
4.3.3 Manhole Rung Hanger (Optional)

The Manhole Rung Hanger (P/N 3533) is a convenient way to hang the 950 Flow Meter from a manhole ladder rung. Constructed of 304 Stainless Steel, it makes a temporary mounting as secure as a permanent one.

The Manhole Rung Hanger has two captive thumb screws for securing the bracket to the top two threaded inserts on the 950 Flow Meter. The Manhole Rung Hanger also has a spring loaded handle that secures the Hanger over a rung of up to 1¾ in. (4.4 cm) in diameter.

When suspending the flow meter, the Manhole Rung Hanger utilizes only the top two threaded mounting inserts, leaving the bottom two inserts free. **Do not use the bottom inserts for suspending any additional equipment.** The inserts are designed to support only the weight of a 950 Flow Meter and will not adequately support additional weight. (See Figure 3 on page 24).

Figure 3 Manhole Rung Hanger



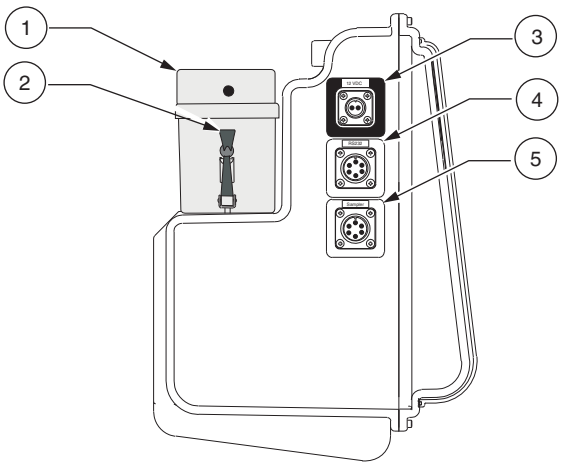
1	Place over ladder rung.	**2**	Connect bottom inserts to meter.

4.4 Installing the Power Supply

The 950 Flow Meter is designed to accept either the manufacturer's 12 VDC battery pack or ac power converter.

1. Place the power supply on the back of the flow meter. (See Figure 4).
2. Pull the two rubber hold-down clamps up and over the clips on each end of the power supply.
3. Connect the power supply connector to the port labeled 12 VDC on the top left side of the case.

Figure 4 Power Supply and Interface Connectors



1	Power Supply	**3**	12 VDC Port	**5**	Sampler Port
2	Rubber Hold-down Clamp	**4**	RS232 Port		

4.5 Interface Connector Descriptions

Note: *All interface receptacles are covered with push-on caps. These caps are designed to protect the connector pins from dirt and moisture and should be attached to any receptacle not in use.*

The interface connector ports are located on the left side of the flow meter case. The 950 Flow Meter comes standard with three interface ports.

- 12 VDC (Power Input)
- RS232 (Serial Communications Port)—(See section 8.1 on page 61 for connection and programming details).
- Sampler (Automatic Liquid Sampler Control)

In addition, the flow meter can be connected to a wide variety of optional peripheral devices:

- Rain Gauge (section 7.1 on page 53)
- pH (section 7.2 on page 54)
- ORP (section 7.3 on page 55)
- Dissolved Oxygen (section 7.4 on page 56)
- Conductivity (section 7.5 on page 58)
- Modem (section 8.2.1 on page 63)
- Analog Inputs (section 8.3.2 on page 70)
- Alarm Relays (section 8.4.1 on page 72)
- 4–20 mA Current Loop(section 8.3.1 on page 68)

One or a combination of up to three sensors can be connected to the 950 Flow Meter, depending on the system configuration.

- Downlook Ultrasonic Depth Sensor (section 6.1 on page 37)
- In-Pipe Zero Deadband Ultrasonic Depth Sensor (section 6.2 on page 40)
- Submerged Area/Velocity Sensor (section 6.3 on page 42)
- Low Profile Velocity Only Sensor (section 6.4 on page 45)
- Submerged Depth Only Sensor (section 6.5 on page 46)
- Bubbler Depth or Bubbler Area/Velocity Sensor (section 6.6 on page 48)

4.6 12 VDC Connections

This connection supplies power to the flow meter. Power sources include a battery (Ni-Cad or Lead Acid), an ac power pack, or an external source such as a deep-cycle marine battery or vehicle cigarette lighter connection. Refer to Batteries and Chargers on page 133 for more information.

Although the 950 Flow Meter will operate on any attached 12 VDC power supply, the instrument will assume it is battery operated if it detects a less than 14.2 VDC input and will assume it is operating on an ac power converter if it detects a greater than 14.2 VDC input.

Table 2 12 VDC Connector Pin Assignments

Pin	Signal Description
A	Ground
B	12 to 17 VDC, unregulated

4.7 Sampler

4.7.1 Sampler Connections

The sampler interface receptacle is used to connect a wastewater sampler to the 950 Flow Meter.

Table 3 Sampler Connector Pin Assignments

Pin	Signal Description	Wire Color	Purpose	Rating
A	12 VDC (input only)	orange	Pin A may receive power from an external device, 500 mA max load. Pin B provides the ground line that is used in conjunction with the other signals on the connector.	12 VDC (w/battery) to 17 VDC pulse (w/ac power pack) 500 mA max.
B	ground	brown		
C	flow pulse output	yellow	Used in with Pin B to signal a sampler that a pre-determined amount of flow has accumulated with a 500 ms pulse.	12 VDC (w/battery) to 17 VDC pulse (w/ac power pack)
D	sampler start	black	Used to “wake up” a waste water sampler when a set point condition is met so that it can begin its sampling program. Configure the flow meter for this pin in Set Point Sampling on page 105. Used in conjunction with Pin B, this line is normally allowed to float and is switched to ground (by transistor) for the entire period that the set point condition exists.	24 VDC (max) at 100 mA (max)
E	event input	red	Received from a waste water sampler and indicates that a sample has been collected. “Sample Taken” information will appear in the data printout when downloaded.	N/A
F	bottle number input	green	Received from a waste water sampler and used in conjunction with the Event Input signal. It tells the flow meter which bottle was used when a sample was taken. “Sample Times and Dates” information will appear in the data printout when downloaded.	N/A

Cable Required for Sampler Connections

- Multi-Purpose Half Cable Assembly, 3.0 m (10 ft), 6-pin connector on one end, tinned wire leads on the other end (P/N 941) or
- Multi-Purpose Full Cable Assembly, 3.0 m (10 ft), 6-pin connector on both ends (P/N 940).
- Cables with 7.6 m (25 ft) lengths and custom sizes are also available.

4.7.2 Sampler Programming

1. From the Main Menu, select **SETUP>MODIFY SELECTED ITEMS.**
2. Scroll down and highlight **SAMPLER PACING** using the up and down arrow soft keys. Press **SELECT** to continue.
3. Enable Sampler pacing using the **CHANGE CHOICE** soft key. Press **ACCEPT** to continue.
4. Set the Sampler Pacing using the numeric keypad and Change Units using the **CHANGE UNITS** soft key. The 950 Flow Meter will output one 12 VDC pulse each time the specified amount of flow has occurred.
5. Press **ACCEPT**.

4.8 Installation Requirements for CE Marked 950 Flow Meter Models

Sigma 950 Flow Meters bearing a CE mark have special use and installation requirements that are subject to the European Union's Notified Body use limitations as indicated below.

Only the 950 flow meter models, part numbers and options listed below are approved for use in the EU under Hach's CE marking scope:

Description	Catalog Number
950 Combination Flow Meter with both AV + Bubbler Sensors	3248
950 Flow Meter with AV Sensors only	3522
950 Flow Meter with Bubbler Sensors only	2672
AV Sensor Options (xx-xxx = depth range, fill option and cable length)	770xx-xxx
Bubbler Sensor Options (xxx = cable lengths)	88007-xxx
pH Sensors with 7.6 m / 25 ft cable length	3328
pH Sensors with 15.2 m / 50 ft cable length	5172
4-20mA output option	2684
12VDC Battery Option	1414
230V 50Hz Battery Eliminator with Continental EU plug	5721400
230V 50Hz Battery Eliminator with UK plug	6244500
230V 50Hz Battery Eliminator with Italian plug	6244600

The use and location restrictions below apply:

- The Sigma 950 Flow Meter is approved for use in the EU only when placed underground in sewers, drain pipes and similar underground locations.
- The 950 Flow Meter shall be connected only to an AC Mains source that is dedicated to underground service. The mains service must not feed any residential locations.

If the 950 Flow Meter is operated in areas where high levels of RF energy or severe electrical transients are present, performance-related problems can result from electromagnetic interference. These conditions are not expected to be present in the types of underground locations indicated above for the 950 Flow Meter use model.

Section 5 Basic Programming Setup

5.1 Initial Power-Up of Meter

After power is applied, the flow meter performs a complete diagnostic self-test and displays the menu shown when the unit was last turned off. The Main Menu is the starting point for all programming operations. The Main Menu offers four choices:

- Setup—Basic programming
- Status—Lists all currently measured readings
- Display Data—Shows graphs and tables of logged data (See Displaying Data on page 95)
- Options—Advanced programming

Regardless of the current menu displayed, pressing the Main Menu function key will bring up the Main Menu screen.

Setup and Option functions lead to sub-menus which configure the basic and advanced features of the flow meter. Refer to the 950 Flow Meter Basic Programming Setup on page 87. The Display Data and Status lead to sub-menus which provide information only. Press the **STATUS** soft key to display any data channels that have enabled logging (flow, pH, temp., etc.).

5.2 Basic Programming

Note: *To make changes to the program entries after the basic programming setup, press the* ***MAIN MENU*** *key and select* ***SETUP>MODIFY SELECTED ITEMS.*** *Highlight the program entry using the up and down arrow soft keys.*

Basic programming setup must be performed, in its entirety, after the instrument is installed. Refer to the 950 Flow Meter Basic Programming Setup on page 87 for more information.

The basic program setup will modify all items: flow units, primary devices, program lock, sampler pacing, site ID, velocity direction, velocity units, velocity cutoff/velocity default.

Note: *Velocity features will only display when using a 950 area/velocity flow meter.*

Step 1 - Setup

1-A. Press **SETUP** from the Main Menu to prepare the 950 Flow Meter for use.

1-B. Press **MODIFY ALL ITEMS** and press **ACCEPT** to begin setting up the flow units.

Step 2 - Flow Units

Note: *Different flow units can be selected in the Sampler Pacing programming section (see Sampler Pacing on page 32).*

2-A. From the Modify All Items screen, highlight Flow Units using the **UP** and **DOWN** keys. Press the **SELECT** soft key to continue.

2-B. Press **CHANGE CHOICE** to cycle through the flow unit choices. Refer to Table 4 for flow unit choices. The flow unit will be used whenever a flow reading is displayed or logged.

2-C. When the desired choice is displayed press **ACCEPT** to continue and set level units.

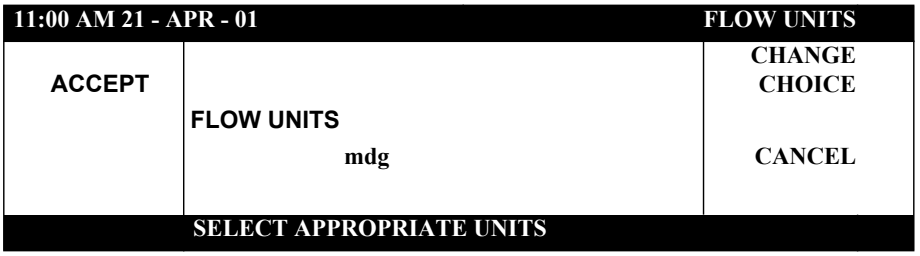


Table 4 Flow Unit Choices

Abbreviation	Flow Unit	Abbreviation	Flow Units
gps	Gallons per second	cfs	Cubic feet per second
gpm	Gallons per minute	cfm	Cubic feet per minute
gph	Gallons per hour	cfh	Cubic feet per hour
lps	Liters per second	cfd	Cubic feet per day
lpm	Liters per minute	cms	Cubic meters per second
lph	Liters per hour	cmm	Cubic meters per minute
mgd	Million gallons per day	cmh	Cubic meters per hour
afd	Acre-feet per day	cmd	Cubic meters per day

Step 3 - Level Units

3-A. Next the flow meter will display the Level Units screen.

3-B. Select the units of measure to use when displaying level readings (Table 5). Level units of measure are used whenever a level reading is displayed or logged.

Table 5 Level Units Choices

Abbreviation	Level Unit
in.	inches
ft	feet
cm	centimeters
M	meters

3-C. Press **CHANGE CHOICE** to cycle through each of the level unit choices. Press **ACCEPT** to continue to primary device setup.

Step 4 - Primary Device

Note: *Selecting the appropriate primary device is critical for proper flow rate calculations.*

4-A. Next, the flow meter will display the Primary Device screen.

4-B. Select the desired primary device, enter the calculation method, shape, and pipe diameter for that primary device.

4-C. Press **CHANGE CHOICE** to cycle through the primary device choices (see Table 6, Table 7, Table 8, and Table 9). Show the size and details required for each. Press **ACCEPT** to continue to Program Lock.

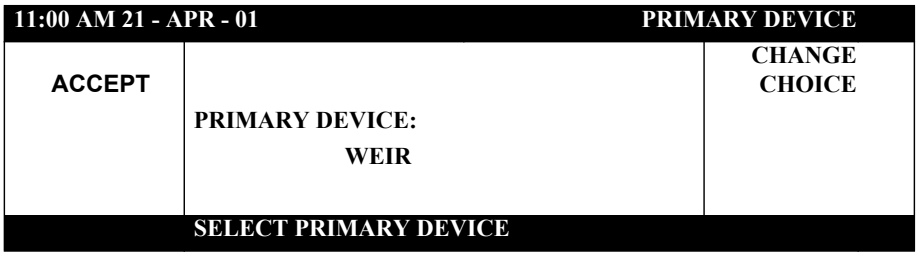


Table 6 Primary Device Choices

Primary Device	Description
None—Level Only	No primary device installed. Level measurement only.
Weir	Compound, Cipolletti, Contracted rectangular, Non-contracted rectangular, ThelMar, V-Notch (22.5-120°), Compound V-Notch (See Table 7)
Flume	Parshall, Trapezoidal, H-type, HL-type, HS-type, Leopold-Lagco, Palmer Bowlus (See Table 8)
Nozzle	California pipe
Power Equation	Enter variables K_1, K_2, n_1 and n_2 $Q = K_1H^{n1} + K_2H^{n2}$ K_1 (0–9999.99), K_2 (+/- 0–9999.99), n_1 and n_2 (1–9.99)
Head vs. Flow	Two independent user–entered look up tables of up to 99 points each Enter up to two tables of up to 100 user-defined head vs. flow points. Head: 0–99.99 in feet or centimeters Flow: 0–99999.99 in any desired units
Manning Equation	Rectangular channel, U-shaped, trapezoidal channel or Circular pipe Enter pipe diameter, slope & roughness coefficient. Pipe dia.: 4–240 in. or 101–6096 cm Percent Slope: 0.001–1.00 [1 unit per hundred units = 0.01 slope] Example: 1 m of decline every 100 m = 0.01 slope. Manning Roughness
Area Velocity	Circular Pipe: Enter pipe dia., 4–240 in.(10–610 cm) Rectangular Channel: Enter width, 4–999.99 in. (10– 2540 cm) Trapezoidal Channel: Enter width of channel bottom, width of channel top and channel depth, range for all: 4–999.99 in. (10– 2540 cm) U-Shaped Channel: Enter channel width, 4–999.99 in. (10–2540 cm)

Table 7 Weir Choices

Weir	Description
Cipolletti	Crest width is in. or cm (1–960 in. or 2.54–2438 cm)
Contracted Rectangular	Crest width is in. or cm (1–960 in. or 2.54–2438 cm)

Table 7 Weir Choices (continued)

Weir	Description
Non-Contracted Rectangular	Crest Width is in. or cm (1–960 in. or 2.54–2438 cm)
ThelMar	Size in inches. (6, 8, 10, 12 or 15 in.)
V-Notch	Angle of notch in degrees (22.5 to 120°)
Compound V-Notch	Angle of notch in degrees (22.5–120°), notch depth in inches, rectangular width in inches (0–120 in. or 0–304 cm), Contracted or non-contracted.

Table 8 Flume Choices

Flumes	Description
Parshall	Flume size in inches (1, 2, 3, 6, 9, 12, 18, 24, 30, 36, 48, 60, 72, 84, 96, 108, 120 or 144 in.)
Trapezoidal	Flume size (60° S, 60° L, 60° XL, 45° 2", 45° 12")
H - Type	Flume size in feet (0.5, 0.75, 1.0, 1.5, 2.0, 2.5, 3.0 or 4.5 ft)
HL - Type	Flume size in feet 3.5', 4.0'
HS -Type	Flume size in feet (0.4, 0.6, 0.8 or 1.0 ft)
Leopold-Lagco	Flume size in inches (4, 6, 8, 10, 12, 15, 18, 20, 21, 24, 27, 30, 36, 42, 48, 54, 60, 66 or 72 in.)
Palmer-Bowlus	Flume size in inches (4, 6, 8, 10, 12, 15, 18, 21, 24, 27, 30, 36, 42, 48, 60 or 72 in.)

Table 9 Other Primary Devices

Device or Equation	Description
Level vs. Area Table (two level vs. area tables are provided)	Enter up to two tables of up to 99 user-defined level vs. area points; Level: 0–999.9 in ft, in., m or cm Area: 1–99999.99 in ft^2, $in.^2$, m^2 or cm^2
Nozzle	Enter nozzle diameter

Step 5 - Program Lock

Program Lock provides a protective passcode to keep unauthorized personnel from tampering with the keyboard and/or prevent access via RS232 or modem. When enabled, a screen will require a password to be entered. **The Program Lock password factory is set as 9500 and cannot be changed.**

5-A. Next, the flow meter will display the Program Lock screen.

5-B. Enable or Disable the program lock using the **CHANGE CHOICE** soft key. Press **ACCEPT** to continue to Sampler Pacing.

Step 6 - Sampler Pacing

6-A. Next, the flow meter will display the Sampler Pacing screen.

6-B. Enable Sampler Pacing using the **CHANGE CHOICE** soft key. Refer to Table 10 for flow unit choices for sampler pacing.

6-C. Press **ACCEPT** to continue with Site ID.

11:00 AM 21 - APR - 01		SAMPLER PACING
ACCEPT	SAMPLER PACING	CHANGE UNITS
CLEAR ENTRY	500 gal	CANCEL
	(USE NUMERIC KEYPAD)	

Table 10 Flow Unit Choices

Abbreviation	Volume
gal	gallons
ltr	liters
m^3	cubic meters
af	acre-feet
cf	cubic-feet

Step 7 - Site ID

Note: *A text Site ID may be programmed via Hach's management software and an RS232 connection.*

Creates an 1–8 digit site identification number. The site ID will appear on all data printouts. This feature is useful when multiple sites are monitored using a single flow meter or if data readings from multiple flow meters are collected.

7-A. Next, the flow meter will display the Site ID screen.

7-B. Enter the site ID using the numeric keypad.

7-C. Press **ACCEPT** to continue to total flow units.

Step 8 - Total Flow Units

8-A. Next, the flow meter will display the Total Flow Units screen.

8-B. Set the Total Flow Units (gal, ltr, m^3, af, cf) using the **CHANGE CHOICE** soft key. Total flow units of measure are used whenever a total flow unit is displayed or logged.

8-C. Press **ACCEPT** to continue to velocity direction.

Step 9 - Velocity Direction (only when logging velocity)

9-A. Next, the flow meter will display the Velocity Direction screen.

9-B. Set the Velocity Direction using the **CHANGE CHOICE** soft key.

The Velocity Direction feature adapts to a number of difficult sites that would otherwise not be able to measure velocity properly (Upstream, Downstream, and Always Positive). For more information see the Velocity-Only Sensor Instruction Sheet (Cat. No. 88006-89).

9-C. Press **ACCEPT** to move to velocity units setup.

9-D. Set the velocity units (ft/s, mS) using the **CHANGE CHOICE** soft key.

9-E. Read the Velocity cutoff warning on the screen. Press any key to continue.

9-F. Enter the Velocity Cutoff, using the numeric keypad. Press **ACCEPT** to continue.

9-G. Enter the Velocity Default using the numeric keypad. Press **ACCEPT** to end the basic programming setup.

Note: *Velocity Cutoffs are used at sites where low velocities and frequent low particulate concentrations occur, if velocity cannot be measured.*

Example 1:

Velocity Cutoff = 0.20 ft/s, Velocity Default = 0 ft/s

If the velocity falls below 0.20 ft/s, the meter will store a value of 0 ft/s until the velocity increases above 0.20 ft/s.

Example 2:

Velocity Cutoff = 0.20 ft/s, Velocity Default = 0.20 ft/s

If the velocity falls below 0.20 ft/s, the meter will store a value of 0.20 ft/s until the velocity increases above 0.20 ft/s.

5.3 Starting and Stopping Programs

Note: *When selecting START FROM BEGINNING, all logged data will be cleared from memory. When saving the logged data, make sure the data is downloaded to a DTU or personal computer. If a program is complete, the logger can only be restarted from the beginning (and will clear all logged data).*

When basic programming setup is completed, “run” (or execute) the program selections. Press the **RUN/STOP** key to run a program, resume a currently halted program, or stop a program.

If a program has been halted (and no changes to the program settings were made while it was stopped), press the **RUN** key. Select either resume to previously running program (and retain all logged data) or Start From Beginning (and clear all logged data).

Status	Description
Program is Running	
	Data Logging, 4-20 mA outputs, sampler control and alarm checking are active.
Program is Halted	
	Logging stops until the program is restarted. It continues with the last logged value when restarted.
	4–20 mA outputs remain unchanged
	Sampler control is disabled
	Alarm checking is disabled
Program is Complete or Ready to Start	
	No data logging
	4–20 mA outputs stay at last value
	No sampler interface
	No alarm checking
Program Complete	
	A logger is off or lost power for longer than 3 hours or datalogging memory is full (see Data Log on page 99).

Section 6 Sensor Installation

An individual Sigma 950 flow meter may have one or more of the following sensors:

- Downlooking Ultrasonic Sensor
- Submerged Pressure Area/Velocity Sensor
- Submerged Pressure Sensor
- In-Pipe Ultrasonic Sensor
- Velocity-Only (Low Profile) Sensor
- Bubbler
- AV Bubbler

6.1 Downlooking Ultrasonic Depth Sensor

6.1.1 Downlooking Ultrasonic Depth Sensor Connection

Note: *Use a bare leads sensor and junction box (P/N 3658) for conduit installation.*

The Sigma 950 Flow Meter uses a 50 kHz or 75 kHz Downlooking Ultrasonic Depth Sensor. The ultrasonic sensor receptacle is on the left side of the flow meter and labeled Ultrasonic. The connector is keyed and can only be inserted key up.

Table 11 Downlooking Ultrasonic Depth Sensor Connector Pin Assignments

Pin	Signal Description	Wire Color
A	temperature (+)	red
B	temperature (-)	black
C	ultrasonic (+)	shield
D	ultrasonic (-)	clear

Note: *Cutting or splicing the sensor cable may cause instrument malfunction and void the warranty.*

Remote Ultrasonic Connection
A Remote Ultrasonic factory-installed Option is available (P/N 3170) which allows for the extension of the ultrasonic sensor cable (see Figure 5).

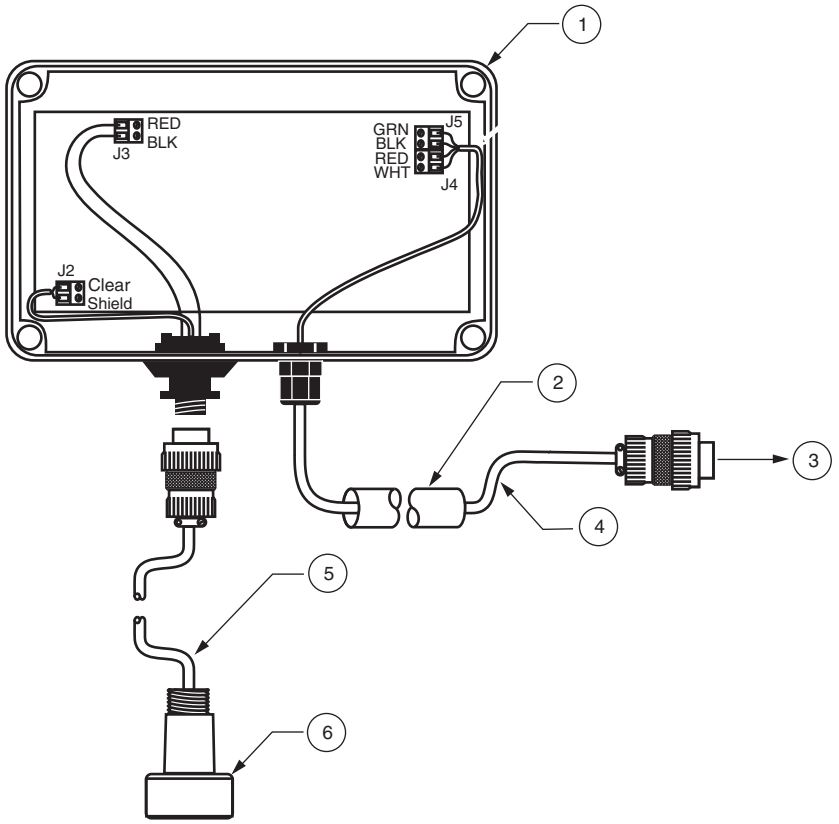
6.1.2 Downlooking Ultrasonic Depth Sensor Programming

The downlooking ultrasonic depth sensor does not require specific programming, unless more than one sensor option is connected to the meter. When more than one sensor option is connected:

1. From the Main Menu, select **OPTIONS>LEVEL SENSOR.**

Select Ultra-Sonic using the **CHANGE CHOICE** soft key, then press the **ACCEPT** soft key.

Figure 5 Remote Ultrasonic Sensor Option



1	Enclosure 13.97 x 22.86 x 4.0 cm (5.5 x 9.0 x 4.0 in.)	**3**	To flow meter	**5**	Cable (P/N 2716)
2	Customer-supplied conduit to 950 flow meter.	**4**	Cable (P/N SE 818)	**6**	Ultrasonic Transducer

6.1.3 Downlooking Ultrasonic Depth Sensor Calibration

Calibrate the current water depth via one of two methods; Liquid Depth or Sensor Height. An Invisible Range can also be set which allows the transducer to ignore reflections from obstructions between the sensor and the water surface, such as ladder rungs, channel side walls, etc. Each method has its own advantages and disadvantages; selecting the proper method will depend upon the site conditions. Calibrate the ultrasonic sensor each time the sensor is installed at a new site.

6.1.3.1 Liquid Depth

This method requires the depth of liquid in the channel that is contributing to flow. In a round pipe, the entire depth typically contributes to flow. In a weir, only the depth that is flowing over the weir plate contributes to flow. Many flumes have specific requirements, refer to Working with Primary Devices on page 105. Depth calibration is primarily used when:

Access is available to the primary device for a physical measurement of the liquid depth, and when water is flowing during installation of the 950 Flow Meter (channel is not dry).

Note: *Always re-check the Level Adjust when re-installing the flow meter.*

1. From the Main Menu, select **OPTIONS>ADVANCED OPTIONS> CALIBRATION>ULTRASONIC SENSOR.**
2. Select Calibrate U-Sonic using the **UP** and **DOWN** soft keys. Press **SELECT**.

3. Select Standard as the type of Ultrasonic Transducer using the **CHANGE CHOICE** soft key. Press **ACCEPT** to continue.

Temperature Time Constant
The speed of sound in air varies with the temperature of the air. The ultrasonic sensor is equipped with temperature compensation to help eliminate the effect of temperature variation under normal site conditions. The transducer must be equal to the ambient air temperature at the site prior to calibration for optimum results. The manufacturer also recommends that sensors be shielded from direct sunlight for this reason.

4. Enter the ambient air temperature at the transducer location. For optimum results, allow enough time (100 minutes) to ensure that the sensor is at equilibrium with the surrounding ambient temperature. Press **ACCEPT** to continue.
5. Select the Liquid Depth method and enter the new level.
6. Take a physical measurement of the liquid depth and enter the value.
7. Press **ACCEPT** when finished.

6.1.3.2 Sensor Height

This method requires you to enter the distance between the face of the ultrasonic sensor and the zero flow point in the primary device. The zero flow point in a primary device is the level at which flow ceases. In a round pipe the zero flow point would typically be the invert or bottom of the pipe. In a V-notch weir the zero flow point occurs when the liquid behind the weir is level with the bottom of the 'V'. (There would still be liquid behind the weir plate but it would not be contributing to flow). Sensor Height calibration is generally used when access to the primary device is difficult (such as confined space entry in a manhole) or there is no liquid flowing during installation of the flow meter.

1. From the Main Menu, select **OPTIONS>ADVANCED OPTIONS>CALIBRATION>ULTRASONIC SENSOR.**
2. Select Calibrate U-Sonic using the **UP** and **DOWN** soft keys. Press **SELECT**.
3. Select Standard as the type of Ultrasonic Transducer using the **CHANGE CHOICE** soft key. Press **ACCEPT** to continue.
4. Enter the ambient air temperature at the transducer location. For optimum results, allow enough time (100 minutes) to ensure that the sensor is at equilibrium with the surrounding ambient temperature. Press **ACCEPT** to continue.
5. Select the Sensor Height method and enter the new level.
6. Enter the distance from the face of the transducer to the zero flow point of the primary device.
7. Press **ACCEPT** when finished.

6.1.3.3 Setting the Invisible Range

1. From the Main Menu, select **OPTIONS>ADVANCED OPTIONS>CALIBRATION>ULTRASONIC SENSOR.**
2. Select the Invisible Range option using the **UP** and **DOWN** soft keys. Press **SELECT** to continue.
3. Enter the Distance to End of the Invisible Range using the keypad.
4. Select either inches or centimeters using the **CHANGE UNITS** soft key. The distance must be greater than the minimum deadband of 23 cm (9 in.) for the 75 kHz sensor and 38.1 cm (15 in.) for the 50 kHz sensor.
5. Press **ACCEPT** when finished.

6.2 In-Pipe Zero Deadband Ultrasonic Depth Sensor

The in-pipe zero deadband ultrasonic depth sensor is used in pipes where depth measurement near the top of the pipe is desired. The sensor will read the depth until liquid reaches from the bottom of the sensor housing.

6.2.1 In-Pipe Zero Deadband Ultrasonic Depth Sensor Connection

Table 12 In-Pipe Zero Deadband Ultrasonic Depth Sensor Connector Pin Assignments

Pin	Signal Description	Wire Color
A	temperature (+)	red
B	temperature (-)	black
C	ultrasonic (+)	shield
D	ultrasonic (-)	clear

6.2.2 Programming the In-Pipe Zero Deadband Ultrasonic Depth Sensor

The in-pipe zero deadband ultrasonic depth sensor does not require operator programming, unless more than one sensor option is connected to the 950 Flow Meter. When more than one sensor option is connected:

1. From the Main Menu, select **OPTIONS > LEVEL SENSOR**
2. Select Ultra-Sonic Sensor using the **CHANGE CHOICE** soft key, then press **ACCEPT**.

6.2.3 Beam Angle

The narrow beam of sound that emanates from the bottom of the in-pipe ultrasonic sensor spreads out at an angle of ±12° (-10 dB) as it travels away from the sensor. This means that if the sensor is mounted too high above a narrow channel, the beam may be too wide when it reaches the bottom of the channel. This may cause false echoes from the sides of the channel walls.

6.2.4 Calibrating the In-Pipe Zero Deadband Ultrasonic Depth Sensor

Calibrate the in-pipe sensor each time the sensor is installed at a new site. Calibrate the in-pipe via one of two methods; Liquid Depth or Sensor Height. Each method has its own advantages and disadvantages. Liquid Depth calibration is the recommended calibration method. Use the sensor height method **only** when Liquid Depth calibration is not an option. An Invisible Range can also be set which allows the transducer to ignore reflections from obstructions between the sensor and the water surface, such as ladder rungs, channel side walls, etc.

1. From the Main Menu, select **OPTIONS > ADVANCED OPTIONS.**
2. Highlight Calibration, using the **UP** and **DOWN** soft keys. Press **SELECT**.
3. Highlight Ultra-Sonic Sensor, using the **UP** and **DOWN** soft keys. Press **SELECT** to continue.
4. Highlight Calibrate U-Sonic Sensor and press **SELECT**.
5. Select the type of ultrasonic transducer (In-Pipe), using the **CHANGE CHOICE** soft key.
6. Press **ACCEPT** to continue.

7. Enter the ambient air temperature at the transducer location. For optimum results, allow enough time (100 minutes) to ensure that the sensor is at equilibrium with the surrounding ambient temperature.

The speed of sound in air varies with the temperature of the air. The ultrasonic sensor is equipped with temperature compensation to help eliminate the effect of temperature variation under normal site conditions.

8. Press **ACCEPT** to continue.

Liquid Depth
Liquid depth requires knowing the level or depth of the liquid in the channel that is contributing to flow. Liquid depth calibration is the recommended calibration method for the in-pipe ultrasonic sensor.

Continue from Step 8, above:

1. Select the Liquid Depth method.
2. Take a physical measurement of the liquid depth (head) and enter the value.
3. Press **ACCEPT** when finished.

Sensor Height
Sensor height calibration is generally used when access to the primary device is difficult (such as confined space entry in a manhole) or when there is no liquid flowing during installation of the flow meter. This calibration method requires compensation for the internal deadband in the sensor housing. Measurement uncertainty increases to 1.07 cm (0.035 ft) for a ±30 cm (±1 ft) change in level from the calibration point.

Use this method only if the Liquid Depth method is not an option.

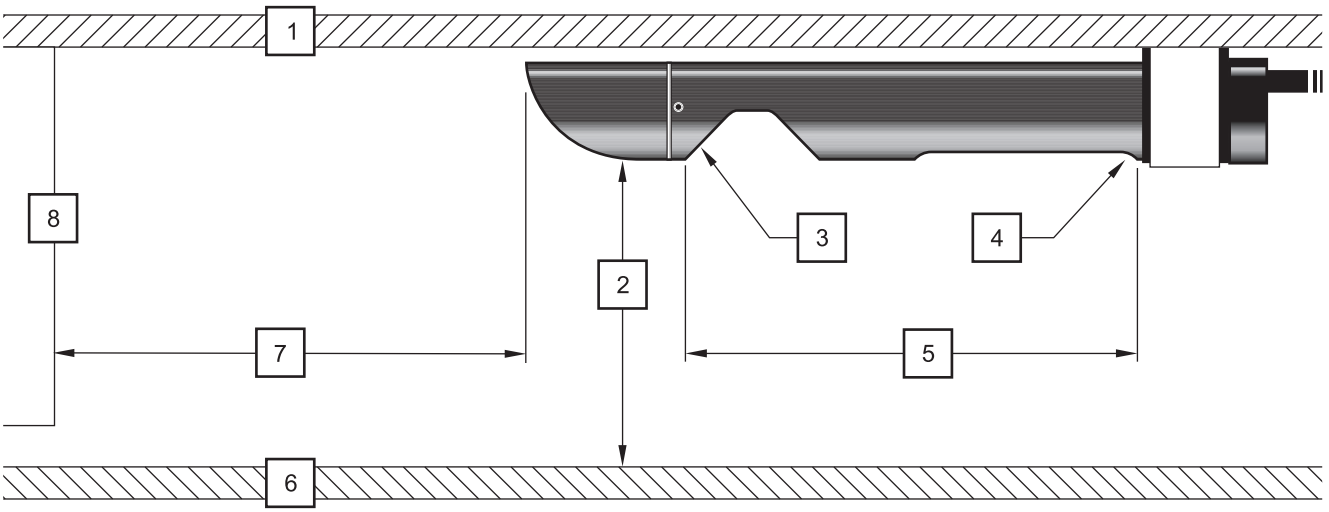
Continue from Step 8, above:

1. Measure the distance from the bottom of the sensor to the zero flow point. Add 18 cm (7.09 in.) to the measured distance to obtain the total zero flow distance for the in-pipe sensor. Refer to Figure 6 on page 42.
2. Select the Sensor Height calibration method and enter the total zero flow distance from Step 1.
3. Press **ACCEPT** when finished.

Setting the Invisible Range
Note: *When programming the invisible range, 18 cm (7.09 in.) must be added to the desired range to compensate for the internal deadband distance between the sensor, the reflector, and the bottom of the sensor housing.*

The 950 Flow Meter is equipped with an invisible range feature to prevent false echoes from tops of channel walls, ladder rungs, shelves, etc. A user-selected range is defined that is invisible to the flow meter. Do not extend the invisible range to where it meets or overlaps the highest expected level in the channel. Have a gap of at least 5 cm (2 in.) between the invisible range and the highest expected level. Only objects beyond the invisible range can be detected.

Figure 6 Side View of In-Pipe



1	Pipe Ceiling	**5**	Internal Deadband (18 cm (7.09 in.))
2	Distance from Sensor (Range: 0 to 2.4 m (0 to 8 ft))	**6**	Pipe Floor
3	45° Deflector	**7**	Minimum distance to reflecting obstruction (2 m (82 in.))
4	Ultrasonic Sensor	**8**	Reflecting Obstruction

1. From the Main Menu, select **OPTIONS>ADVANCED OPTIONS> CALIBRATION> ULTRASONIC SENSOR.**
2. Select the Invisible Range option using the **UP** and **DOWN** soft keys. Press **SELECT** to continue.
3. Enter the Distance to End of the Invisible Range using the keypad.
4. Select either inches or centimeters using the **CHANGE UNITS** soft key. Press **ACCEPT** when finished.

6.3 Submerged Area/Velocity Sensor

Submerged Area/Velocity sensors can measure depth and velocity simultaneously.

6.3.1 Bare Lead Sensor Cables

Bare lead sensor cables are used in those cases where the cable will be run through a conduit. When conduit is used, it is recommended that the conduit be 1-inch or larger.

6.3.2 Junction Box Connection Procedure

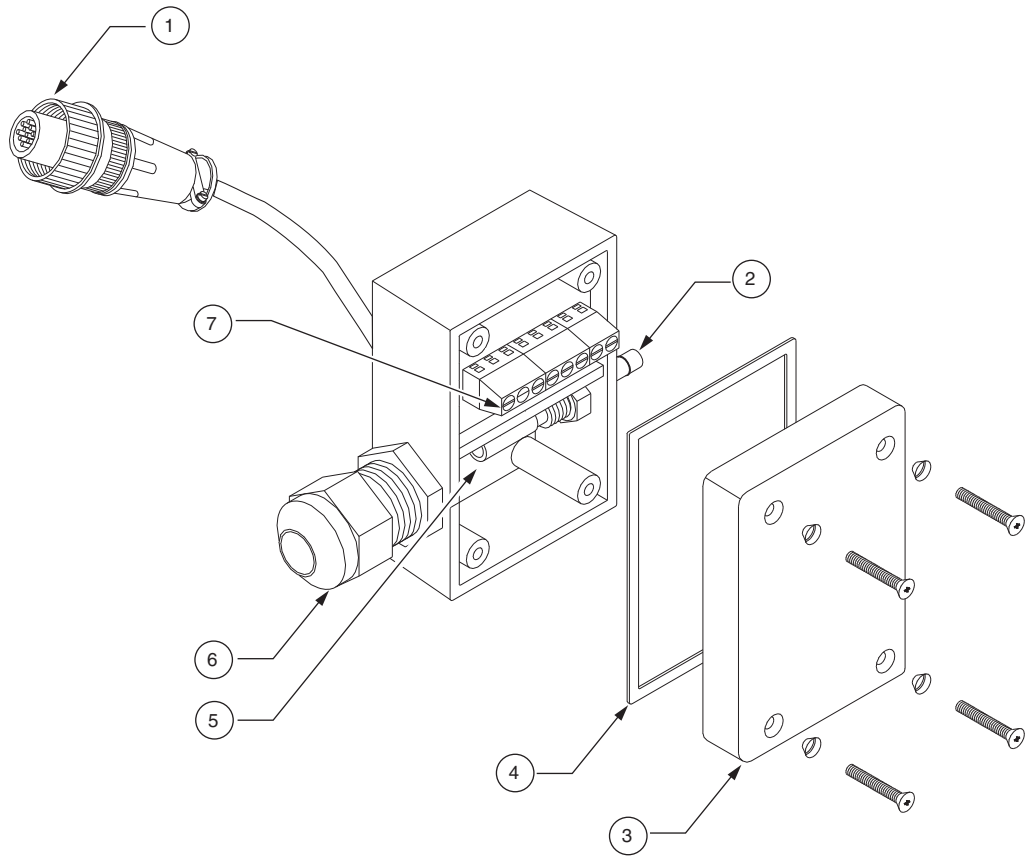
Connect the bare leads to the flow meter using a junction box (P/N 4730). This junction box is a physical connection point for the sensor wires and breather tubing.

Refer to Figure 7 for the following procedure.

1. Remove the four cover screws, cover, and cover gasket from the junction box. Unscrew the cable-clamp hex nut on the box enough to allow insertion of the sensor cable.

2. Insert the sensor cable into the box and make connections. Refer to the wiring diagram on the inside cover of the box, connect each wire to its corresponding terminal screw, observing the wire colors listed in that diagram. See Table 13.
3. Connect the tubing in the cable to the clear tubing in the box that is already connected to the exit fitting.
4. Slip the cable in or out of the box sufficiently to create a slight loop in the wires and tubing to allow strain relief and then tighten the cable-clamp hex nut.
5. Being careful to align the cover gasket (P/N 2101), reattach the cover and gasket to the box with the screws.
6. Connect clear tubing between the top tubing nipple on the desiccant canister and the brass tubing nipple on the junction box.
7. Connect the short, connector-terminated cable to the “velocity” connector on the flow meter.

Figure 7 Junction Box Probe and Cable Connection



1	Connect to meter	**4**	Gasket (P/N 2101)	**7**	Connect sensor cable wires
2	Connect to desiccant tubing	**5**	Insert tubing (P/N 4628)		
3	Cover	**6**	Connect to sensor cable		

Table 13 Submerged Area/Velocity Sensor Connection Pin Assignments

Pin	Signal Description	Wire Color
A	+12 VDC	red
B	ground	green
C	receive (ground)	b/w shield

Table 13 Submerged Area/Velocity Sensor Connection Pin Assignments

Pin	Signal Description	Wire Color
D	receive (+)	b/w center
E	transmit (ground)	black shield
F	transmit (+)	black center
G	depth (-)	black
H	depth (+)	white

6.3.3 Submerged Area/Velocity Sensor Programming

1. If the flow meter is equipped with multiple sensors, from the Main Menu, select **OPTIONS>LEVEL SENSOR.**
2. Select Submerged Xducer using the **CHANGE CHOICE** soft key, then press **ACCEPT**.
3. From the **MAIN MENU**, select **SETUP>MODIFY SELECTED ITEMS.**
4. Highlight Velocity Direction using the **UP** and **DOWN** soft keys. Press **SELECT** to continue.
5. Set the velocity direction (upstream, downstream, or always positive) using the **CHANGE CHOICE** soft key.
6. Press **ACCEPT** to continue.
7. Highlight Velocity Units using the **UP** and **DOWN** soft keys. Press **SELECT** to continue.
8. Set the Velocity Units (ft/s or m/s), using the **UP** and **DOWN** soft keys. Press **ACCEPT** to continue.
9. Highlight Velocity Cutoff, using the **UP** and **DOWN** keys. Press **SELECT** to continue.
10. Read the Velocity Cutoff information screen. Press any key to continue.
11. Set the Velocity Cutoff using the numeric keypad. Press **ACCEPT** to continue.
12. Set the Velocity Default, using the numeric keypad. Press **ACCEPT**. Press **RETURN** to go back to the Setup Menu or the Main Menu key to return to the beginning.

6.3.4 Submerged Area/Velocity Sensor Calibration.

Note: *The data is constant if the difference between the level reading of the flow meter and the independent verification is constant; recalibration is not required.*

The manufacturer recommends calibrating the Submerged Area/Velocity Sensor when:

- The sensor is first used.
- Installing a new or different sensor on a flow meter or input receptacle.
- The difference between the level reading of the flow meter and the independent verification (measurement with a dipstick and ruler) is increasing.

Note: *Errors are caused by variation in site conditions and measurement abilities. These errors may cause slight changes in the difference, therefore, not indicating a true change in the difference.*

1. From the Main Menu, select **OPTIONS > ADVANCED OPTIONS > CALIBRATION > SUBMERGED PROBE.**
2. Place the sensor flat on a table top or floor with the sensor (the plate with holes) facing down onto the surface.
3. Press any key to continue.

6.4 Low Profile Velocity-Only Sensor

The Low Profile Velocity-Only Sensor is an extremely low-profile velocity sensor. It does not measure depth. Therefore it is usually used in conjunction with the in-pipe ultrasonic sensor. The streamlined shape of the velocity-only sensor allows velocity measurement in very low-flow conditions. When used in conjunction with a depth sensor, the meter can calculate flow.

6.4.1 Low Profile Velocity-Only (Low Profile) Sensor Connection

Note: *Use bare-lead sensor and junction box for conduit installation.*

The low profile velocity-only sensor connector is located on the right side of the flow meter (when facing the flow meter) and is labeled Velocity. The connector is keyed and can only be inserted in the proper orientation (key up). See Table 14 for pin assignments.

Table 14 Submerged Velocity Sensor Connector Pin Assignments

Pin	Signal Description	Wire Color
A	+12 VDC	red
B	ground	green
C	receive (shield)	b/w shield
D	receive (+)	b/w center
E	transmit (shield)	black shield
F	transmit (+)	black center

6.4.2 Low Profile Velocity-Only Sensor Programming

1. From the **MAIN MENU**, select **SETUP>MODIFY SELECTED ITEMS.**
2. Highlight Velocity Direction using the **UP** and **DOWN** soft keys. Press **SELECT** to continue.
3. Set the velocity direction (upstream, downstream, or always positive) using the **CHANGE CHOICE** soft key.
4. Press **ACCEPT** to continue.
5. Highlight Velocity Units using the **UP** and **DOWN** soft keys. Press **SELECT** to continue.
6. Set the Velocity Units (ft/s or m/s), using the **UP** and **DOWN** soft keys. Press **ACCEPT** to continue.
7. Highlight Velocity Cutoff, using the **UP** and **DOWN** soft keys. Press **SELECT** to continue.
8. Read the Velocity Cutoff information screen. Press any key to continue.
9. Set the Velocity Cutoff using the keypad. Press **ACCEPT**.
10. Set the Velocity Default, using the numeric keypad. Press **ACCEPT**. Press **RETURN** to go back to the Setup Menu or the Main Menu key to return to the beginning.

6.4.3 Low Profile Velocity-Only Sensor Calibration

No calibration is required for the velocity sensor. The transmit frequency is fixed with a highly accurate quartz crystal-controlled frequency generator that cannot be adjusted.

6.5 Submerged Depth Only Sensor

The submerged depth only pressure sensor is a pressure transducer that contains a titanium diaphragm. As the water pressure increases, (with increasing depth in the flow stream) the diaphragm is deflected, or pushed, against a solid state device called a strain gauge. The strain gauge converts the pressure against the diaphragm to a voltage. As the depth in the flow stream increases, the voltage coming from the submerged pressure sensor increases. The voltage is read by the microprocessor in the 950 Flow Meter at a regular interval and converted to a number which represents the depth in the flow stream. The depth reading can then be converted by the meter to a flow rate based on the mathematical formula for the selected primary device.

6.5.1 Submerged Depth Only Sensor Connection

The submerged depth only sensor connector is located on the left side of the flow meter and is labeled Sub Probe. The connector is keyed and can only be inserted in the proper orientation (key up). See Table 15 for pin assignments.

Table 15 Submerged Pressure Sensor Interface Pin Assignments

Pin	Signal Description	Wire Color
A	V (+)	red
B	signal (+)	yellow
C	signal (-)	green
D	ground	black

6.5.2 Submerged Depth Only Sensor Programming

1. From the Main Menu, select **OPTIONS>LEVEL SENSOR.**
2. Select Submerged Xducer using the **CHANGE CHOICE** soft key, then press **ACCEPT**.

6.5.3 Submerged Depth Only Sensor Calibration

The submerged depth only sensor does not need to be calibrated for each use. In general, calibrate the probes:

- The first time a new meter and sensor is used
- Whenever a sensor is replaced with another sensor
- Every 6 months

Submerged depth only sensor calibration requires a graduated cylinder or bucket with at least 16 cm (6 in.) of water and a ruler. Calibrating the submerged sensor characterizes the 950 Flow Meter electronics to the unique characteristics of each individual sensor. In addition, the calibration compensates for any sensor drift that may occur over time (6 months or greater) as the materials in the sensor age.

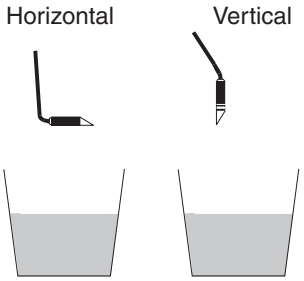
To ensure optimum accuracy, calibrate the meter approximately twice per year or when changing to a different submerged sensor.

1. From the Main Menu, select **OPTIONS > ADVANCED OPTIONS > CALIBRATION > SUBMERGED PROBE.**
2. Choose the orientation that the sensor will be mounted in the flow stream, horizontal or vertical, using the **CHANGE CHOICE** soft key. Use this same position during calibration to ensure optimum accuracy. Press **ACCEPT** to continue.

ACCEPT	ORIENTATION OF SUBMERGED PROBE: HORIZONTAL	CHANGE CHOICE
CANCEL		
	SELECT APPROPRIATE UNITS	

3. Lift the sensor out of the water and hold it in the air in the same orientation that you selected in the previous step (horizontal or vertical) (Figure 8). Press **ACCEPT** to continue.

Figure 8 Lifting the Sensor Out of the Water



4. Follow either the vertical or horizontal procedure below.

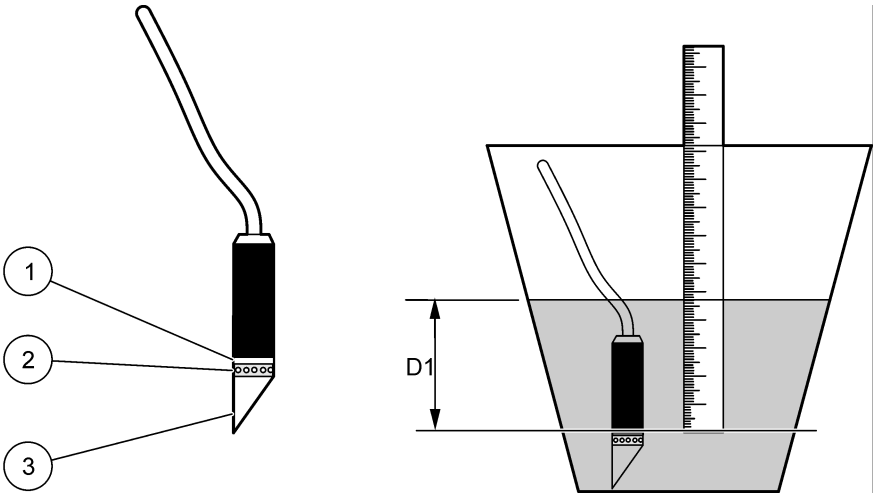
Vertical Orientation Only

a. Place the sensor under at least 16 cm (6 in.) of water in a vertical orientation. Make sure the sensor is stable and not moving around. Press **ACCEPT** to continue.

b. Carefully measure the depth (D1) from the surface of the water to the first weld mark that encircles the sensor body just above the breather vent holes (Figure 9). The weld mark indicates the location of the internal diaphragm.

c. Enter the depth (D1) using the numeric keypad then press **ACCEPT** when done.

Figure 9 Measuring Submerged Depth, Vertical Orientation



1	Gray band	**2**	Breather vents	**3**	Detachable nose cone

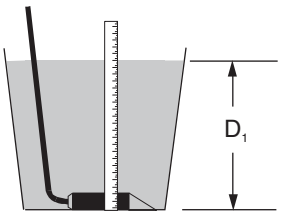
Horizontal Orientation Only

Note: *Always check the Level Adjust when reinstalling the flow meter following a calibration.*

a. Place the sensor under at least 16 cm (6 in.) of water in a horizontal orientation. Make sure the sensor is stable and not moving around. Press **ACCEPT** to continue.

b. Measure the depth from the bottom of the bucket to the surface of the water (D1) (Figure 10) and enter the value using the numeric keypad. Press **ACCEPT** to continue.

Figure 10 Measuring Submerged Depth, Horizontal Orientation



6.6 Bubbler

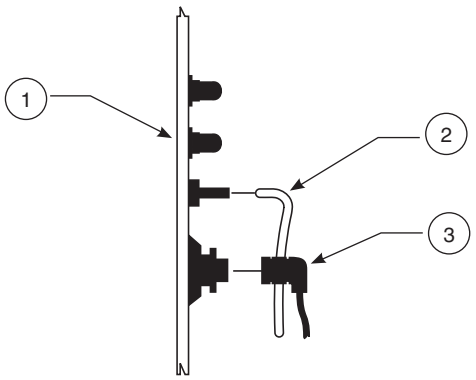
The 950 Bubbler Flow Meter utilizes the bubbler method of level measurement. A length of tubing is placed in the flow stream at the proper location for head measurement. A small amount of air is continuously pushed through the tubing and bubbles slowly come out the end. The pressure in the tubing changes in proportion to the liquid level in the flow stream. The 950 Flow Meter reads the this pressure and converts it to a level reading. The 950 Flow Meter will accurately measure the level in the channel as long as the end of bubbler line remains below the zero level point of the channel. After measuring the level, the 950 microprocessor converts the level reading to a flow rate based on the user defined characteristics of a primary device.

6.6.1 Bubbler Connections

Note: Note: *To connect a level-only bubbler, push the 1/8" I.D. vinyl tubing (P/N3807) onto the bubbler line port and the other tubing end in the flow stream.*

The Depth Only and bubbler Area/Velocity Sensor connector, bubbler line connection, and air dryer canisters are located on the right side of the flow meter. A small diameter tube is contained within the sensor cable to supply air from the 950 Flow Meter to the sensor in the flow stream. See Figure 11.

Figure 11 Bubbler Connections



1	Right-side of 950 meter	**2**	Bubbler line connection	**3**	Velocity connection

Three ports on the 950 Flow Meter pertain to air flow for bubbler operation:

- **Intake Port**—This port supplies fresh air to the internal air pump. The air is drawn through a dryer tube consisting of two hydrophobic filters and a desiccant material that removes moisture and dirt from the incoming air.

- **Reference Port**—This port provides a reference to atmosphere. The flow meter measures level by comparing the back pressure against the bubble in the bubbler line with ambient air pressure. As the water level increases, the back pressure pushing against the bubble increases.

  The transducer first reads the pressure in the bubbler line, then, at regular intervals, switches to the reference port to compare it to the atmospheric pressure. This pressure difference is converted to a number which represents the liquid level. At a regular interval, both the bubbler port and the reference port are switched to open air together and electronically zeroed to eliminate any drift due to changing barometric pressure.

  If the flow meter is to be located where there is **any** threat of temporary submersion you should attach a length of ¼-in. ID tubing to both the reference port and the intake port barbed fittings. Route the ends of this tubing to a safe area that is free from the possibility of submersion. Reattach both desiccant cartridges to the tubing, with the cartridge openings facing downward to ensure that moisture, condensation, and/or precipitation does not accumulate in the vent openings of the cartridge. This precaution will protect the air pump and internal plumbing systems from water damage. **Do not leave the desiccant cartridges with the vent openings facing up!**

- **Bubbler Line Port**—The bubbler line connects from this port to the measurement point in the primary device. Push the 1/8” (3.17 mm) ID vinyl bubbler tubing over the brass barbed fitting. No clamps are required.

6.6.1.1 Meter-End Cable Terminations

Bubbler Area/Velocity sensors are terminated with a velocity connector and bubbler tube or with bare leads and the bubbler tube. Use the bubbler with bare leads at sites where the sensor cable is routed through a conduit.

1. At the meter end of the conduit, connect the cable to the meter with a junction box (Figure 7 in section 6.3.2 on page 42).
2. Connect the bubbler tube to the brass tubing coupler in the junction box.
3. Connect another section of tubing from the brass coupler to the top connector on the Intake Port Dryer Canister.
4. Connect the velocity leads to the junction box terminals as indicated on the junction box.

6.6.1.2 Routing the Bubbler Line

There are several important things to consider when routing the bubbler line.

- Route the tubing so that it slopes downward from the flow meter or sensor cable to the flow stream whenever possible. This assures that any condensation that forms in the tubing will drain out of the tube. If moisture collects in a low spot in the tubing it could restrict the flow of air and cause erroneous readings.

- Don't use more bubbler line than you need. Remove excess coils of tubing to decrease the likelihood of moisture problems, cuts, or kinks.

- Use a single continuous length with no spliced connections to eliminate the possibility of air leaks.
- Use care not to cut or kink the tubing during installation.

6.6.2 Bubbler Installation

6.6.2.1 Installation Guidelines

- Locate the end of the bubbler line at the proper head measurement point for that primary device. All weirs and flumes either come equipped or can be retrofitted with a connection for the bubbler line. Stainless steel bubbler line extensions are available where no provisions have been made. Optional mounting bands with built-in bubbler tube connections for use in round channels are also available.
- Place the end of the bubbler perpendicular (at a right angle) to the flow stream.
- Locate the end of the bubbler line 2.5 to 5 cm (1 to 2 in.) below the lowest expected level in the channel. Pressing the **LEVEL ADJUST** key will calibrate the displayed reading to the actual level in the channel.
- In a weir or flume, use a stilling well. Silt and sediment build-up in the stilling well is unlikely.
- In round pipes, use the manufacturer's mounting bands or locate the bubbler line along the wall in a slot or groove and cover it so it does not protrude into the flow stream and collect debris.

6.6.3 Depth Only and Bubbler Area/Velocity Calibration

Bubbler calibration requires a graduated cylinder with at least 16 cm (6 in.) of water, a ruler, and 1 m (3 ft) of bubbler line.

The bubbler is calibrated at the factory and characterizes the electronics to the internal pressure transducer. The internal pressure transducer is the device that converts the pressure in the bubble line to a voltage that is read by the microprocessor. Recalibrate the sensor at least once per year to ensure optimum accuracy.

When selecting Bubbler from the calibration menu you are presented with three choices:

- Set Bubbler Rate
- Calibrate Bubbler
- Auto-Purge

Set Bubble Rate
Note: *Excessive bubble rates could cause an increase in the level reading due to friction on the bubbler line. Always readjust the level using the* ***LEVEL ADJUST*** *key after making changes to the Bubble Rate. This will compensate for errors induced by changes in the bubble rate.*

This setting allows you to vary the rate of bubbles coming from the end of the bubbler line. Some streams with a high solids or grease content may require a slightly higher bubble rate to keep debris from plugging the bubbler line. However, setting an excessively high bubble rate to keep the line clear is not advised. Instead, use the Auto Purge feature. This applies a high pressure purge to the bubber line at a regular interval.

The recommended bubble rate is one bubble per second. Check the bubble rate in a depth of water that is typical for the installation and adjust if necessary. When setting the bubble rate at a location other than the installation site, use the same inside diameter and

length of the bubbler line that will be used at the site or the bubble rate may be different when the flow meter is actually installed.

Note: *High bubble rate and/or short Auto-Purge intervals will decrease battery life due to the increased air pump run time required to replenish the air reservoir. When operating the battery power, keep bubble rates at one bubble per second. Set the Auto-Purge intervals to at least 30 minutes.*

To set the bubble rate, highlight the **SET BUBBLE RATE** selection using the **UP** and **DOWN** arrow soft keys, then press the **SELECT** soft key. Enter the bubble rate number from 1 to 5, then press the **ACCEPT** soft key to save the changes.

Calibrate Bubbler Procedure

1. From the Main Menu, select **OPTIONS>ADVANCED OPTIONS>CALIBRATION>BUBBLER.**
2. Set the Bubble Rate to 2 or 3 (or approximately 1 bubble per second).
3. Install 3 ft of new bubbler tubing from the flow meter to a graduated cylinder filled with at least 16 cm (6 in.) of water. Make sure that the tubing is held securely in the cylinder and cannot move during calibration.

Note: *Always recheck the Level Adjust when reinstalling the flow meter following a calibration. (See* *Figure 1 on page 18**.)*

4. Select CALIBRATE BUBBLER from the Bubbler Calibration menu. Carefully measure the depth of the bubbler line with a ruler. Measure from the surface of the water to the bottom of the bubbler line (ignore the bubble).
5. Enter the new depth using the numeric keypad. Press **ACCEPT**. The current reading is shown for reference. This depth value is always entered in the unit of measure that was selected in the Setup menu (inches, centimeter, etc.).

Auto Purge

When enabled, Auto-Purge will cause a one-second high pressure purge of the bubble line on a user-defined time interval. This purge will clear debris such as silt from around the end of the bubble line, and to prompt trouble-free and accurate operation, even in high solids applications. Select **AUTO-PURGE** from the bubbler calibration menu and press **CHANGE CHOICE** to enable or disable Auto-Purge. If enable is selected, the Auto-Purge interval screen is then displayed. Enter an interval between 5 and 90 minutes using the numeric keypad, then press **ACCEPT**.

Section 7 Optional Device Installation

This section describes how to set up a rain gauge to the 950 Flow Meter as well as how to install the optional water quality probes (pH, ORP, Dissolved Oxygen, Conductivity, Temperature Probe).

Important Note: *950 Flow Meter options described in this section of the manual may not be suitable for use with CE marked models of the 950 Flow Meter. See section 4.8 on page 27 for details on approved CE options.*

7.1 Rain Gauge

7.1.1 Rain Gauge Connection

An external “tipping bucket” rain gauge (such as P/N 2149) can be connected to the Rain Gauge connector of the 950 Flow Meter. The rain gauge provides a dry contact closure to the flow meter.

Table 16 Rain Gauge Connector Pin Assignments

Pin	Signal Description
A	+12 VDC source output
B	not used
C	+12 VDC pulse input
D	not used
E	not used
F	not used

7.1.2 Rain Gauge Programming

1. From the Main Menu, select **OPTIONS>ADVANCED OPTIONS>DATALOG.**
2. Highlight **SELECT INPUTS** using the **UP** and **DOWN** arrow soft keys and then press **SELECT**.

Note: *If logging is enabled on any channel, that channel will have an arrow in front of the channel name to signify that the channel is logged.*

3. Highlight Rainfall using the **UP** and **DOWN** soft keys, then press **SELECT**.
4. Press **CHANGE CHOICE** to cycle between Logged and Not Logged, then press **ACCEPT**.
5. Enter a logging interval using the numeric keypad, then press **ACCEPT**. Valid logging intervals are shown on the status bar along the bottom edge of the display.
6. Select Rainfall Units (in. or cm). Press **ACCEPT** to continue.
7. Select another channel to configure, press **RETURN** to back up one step, or press the **MAIN MENU** function key to return to the Main Menu.

7.2 pH Probe

7.2.1 pH Probe Connection

Table 17 pH Connector Pin Assignments

Pin	Signal Description
A	+5 VDC
B	ground
C	reference
D	pH/ORP
E	5 VDC
F	-RTD

The pH probe consists of five wires, three for the pH probe and two for the temperature probe. Since the pH probe reading needs to compensate for temperature variation, there is a temperature probe built into every pH probe.

1. Attach the clear wire to either screw on the terminal strip labeled GLASS.
2. Attach the black wire on the shield of the cable to the REF screw on the other terminal strip.
3. Attach the red wire to the GND screw on the terminal strip.
4. Attach the green and yellow wires to the screws labeled RTD (Resistance Temperature Detector).

Note: *The green and yellow wires can be attached to either one of the RTD terminal screws because there is no polarity present.*

7.2.2 pH Probe Programming

1. From the Main Menu, select **OPTIONS>ADVANCED OPTIONS>DATALOG.**
2. Highlight Select Inputs using the **UP** and **DOWN** keys, then press **SELECT**.
3. Highlight pH using the **UP** and **DOWN** keys, then press **SELECT**.
4. Press **CHANGE CHOICE** to cycle between Logged and Not Logged, then press **ACCEPT**.
5. Enter a logging interval using the numeric keypad, then press **ACCEPT**. Valid logging intervals are shown on the status bar.
6. Select another channel to configure or press **RETURN** to back up one step. Press the **MAIN MENU** function key to return to the Main Menu.

7.2.3 pH Probe Calibration

Once the pH probe is connected and programmed, calibrate the pH probe. Calibrating the pH probe requires a thermometer and any two of the following buffer solutions: 4, 7, or 10 pH. The pH probe is an application sensitive device. When used in harsh environments, the accuracy and life expectancy of the probe decreases.

Calibrate the pH probe each time it is cleaned or replaced. Regular inspection and comparison to a hand-held pH meter can help determine the optimum cleaning and calibration schedule for your application.

1. From the Main Menu, select **OPTIONS > ADVANCED OPTIONS > CALIBRATION > pH.**
2. Place the pH probe into the first buffer solution. Press any key to continue.

3. Enter the temperature of the first buffer solution using the numeric keypad. Press **ACCEPT** to continue.
4. Press the **CHANGE CHOICE** to select the pH for the first buffer solution (4, 7, or 10 pH), then press **ACCEPT** to continue.
5. Remove the probe from the first buffer solution, rinse it under distilled water and place it into the second buffer solution (4, 7, or 10 pH, different from the first buffer used). Press any key to continue.
6. Press **CHANGE CHOICE** to select the pH for the second buffer solution, then press **ACCEPT** to continue.

A “pH Calibration Failed-Gain And/Or Offset Out of Range, Try Again” error message will be displayed if the pH probe is damaged, cannot be calibrated, or if the buffer solutions do not fall within an acceptable range.

Make an attempt at reading the second buffer solution after pressing a key. If this fails, it is likely that you have a poor pH probe or poor buffer solutions. Try a new set of buffer solutions. If that fails try a different pH probe.

7.3 ORP Probe

7.3.1 ORP Probe Connection

Table 18 ORP Connector Pin Assignments

Pin	Signal Description
A	+5 VDC
B	ground
C	reference
D	pH/ORP
E	-5 VDC
F	RTD

Note: *There is no temperature sensor on the ORP sensor.*

The ORP probe consists of three wires: a clear wire, a black wire, and a red wire. The pre-amp required interface is a 6-pin connector on one end and a junction box with terminal strips on the other end (P/N 2078).

1. Attach the clear wire to either screw on the terminal strip labeled GLASS.
2. Attach the black wire to the REF screw on the other terminal strip.
3. Attach the red wire to the GND screw on the terminal strip.

7.3.2 ORP Programming

1. From the Main Menu, select **OPTIONS>ADVANCED OPTIONS>DATALOG.**
2. Highlight Select Inputs using the **UP** and **DOWN** soft keys and then press **SELECT** to continue.
3. Highlight ORP using the **UP** and **DOWN** soft keys, then press **SELECT** to continue.
4. Press **CHANGE CHOICE** to cycle between Logged and Not Logged, then press **ACCEPT** to continue.
5. Enter a logging interval using the numeric keypad, then press **ACCEPT**. Valid logging intervals are shown on the status bar along the bottom edge of the display.

6. Select another channel to configure or press **RETURN** to back up one step. Press the **MAIN MENU** function key to return to the Main Menu.

7.3.3 ORP Preamplifier/Junction Box Calibration

Calibration of the ORP input circuit requires a source of DC voltage between 500 and 2000 m VDC. The reference voltage must be applied to the ORP input terminals on the preamplifier/junction box during calibration. A regulated DC power supply or a standard "C" cell battery (1500 mVDC) make excellent sources for reference voltage.

1. From the Main Menu, select **OPTIONS > ADVANCED OPTIONS > CALIBRATION > ORP.**
2. Install the ORP junction box on the flow meter with the ORP probe removed.
3. Apply a positive reference voltage to the ORP probe terminals in the junction box, using either a 1.5 VDC "C" cell battery or a regulated power supply.
4. Attach the positive battery terminal to the terminal block screw labeled "glass" and the negative battery terminal to the terminal block screw labeled "ref".

7.4 Dissolved Oxygen Probe

The DO/Conductivity option is available with or without additional analog inputs. See Analog Communications on page 68 for wiring and configuration.

7.4.1 Dissolved Oxygen Probe Connection

The pre-amp (P/N 3369 or 3212) is required. Plug the probe into the pre-amp and plug the pre-amp into the 950 flow meter.

Table 19 Dissolved Oxygen Connector Pin Assignments

Pin	Signal Description	Wire Color
A	+12 VDC	white
B	signal ground	blue
C	input 1 (4–20 mA DC)	yellow
D	input 2 (4–20 mA DC	black
E	input 3 (4–20 mA DC)	red
F	dissolved oxygen (+)	green
G	dissolved oxygen temp. probe(+)	gray
H	conductivity (+)	brown
J	conductivity temp. probe	purple
K	not used	orange

7.4.2 Dissolved Oxygen Probe Programming

1. From the Main Menu, select **OPTIONS>ADVANCED OPTIONS>DATALOG**.
2. Highlight Select Inputs using the **UP** and **DOWN** soft keys and then press **SELECT**.
3. Highlight D.O. using the **UP** and **DOWN** soft keys, then press **SELECT**.
4. Press **CHANGE CHOICE** to cycle between Logged and Not Logged, then press **ACCEPT**.
5. Enter a logging interval using the numeric keypad, then press **ACCEPT**. Valid logging intervals are shown on the status bar along the bottom edge of the display.
6. Press **CHANGE CHOICE** to select the appropriate units (ppm, ppb, mg/L, sat). Press **ACCEPT** to continue.

7. Select another channel to configure or press **RETURN** to back up one step. Press the **MAIN MENU** function key to return to the Main Menu.

7.4.3 Dissolved Oxygen Probe Temperature Programming

1. From the Main Menu, select **OPTIONS>ADVANCED OPTIONS>DATALOG**.
2. Highlight Select Inputs using the **UP** and **DOWN** soft keys, then press **SELECT**.
3. Highlight D.O. Temp. using the **UP** and **DOWN** soft keys, then press **SELECT**.
4. Press **CHANGE CHOICE** to cycle between Logged and Not Logged, then press **ACCEPT**.
5. Enter a logging interval using the numeric keypad, then press **ACCEPT**. Valid logging intervals are shown on the status bar along the bottom edge of the display.
6. Press **CHANGE CHOICE** to select the temperature units (°C, °F). Press **ACCEPT**.

7.4.4 Dissolved Oxygen Probe Calibration

Note: *The membrane of a charged sensor must be kept moist. If the membrane is allowed to dry completely, the electrolyte film between the membrane and the platinum will evaporate, destabilizing the sensor. If the sensor will be out of water for more than 30 minutes, put a small amount of water in the silicon soaking cap, and install it over the protective guard. Lift the edge of the cap to break the seal as it is being removed. This will prevent a vacuum from forming inside the soaking cap while it is being removed which can result in the membrane becoming stretched.*

1. Connect a suitable power supply to the flow meter.
2. Power up the unit by pressing the **ON** button.
3. From the Main Menu, select **OPTIONS > ADVANCED OPTIONS > CALIBRATION > DO.**
4. Enter the ambient air temperature (the current reading is displayed for reference) using the numeric keypad.
5. Enter the elevation above sea level for the specific location.
6. Enter the membrane thickness. The operation of the 950 Flow Meter will be affected by the choice of membrane thickness for the oxygen sensor.
7. For general purpose applications, the 1-Mil membrane is standard. This membrane allows measurements in the 0 to 20 ppm range of dissolved oxygen and provides the best general purpose trade-off between response time and durability.
8. The 2-Mil membrane can be used to measure up to 40 ppm of dissolved oxygen. Its increased thickness slows the response time of the sensor, but this membrane has increased resistance to cuts and tears. For this reason, it is recommended for use in wastewater aeration basins where solids in the water are in rapid motion.
9. Enter the chlorinity (salinity) of the flow stream (typical wastewater is zero, sea water is higher).
10. Place the D.O. probe in open air and press any key. The 950 Flow Meter will wait for the reading to stabilize before storing the calibration value. The screen will automatically return to the calibration menu.

Calibrating the D.O. Temperature

1. Place the probe and the thermometer in a liquid.
2. Wait for the temperature reading to stabilize, approximately 30 minutes.
3. Enter the actual temperature of the liquid.

7.5 Conductivity Probe

7.5.1 Conductivity Probe Connection

The pre-amp (P/N 3369 or 3212) is required. Plug the probe into the pre-amp and plug the pre-amp into the 950 Flow Meter.

Table 20 Conductivity Pin Assignments

Pin	Signal Description	Wire Color
A	+12 VDC	white
B	signal ground	blue
C	input 1 (4–20 mA DC)	yellow
D	input 2 (4–20 mA DC	black
E	input 3 (4–20 mA DC)	red
F	dissolved oxygen (+)	green
G	dissolved oxygen temp. probe (+)	gray
H	conductivity (+)	brown
J	conductivity temp. probe	purple
K	not used	orange

7.5.2 Conductivity Probe Programming

1. From the Main Menu, select **OPTIONS>ADVANCED OPTIONS>DATALOG.**
2. Highlight Select Inputs using the **UP** and **DOWN** soft keys and then press **SELECT**.
3. Highlight Conductivity (COND.) using the **UP** and **DOWN** soft keys, then press **SELECT**.
4. Press **CHANGE CHOICE** to cycle between Logged and Not Logged, then press **ACCEPT**.
5. Enter a logging interval using the numeric keypad, then press **ACCEPT**. Valid logging intervals are shown on the status bar along the bottom edge of the display.
6. Press **CHANGE CHOICE** to select the appropriate units (mS, uS). Press **ACCEPT** to continue.
7. Select another channel to configure or press **RETURN** to back up one step. Press the **MAIN MENU** function key to return to the Main Menu.

7.5.3 Conductivity Temperature Programming

Note: *Conductivity measurements are only temperature compensated if the conductivity temperature is enabled in the datalog.*

1. From the Main Menu, select **OPTIONS>ADVANCED OPTIONS>DATALOG.**
2. Highlight Select Inputs using the **UP** and **DOWN** soft keys and then press **SELECT**.
3. Highlight Conductivity Temperature (COND. TEMP.) using the **UP** and **DOWN** soft keys, then press **SELECT**.
4. Press **CHANGE CHOICE** to cycle between Logged and Not Logged, then press **ACCEPT**.
5. Enter a logging interval using the numeric keypad, then press **ACCEPT**. Valid logging intervals are shown on the status bar along the bottom edge of the display.

6. Press **CHANGE CHOICE** to select temperature units (°C, °F).
   Press **ACCEPT**.

7.5.4 Conductivity Probe Calibration

1. From the Main Menu, select **OPTIONS > ADVANCED OPTIONS > CALIBRATION > CONDUCTIVITY.**
2. Clean and dry the probe.
3. Place the sensor and thermometer in the calibration solution. The temperature sensor is located in the middle of the sensor body allowing the probe to be completely submerged in the solution.
4. Allow the sensor to stabilize in the solution about 10 minutes to ensure that the probe and the solution are the same temperature.
5. Enter the temperature correction factor or enter zero (0) for no correction factor.

Note: *The temperature correction factor is used to compensate for the effects of temperature on the conductivity readings at the point of installation. The conductivity of a solution is temperature sensitive. Therefore the actual conductivity of the solution will change with the temperature. Each site may have a different correction factor depending on the major constituent of the flow stream. This is not used for calibration and has no effect on the calibration of the sensor. Below are some examples of compensation factors of various liquids.*

- 0.96%/°C 5% Sulfuric Acid
- 1.88%/°C Dilute Ammonia
- 1.91%/°C 'Typical' Wastewater
- 1.97%/°C Potassium Chloride
- 2.12%/°C Salt (Sodium Chloride)
- 2.84%/°C 98% Sulfuric Acid
- 4.55%/°C Ultra-pure Water

6. With the sensor still in the calibration solution, press any key. Wait for the sensor to stabilize. Calculate the actual conductivity of the calibration solution. If using the KCl solution provided by the manufacturer, make your selection from Table 21 on page 60. If using a solution other than 1.0 mS @ 25 °C KCl available from the manufacturer, you must calculate the conductivity of the solution using temperature correction factors. See the example below.

Example:
The KCl calibration solution is 1.0 mS. at 25°C. The temperature correction factor for KCl is 1.97%/°C. If the actual temperature of the KCl at the time of calibration is 18.4 °C, then the solution has a conductivity value of 0.870 mS.

a. Find the difference between the labeled temperature and the actual temperature of the calibration solution at the time of calibration.

25 °C – 18.4 °C = 6.6 °C

b. Multiply the difference (6.6) by the correction factor per °C (1.97% or 0.0197).

6.6 °C x 0.0197/°C = 0.13002

c. If the calibration temperature is lower than the labeled value, then subtract that value from the standard (1.0 mS) to get the actual value to be used for calibration.

1.0 mS - (correction factor) 0.13002 = 0.86998 mS

d. If the calibration temperature is higher than the labeled value, then add that value to the standard (1.0 mS) to get the actual value to be used for calibration.

7. Using the value that was calculated in step 6, enter the conductivity of the solution then press **ACCEPT**. Conductivity calibration is complete.

Calibrating the Conductivity Temperature
This calibration is necessary **only** when logging temperature.

1. Place the probe in a liquid.
2. Wait for the temperature reading to stabilize, approximately 30 minutes.
3. Enter the actual temperature of the liquid (the current reading is shown for reference). Temperature calibration is complete.

Table 21 Conductivity Values at Temperature for KCl Solution

Solution Temp °C	Calibration Value to be Entered	Solution Temp °C	Calibration Value to be Entered	Solution Temp °C	Calibration Value to be Entered
30	1.099	25	1.000	20	0.902
29.8	1.095	24.8	0.996	19.8	0.898
29.6	1.091	24.6	0.992	19.6	0.894
29.4	1.087	24.4	0.988	19.4	0.890
29.2	1.083	24.2	0.984	19.2	0.886
29	1.079	24	0.980	19	0.882
28.8	1.075	23.8	0.976	18.8	0.878
28.6	1.071	23.6	0.972	18.6	0.874
28.4	1.067	23.4	0.968	18.4	0.870
28.2	1.063	23.2	0.965	18.2	0.866
28	1.059	23	0.961	18	0.862
27.8	1.055	22.8	0.957	17.8	0.858
27.6	1.051	22.6	0.953	17.6	0.854
27.4	1.047	22.4	0.949	17.4	0.850
27.2	1.043	22.2	0.945	17.2	0.846
27	1.039	22	0.941	17	0.842
26.8	1.035	21.8	0.937	16.8	0.838
26.6	1.032	21.6	0.933	16.6	0.835
26.4	1.028	21.4	0.929	16.4	0.831
26.2	1.024	21.2	0.925	16.2	0.827
26	1.020	21	0.921	16	0.823
25.8	1.016	20.8	0.917	15.8	0.819
25.6	1.012	20.6	0.913	15.6	0.815
25.4	1.008	20.4	0.909	15.4	0.811
25.2	1.004	20.2	0.905	15.2	0.807

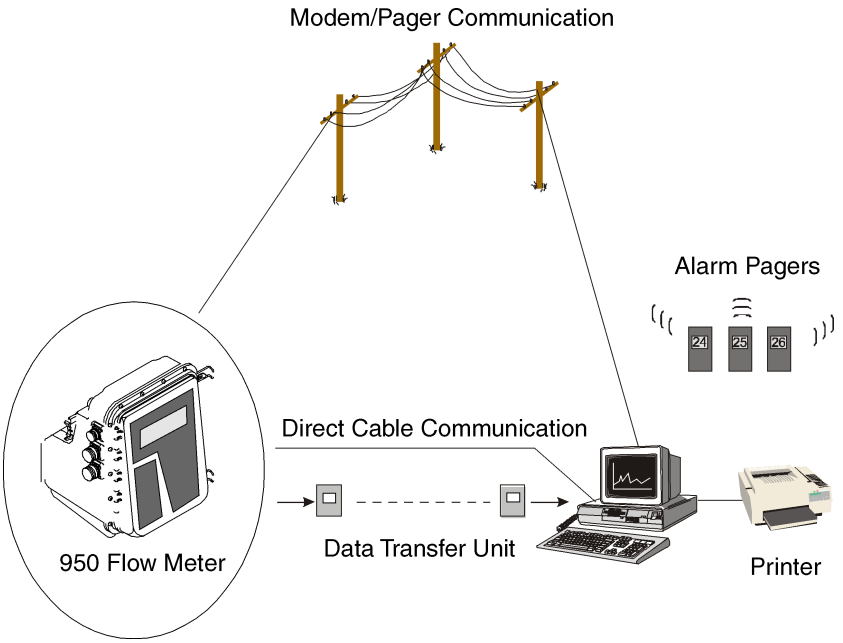
Important Note: *950 Flow Meter options described in this section of the manual may not be suitable for use with CE marked models of the 950 Flow Meter. See section 4.8 on page 27 for details on approved CE options.*

Data in the 950 Flow Meter can be transferred to a personal computer (PC) using data management software through a direct cable between the PC and meter, the cellular modem option, standard modem, or the portable Data Transfer Unit (DTU). See Figure 12.

The Data Transfer Unit (DTU) is a hand-held portable device that allows the user to connect to the flow meter using an RS232 serial cable. Data is transferred from one or more 950 Flow Meters into the DTU. After collecting data from one or more meters, the DTU can transfer the information to a PC running data management software. For detailed information, refer to the Data Transfer Unit Manual (Cat. No. 3516-89).

The 950 Flow Meter can also use Supervisory Control and Data Acquisition (SCADA) Modbus® communications protocol with the RS232 interface or Modem as described later in this section.

Figure 12 Communication Capabilities



8.1 RS232 Setup

8.1.1 RS232 Connections

Note: *All interface receptacles are covered with push-on caps. These caps are designed to protect the connector pins from dirt and moisture and should be attached to any receptacle not in use.*

The RS232 connector is a serial input/output port for communicating with the flow meter from an external device such as a DTU or direct serial connection to a PC running data management software. This serial interface can also be used for the SCADA-Modbus interface. (See Appendix E on page 117).

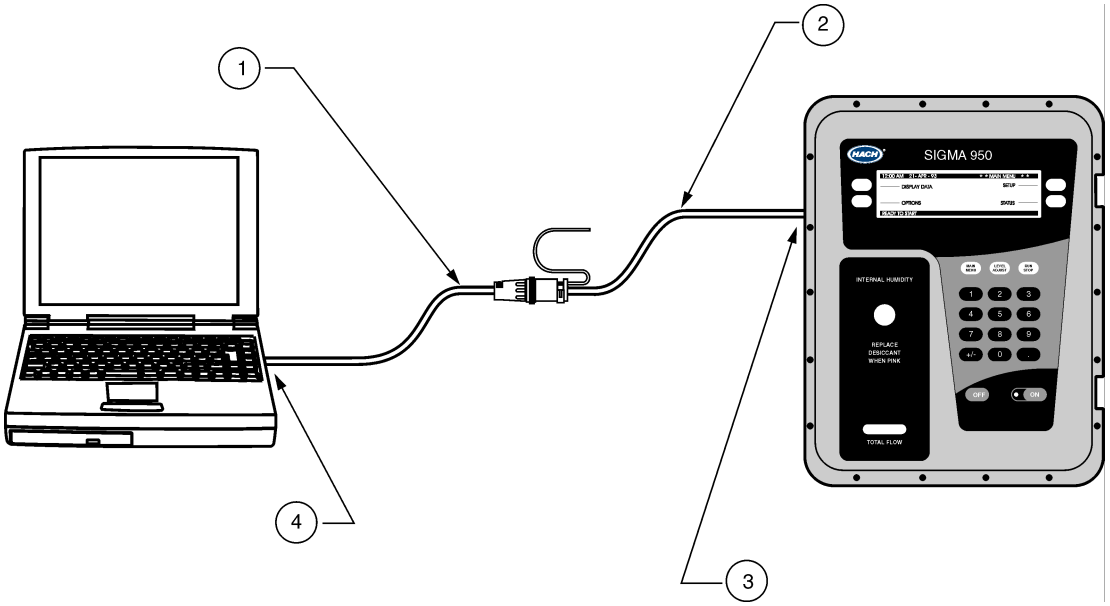
This port may be configured to communicate at 1200, 2400, 4800, 9600, or 19200 baud.

Cable Required
RS232 Flow Meter to PC Cable Assembly, 3.0 m (10 ft) long, 6-pin connector on one end, 9-pin D-type connector on the other end (P/N 1727) (9-pin to 25-pin D-type adapter included).

Table 22 RS232 Connector Pin Assignments

Pin	Signal Description	Wire Color
A	not used	white
B	ground	blue
C	DSR	yellow
D	RCD	black
E	DTR	red
F	TXD	green

Figure 13 PC to Flow Meter Cable Connection



1	Flow Meter to PC Cable (P/N 1727)	**3**	RS232 Connector
2	Extension Cable (optional) (P/N. 3358)	**4**	DB9 Serial COM Port

8.1.2 RS232 Programming

Note: *Long runs of RS232 cable, especially if they are run near large motors or fluorescent lights can cause communication errors and may require a slower baud rate.*

1. From the Main Menu, select **OPTIONS > ADVANCED OPTIONS > COMMUNICATIONS SETUP > RS232 SETUP**.
2. Press **CHANGE CHOICE** to select a baud rate for data communications; 1200, 2400, 4800, 9600 or 19200 baud.

The higher the baud rate setting, the faster data will transfer. Set the baud rate to the highest setting allowed by the computer. The baud rate must correspond to the baud rate selected in the software. Press **ACCEPT**.

8.2 Modem

8.2.1 Modem Connection

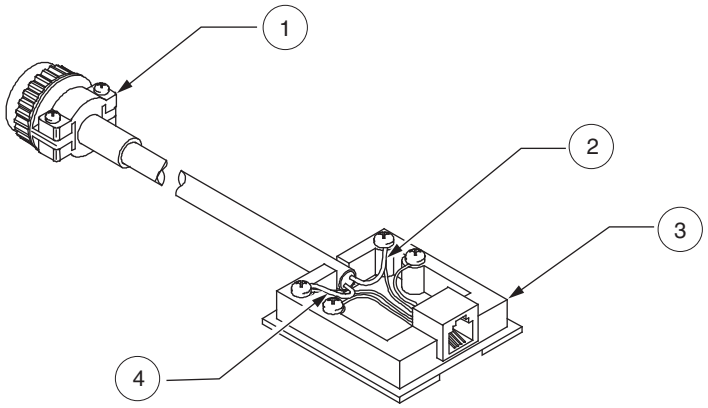
Use this connection with the optional internal modem (P/N 4578) and a standard dial-up public telephone line. This interface can also be used for the SCADA-Modbus interface. (See Appendix E on page 117).

Connect the telephone line to the meter with the Modem Line Filter Connector (P/N 4459 (2-pin connector)). The RJ11-style phone connector adapter (P/N 3188) can also be provided for modular connection if desired (Figure 14).

Table 23 Modem Connection Pin Assignments

Pin	Signal Description	Wire Color
A	tip	red
B	ring	green
C	12 VDC	N/A
D	12 VDC reference	N/A

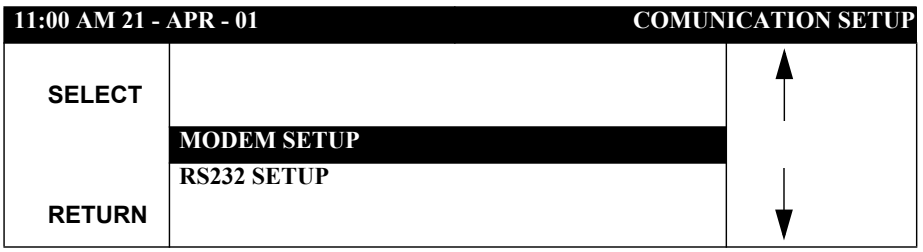
Figure 14 RJ11-Style Modular Connector Adaptor (With Cover Removed)



1	Modem Cable Assembly (P/N 2862)	**3**	RJ11-Style Adaptor (P/N 3188)
2	Red wire	**4**	Green wire

8.2.2 Modem Programming

1. From the Main Menu, select **OPTIONS>ADVANCED OPTION> COMMUNICATIONS SETUP**.
2. Highlight Modem Setup using the **UP** and **DOWN** soft keys. Press **ACCEPT**.



3. Enable modem power by pressing the **CHANGE CHOICE** soft key. Modem power is turned off when not in use to conserve battery power.

11:00 AM 21 - APR - 01		MODEM SETUP
ACCEPT		CHANGE CHOICE
	MODEM POWER: ENABLED	
CANCEL		
	CHOICES: ENABLED, DISABLED	

4. Select either pulse or tone dialing modes. This will depend on the type of phone service selected for the site phone line. Press **ACCEPT**.

11:00 AM 21 - APR - 01		MODEM SETUP
ACCEPT		CHANGE CHOICE
	DIAL METHOD: TONE	
CANCEL		
	CHOICES: TONE, PULSE	

5. Enter a phone number using the numeric keypad. This phone number is used by the modem when it sends an alarm report to a personal computer running Hach's data management software.

11:00 AM 21 - APR - 01		MODEM SETUP
ACCEPT		
	PHONE NUMBER: 555-5555	CLEAR ENTRY
CANCEL		
	(USE NUMERIC KEYPAD)	

8.2.3 Modem Options

8.2.3.1 Pager Option

The 950 Flow Meter can be setup to call up to 3 individual pagers or a remote computer when a given alarm condition has been met. As indicated in the upper right-hand corner of the display menu which follows, the pager setup is an extension of the Modem Setup menus (see above). To have the 950 Flow Meter call a pager, the Pager Option must be enabled.

Pager reporting uses the industry standard Telelocator Alphanumeric Protocol (TAP) to deliver information to a maximum of three alphanumeric pagers. The logger dials your paging service provider and passes the alarm code, site ID and a maximum of three pager phone numbers to the service provider automatically. The pager service then sends the alarm information to all enabled pagers.

When contracting with your local pager service provider you must inform them that the 950 Flow Meter conforms to the TAP standard. With this information they will be able to configure their equipment to work with the meter.

1. Press **CHANGE CHOICE** to enable the Pager Option. Press the **ACCEPT**.

11:00 AM 21 - APR - 01		MODEM SETUP
ACCEPT		CHANGE CHOICE
	PAGER OPTION: ENABLED	
CANCEL		
	CHOICES: ENABLED, DISABLED	

2. Enter the phone number of the paging service. If this number is unknown it can usually be obtained by contacting the pager service's technical support department. Press **ACCEPT**.

11:00 AM 21 - APR - 01		MODEM SETUP
ACCEPT	PAGER SERVICE PHONE NUMBER:	
	555-5555	CLEAR ENTRY
CANCEL		
	(USE NUMERIC KEYPAD)	

3. Enter the number of pagers to call when an alarm occurs. The 950 Flow Meter will support up to 3 pagers. Press **ACCEPT**.

11:00 AM 21 - APR - 01		MODEM SETUP
ACCEPT		
	NUMBER OF PAGERS: 3	CLEAR ENTRY
CANCEL		
	ENTER 1 - 3	

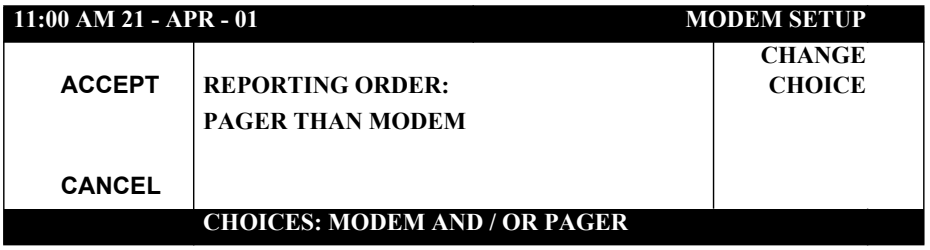
4. Enter the phone numbers of the individual pagers that the message will be sent to. These numbers are usually provided when the pager is purchased. Press **ACCEPT**.

11:00 AM 21 - APR - 01		MODEM SETUP
ACCEPT	PAGER #1 PHONE NUMBER:	CHANGE CHOICE
	555-5555	
CANCEL		
	CHOICES: ENABLED, DISABLED	

8.2.3.2 Reporting Devices

You have the choice of which communication devices will report and in what order. Choices are **MODEM ONLY, PAGER ONLY, PAGER THEN MODEM, and MODEM THEN PAGER**.

1. Press **CHANGE CHOICE** until the desired reporting method is displayed, then press **ACCEPT**.



2. When the 950 Flow Meter calls the pager service, it will transmit a Pager Alarm Code number (see Table 24) which corresponds to a specific alarm condition.

Table 24 Pager Alarm Codes

Alarm	Code #	Reason
Low Main Battery	1	Battery pack is less than 11.5 V
Memory Battery	2	Internal memory battery is low
Low Slate Memory	3	Less than 10% slate memory left
Slate Memory Full	4	Slate memory is used up
—	6	Reserved for Sampler
—	7	Reserved for Sampler
—	8	Reserved for Sampler
—	9	Reserved for Sampler
Low Main Battery	1	Battery pack is less than 11.5 V
U-Sonic Echo Loss	10	No return signal detected
Xducer Ringing	11	The return signal is detected too soon
U-Sonic failure	12	Ultrasonic board detects an error
RS485 Timed Out	13	Comm. problems with RS485
—	14	Reserved for Sampler
—	15	Reserved for Sampler
Low Bubbler Pres.	16	Possible leak in bubble tank
Clogged Bubbler	17	Bubbler tube is plugged
High Level	18	—
High Flow	19	—
High Flow Rate of Chg.	20	—
High pH/ORP	21	—
High Process Temperature	22	—
High Rainfall	23	—
High CH1	24	—
High CH2	25	—
High CH3	26	—
High CH4	27	—
High CH5	28	—
High CH6	29	—
High CH7	30	—

Table 24 Pager Alarm Codes (continued)

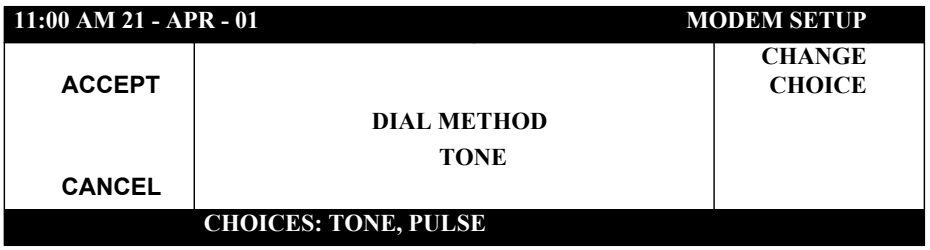
Alarm	Code #	Reason
High Reference Temperature	31	—
High Velocity	32	—
High D.O.	33	—
High D.O. Temp.	34	—
High Conductivity	35	—
High Conductivity Temp.	36	—
Low Level	37	—
Low Flow	38	—
Low pH/ORP	39	—
Low Process Temp.	40	—
Low CH1	41	—
Low CH2	42	—
Low CH3	43	—
Low CH4	44	—
Low CH5	45	—
Low CH6	46	—
Low CH7	47	—
Low Reference Temp.	48	—
Low Velocity	49	—
Low D.O.	50	—
Low D.O. Temp.	51	—
Low Conductivity	52	—
Low Cond. Temp.	53	—

8.2.3.3 Entering the Phone Number of the Remote Computer

If the pager option is disabled, the 950 Flow Meter can be configured to call a remote computer when an alarm condition has been met. Enter the phone number of the remote computer to be called when the alarm condition is met. This same phone number will be used for all other alarms. If the phone number is long distance be sure to enter a “1” and the area code as well. After entering the phone number press **ACCEPT**.

8.2.3.4 Choosing the Dial Method (Tone or Pulse)

Press the **CHANGE CHOICE** soft key until the correct dial method (pulse/tone) appears in the center of the display. Press the **ACCEPT** soft key to continue.



8.3 Analog Communications

Channels 1 through 7 are analog input channels that can accept a signal from an external device. This signal may range from -4 VDC (min.) to +4 VDC (max.) or from 0 to 20 mA DC depending on the input selected. In some cases, input signals from certain devices may also fall somewhere within those ranges. For that reason, each analog input channel must be mapped to the minimum and maximum signal limits of the external device.

8.3.1 4–20 mA Output

8.3.1.1 4–20 mA Connections

Note: *Due to the power demand of current loops, this option requires that an ac power supply be installed on the flow meter. Battery power is not sufficient to support the 4–20 mA current loop power requirements.*

The 4–20 mA option is available as one or two current-loop interfaces for controlling external devices such as a chlorinator or a chart recorder. Either one or both of the 4–20 mA outputs can be factory installed and are isolated from each other.

Isolation Voltage Rating
Note: *950 flow meters are available with one or two 4–20 mA outputs. Both outputs are installed in one receptacle.*

- Between flow meter and either 4–20 mA output: 2500 V ac
- Between the two 4–20 mA outputs: 1500 V ac
- Maximum Resistive Load: 600 ohms
- Output Voltage: 24 VDC, no load

Table 25 4–20 mA Connector Pin Assignments

Pin	Signal Description	Wire Color
A	output A + (pos)	yellow
B	output A - (neg)	black
C	output B + (pos)	red
D	output B - (neg)	green

Cable Required:
4–20 mA Output Cable Assembly, 7.6 m (25 ft), 4-pin connector on one end, tinned wire leads on the other end (P/N 2924).

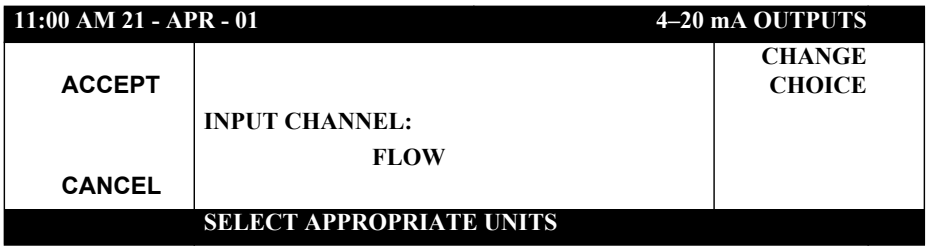
8.3.1.2 Programming the 4–20 mA Output

The dual isolated 4–20 mA current loop outputs on the 950 Flow Meter are unique, they can be assigned to any of the available channels, not just flow. In addition, the 4 mA and 20 mA current levels are programmed to any desired minimum and maximum value for that channel.

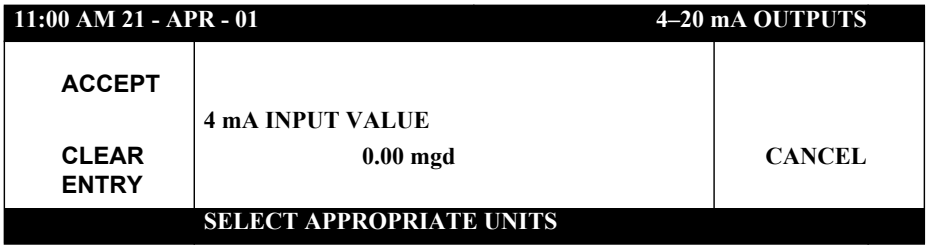
1. From the Main Menu, select **OPTIONS > ADVANCED OPTIONS > 4–20 mA OUTPUTS > SELECT**.
2. When the 4–20 mA outputs are disabled and the 950 is not completely turned off, they will continue to output a steady 4 mA.
3. Press **CHANGE CHOICE** to enable the 4–20 mA outputs. Press **ACCEPT**.

4. Choose **OUTPUT A** or **OUTPUT B** and press **SELECT.**

5. Select an Input Channel (channel 1, 2, 3, flow, etc.) to assign to that output. Press **CHANGE CHOICE** to cycle through the channel names. When the desired channel is displayed, press **ACCEPT**.



6. Assign a channel value to the 4 mA current value. This value is typically 0, however any value can be set. In other words, enter the value of the input needed to generate 4 mA of current at the output.



7. Assign an input value to the 20 mA current level.
8. Repeat this process to configure the other 4–20 mA output.

8.3.1.3 Calibrating the 4–20 mA Output

After wiring the 4–20 mA connection, perform a 4–20 mA output calibration. The 4–20 mA output calibration requires a multimeter and an interface or access to the 4–20 mA current loop wiring. Two 4–20 mA outputs are available and are designated Output A and Output B. Both outputs are calibrated the same way and are isolated from each other.

Calibration may be performed while the 4–20 mA device is in the current loop, as shown in Figure 15 or disconnected from the current loop as shown in Figure 16. In either case, the multimeter must be set to a 20 milliamp DC range or greater.

1. From the Main Menu, select **OPTIONS > ADVANCED OPTIONS > CALIBRATION > 4–20 mA OUTPUTS.**
2. Connect a multimeter to the 4–20 mA current outputs per Figure 15 or Figure 16.
3. Make sure that the 4–20 mA output is enabled. If it is not enabled, press **CHANGE CHOICE** so that the display shows Enabled and press **ACCEPT**.
4. Select the output (A or B) to calibrate.

5. Press any key to set the selected output to 4.00 mA DC.
6. Measure the current on the selected output using the multimeter and enter the measured value using the numeric keypad. Press **ACCEPT**.
7. Press any key to set the output to 20.00 mA DC.
8. Measure the current on the selected output using the multimeter and enter the measured value using the numeric keypad. Press **ACCEPT** to complete the calibration.

By entering the measured current values, the microprocessor will electronically adjust the outputs to compensate for the difference between the measured values and the expected values.

Figure 15 Calibration with the Meter in the Loop

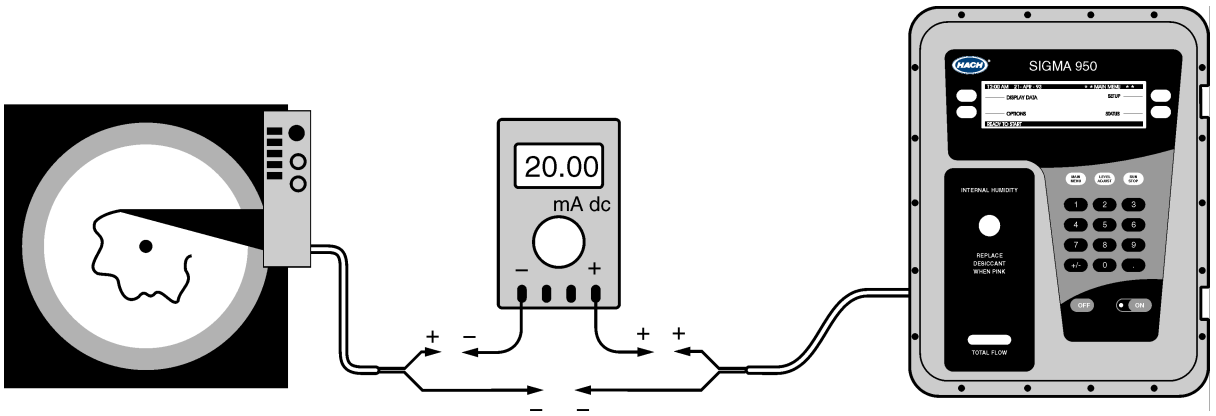
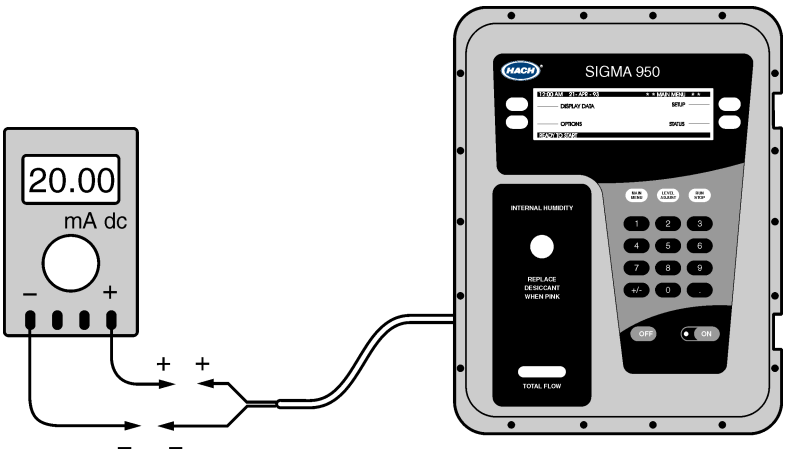


Figure 16 Calibration with the 4–20 mA Device Disconnected from the Loop



8.3.2 Analog Inputs

8.3.2.1 Analog Voltage Inputs

Note: Note: *4–20 mA inputs must be isolated. Maximum load per input is 200 ohms.*

There are a total of seven analog input channels available on the 950 Flow Meter. These inputs accept 0–20 mA DC or -4 to +4 VDC analog signals. They can be logged and graphed in the same manner as the five dedicated channels (level, flow, rainfall, etc.) and

can also be used to trigger alarms, cause set point samples, and control 0–20 mA outputs.

Table 26 Analog Input Pin Assignments[1]

Pin	Signal Description	Description	Wire Color
A	12 VDC	Provides a source of +12 VDC which may be used to power external analog devices	white
B	ground	Used in conjunction with any or all the input signals on Pins C–J.	blue
C	input 1 (0–20 mA DC)	0–20 mA DC inputs for Channels 1 through 3.	yellow
D	input 2 (0–20 mA DC)		black
E	input 3 (0–20 mA DC)		red
F	input 4 (-4 to +4 VDC)	-4 to +4 VDC inputs for Channels 4-7	green
G	input 5 (-4 to +4 VDC)		gray
H	input 6 (-4 to +4 VDC)		brown
J	input 7 (-4 to +4 VDC)		purple
K	not used	N/A	orange

[1] If the DO/Conductivity options was purchased, only three additional inputs are available (Pins C, D, and E).

Cable Required
Analog Input Cable Assembly, 25 ft (7.6 m), 10-pin connector on one end, tinned wire leads on the other end (P/N 2706).

8.3.2.2 Analog Voltage Inputs Programming

To map an external device to an analog input channel:

Select an analog input channel (1, 2, and 3 are current inputs and 4 through 7 are voltage inputs).

1. Select **DATA LOG** from the Advanced Options menu.
2. Highlight **SELECT INPUTS** using the **UP** and **DOWN** keys. Press **SELECT**.

Note: *A channel with logging enabled will have an arrow in front of it to signify that the channel is logged.*

3. Highlight the analog channel to log using the **UP** and **DOWN** keys, then press **SELECT**.
4. Press **CHANGE CHOICE** to cycle between “Logged” and “Not Logged”, then press **ACCEPT**.
5. Enter a Logging Interval.
6. Select Unit of measurement (ppm, ppb, afd, cfs, cfm, cfd, cms, cmm, cmh, cmd, gps, gpm, gph, lps, lpm, lph, or mgd).
7. Enter Low Point.
8. Apply minimum current output (4 mA) from other instrument.
9. Enter High Point.
10. Apply maximum current output (20 mA) from the other instrument.

11. Select another channel to configure, or press **RETURN** to back up one step. Press the **MAIN MENU** function key to return to the Main Menu.

Example: A dissolved oxygen meter has an analog output signal that will connect to the 950 Flow Meter analog input channel 4. The DO meter puts out an analog signal which ranges from +1 VDC to +3 VDC, which is equivalent to 0 to 500 ppm. The DO meter is connected to Channel 1 and log readings from the DO meter occur once per minute.

To configure data logging for this example, follow the steps below.

1. Select **DATA LOG** from the Advanced Options menu.
2. Highlight **SELECT INPUTS** using the **UP** and **DOWN** soft keys and then press **SELECT**.
3. Highlight the analog channel to log (Channel 4) using the **UP** and **DOWN** soft keys, then press **SELECT**.
4. Press **CHANGE CHOICE** to select “Logged,” then press **ACCEPT**.
5. Enter a 1-minute logging interval using the numeric keypad, then press **ACCEPT**.
6. Press **CHANGE CHOICE** to cycle through the units of measure until ppm is displayed. Press **ACCEPT**.
7. Apply a voltage to the desired analog input which corresponds to 0 ppm (or +1 VDC). Enter 0 ppm using the numeric keypad and press **ACCEPT**.
8. Apply a voltage to the same analog input that corresponds to 500 ppm or +3 V dc. Enter 500 ppm using the numeric keypad and then press **ACCEPT** to complete the analog channel setup.

8.4 Alarm Relays

8.4.1 Alarm Relay Connections

Note: *One cable is required for each set of two installed relays.*

Up to four optional alarm relay outputs are available as factory installed options. Two relays can be added at a time and each set of two relays share a single interface connector.

Table 27 Relay 1 & 2 Connector Pin Assignments

Pin	Signal Description	Wire Color
A	relay #1 N.O. (normally open)	green
B	relay #1 common	black
C	relay #1 N.C. (normally closed)	white
D	relay #2 N.O. (normally open)	green
E	relay #2 common	black
F	relay #2 N.C. (normally closed)	white

Table 28 Relay 3 & 4 Connector Pin Assignments

Pin	Signal Description	Wire Color
A	relay #3 N.O. (normally open)	green
B	relay #3 common	black
C	relay #3 N.C. (normally closed)	white
D	relay #4 N.O. (normally open)	green

Table 28 Relay 3 & 4 Connector Pin Assignments

Pin	Signal Description	Wire Color
E	relay #4 common	black
F	relay #4 N.C. (normally closed)	white

Rating
Form C relays are rated for 10 amps at 120 V ac or 5 amps at 240 V ac resistive load min. Normally open and normally closed contacts are available.

Cable Required
Alarm Relay Cable Assembly, 25 ft (7.6 m), 6-pin connector on one end, tinned wire leads on the other end (P/N 2705).

8.4.2 Alarm Relays Programming

Alarms can be programmed to activate based on certain conditions (low battery, low memory, etc.). Refer to 950 Flow Meter Advanced Options on page 87. When an alarm is tripped, an action is initiated (report via modem, dial a pager, or set a relay). Two types of alarms are trouble and set point alarms.

8.4.2.1 Trouble Alarms

Trouble Alarms initiate an action when a trouble condition occurs. For example, a relay may close when the memory is full.

1. From the Main Menu, select **SETUP > ADVANCED OPTIONS > ALARMS.**
2. Enable one of the trouble conditions.
3. Select an action to occur when the alarm is activated. Table 29 shows each Trouble Condition and its cause.

Table 29 Trouble Alarms

Trouble Condition	Cause
Low Memory Battery	Internal memory battery voltage is too low. Change batteries.
Low Slate Memory	Free slate memory is less than 20%
Low Bubbler Pressure	Bubbler system not developing sufficient air pressure. (Inspect air pump, reservoir, and associated tubing assemblies for problem.)
Clogged Bubbler	Bubbler line obstructed or submerged below ten feet.
U-Sonic Echo Loss (A pulse of sound was sent but no echo was received back)	The echo has been temporarily deflected by a change in site conditions such as floating debris or foam in the channel, wind, etc.
Transducer Ringing	Transducer is operating within the deadband.
U-Sonic Failure	Transducer not plugged in. Cable damaged. Transducer thermal sensor damaged.
RS485 Timed Out	Problem with communications between the flow meter and a remote ultrasonic sensor. May indicate open thermal sensor.
Alarm Action(s):	
Set Relay #1	
Set Relay #2	
Set Relay #3	
Set Relay #4	
Report via Modem	

8.4.2.2 Set Point Alarms

Set Point Alarms activate when a user-definable high and/or low set point is reached. Set Point Alarms look for trip points to be reached before initiating an action.

Note: *The rate of change alarm can be used with any primary device except when the primary device is defined as area-velocity.*

4. Enable one of the alarm conditions (level, flow rate of change, rainfall, DO/Conductivity, Flow, pH, or Analog Channels 1–7).
5. Select an action to occur when the alarm is activated.
6. Set either a High trip point or a Low trip point.
7. Enter the deadband value. The deadband is the area between the alarm “turn on” and “turn off”. Refer to Setting the Deadband on page 98.

DANGER
Some of the following manual sections contain information in the form of warnings, cautions and notes that require special attention. Read and follow these instructions carefully to avoid personal injury and damage to the instrument. Only personnel qualified to do so, should conduct the maintenance tasks described in this portion of the manual.

DANGER
Certains des chapitres suivants de ce mode d'emploi contiennent des informations sous la forme d'avertissements, messages de prudence et notes qui demandent une attention particulière. Lire et suivre ces instructions attentivement pour éviter les risques de blessures des personnes et de détérioration de l'appareil. Les tâches d'entretien décrites dans cette partie du mode d'emploi doivent être seulement effectuées par le personnel qualifié pour le faire.

PELIGRO
Algunos de los capítulos del manual que presentamos contienen información muy importante en forma de alertas, notas y precauciones a tomar. Lea y siga cuidadosamente estas instrucciones a fin de evitar accidentes personales y daños al instrumento. Las tareas de mantenimiento descritas en la presente sección deberán ser efectuadas únicamente por personas debidamente cualificadas.

GEFAHR
Einige der folgenden Abschnitte dieses Handbuchs enthalten Informationen in Form von Warnungen, Vorsichtsmaßnahmen oder Anmerkungen, die besonders beachtet werden müssen. Lesen und befolgen Sie diese Instruktionen aufmerksam, um Verletzungen von Personen oder Schäden am Gerät zu vermeiden. In diesem Abschnitt beschriebene Wartungsaufgaben dürfen nur von qualifiziertem Personal durchgeführt werden.

PERICOLO
Alcune parti di questo manuale contengono informazioni sotto forma d'avvertimenti, di precauzioni e di osservazioni le quali richiedono una particolare attenzione. La preghiamo di leggere attentivamente e di rispettare quelle istruzioni per evitare ogni ferita corporale e danneggiamento della macchina. Solo gli operatori qualificati per l'uso di questa macchina sono autorizzati ad effettuare le operazioni d'istallazione e di manutenzione descritte in questa parte del manuale.

This chapter explains how to maintain, repair, and upgrade the Sigma 950 Flow Meter. It describes how to open the case, inspect and replace fuses, replace desiccant, and perform operating system software upgrades.

9.1 Routine Maintenance

Routine maintenance of the 950 Flow Meter consists of calibrating input channels and cleaning the case.

9.1.1 Calibration

Calibration should be performed on all channels at the proper interval for that type of input.

9.1.2 Cleaning the Case

Clean the outside of the case with a damp cloth and mild detergent. Use a non-abrasive plastic cleanser on the front cover if necessary. Avoid harsh chemicals or solvents because they may harm the case or fog the front cover.

9.1.3 Maintaining Desiccant Cartridges and Desiccant

The desiccant cartridges are located on the right side of the case on bubbler units and are connected to the reference and intake ports. They keep the air that is used by the bubbler system dry. The desiccant material in the tubes remove moisture from the air. Eventually the desiccant becomes saturated and needs to be replaced. The desiccant material contains tiny blue beads that will turn pink when saturated. When the beads turn pink, either replace the dryer tubes (P/N 5027), replace the desiccant (P/N 3624), and membrane (P/N 3390) or rejuvenate the desiccant as described in section 9.1.3.2.

Moisture in the reference port and intake lines can damage the mechanical components of the bubbler system. Maintaining the desiccant in both dryer tubes will greatly prolong the life of the bubbler system in the 950 Flow Meter.

9.1.3.1 Replacing the Desiccant

1. Remove the desiccant cartridges by pulling them out of their clips.
2. Remove the end caps and dump out the old desiccant.
3. Replace the white hydrophobic filter membrane (P/N 3390) in each end cap. The dull side of the membrane must face into the incoming air flow.
4. Pour new desiccant into the tubes and replace the end caps.
5. Snap both dryer tubes back into their clips.

9.1.3.2 Rejuvenating the Desiccant

Remove the beads from the cartridge and heat in an oven at 100 to 180 °C (212 to 350 °F), until the beads turn blue again. If the beads do not turn blue, replace them with new desiccant.

9.1.3.3 Maintaining the Hydrophobic Membrane

When checking or changing the desiccant in the external desiccant cartridge, check the white hydrophobic filter membrane in the ends of the desiccant cartridges and replace as necessary. These membranes keep liquid out of the cartridge while still allowing air into the cartridge. If the membrane becomes plugged, the flow meter will not read accurately and may display error messages. Each cartridge contains one membrane. The membrane is located in the threaded fitting at the top of the cartridge. If these membranes are any other color then white, replace the membrane.

9.2 Upgrades, Repairs, General Maintenance

Only a qualified technician should service the 950 Flow Meter. For example, steps that require knowledge of CMOS electrostatic discharge precautions and advanced electronics training should be performed only by a qualified technician. If you need assistance in performing any of the following service steps, please contact the manufacturer.

Electrostatic Discharge (ESD) Considerations

To minimize hazards and ESD risks, maintenance procedures not requiring power to the analyzer should be performed with power removed.

Delicate internal electronic components can be damaged by static electricity, resulting in degraded instrument performance or eventual failure.

The manufacturer recommends taking the following steps to prevent ESD damage to your instrument:

- Before touching any instrument electronic components (such as printed circuit cards and the components on them) discharge static electricity from your body. This can be

accomplished by touching an earth-grounded metal surface such as the chassis of an instrument, or a metal conduit or pipe.

- To reduce static build-up, avoid excessive movement. Transport static-sensitive components in anti-static containers or packaging.
- To discharge static electricity from your body and keep it discharged, wear a wrist strap connected by a wire to earth ground.

Handle all static-sensitive components in a static-safe area. If possible, use anti-static floor pads and work bench pads.

9.2.1 Internal Maintenance Items

The following items require access to the inside of the case for service:

- Fuses for the 12 VDC input, as well as the RS485 and sampler and analog interface connectors (if so equipped)
- Internal desiccant module
- RAM memory batteries
- Bubbler Module
- System upgrades or enhancements (4–20 mA, modem, alarm relays, etc.)
- Circuit board repair

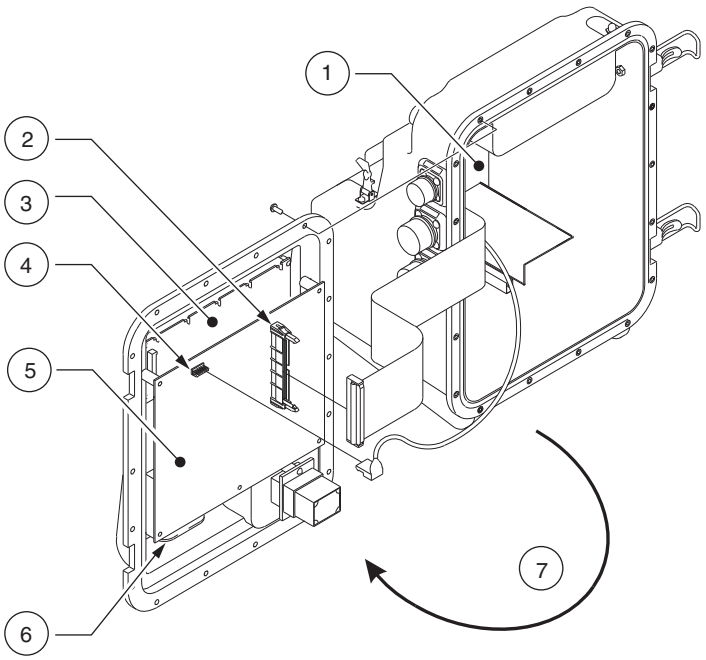
9.2.2 Removing the Front Panel

Always disconnect the power cable and all other cables from the 950 Flow Meter before removing the front panel.

1. Disconnect and remove the power supply and all cables.
2. Remove the 18 screws from around the perimeter of the case.
3. Carefully pull open the front panel in the same direction as you would to open the front cover. Be sure to let the attached connectors (J4 and J6) swing out of the way (see Figure 17).

Note: *The front panel gasket has a light coating of grease to help assure a water tight seal. Do not to contaminate the grease or gasket area during servicing. Always replace the gasket if it is damaged or missing. Never reassemble the case without the gasket properly installed.*

Figure 17 950 Flow Meter Inside View



1	Base Board	**3**	LCD Board	**5**	CPU Board	**7**	Opening the Front Cover
2	J4 Connector	**4**	J6 Connector	**6**	Memory Batteries		

9.2.3 Re-Installing the Front Panel

Always follow the procedure below when re-installing the front panel. Improper front panel installation may result in damage to the instrument.

1. Hand tighten the screws in the sequence shown in Figure 18 on page 79 until the head of each screw makes contact with the front panel.
2. Tighten screws in sequence shown in Figure 18 on page 79 to 5 in.-lb (0.565 Newton-meter).
3. Repeat the tightening procedure in the same sequence to 10 in.-lb (1.125 Newton-meters).

Figure 18 Screw-Tightening Sequence

9.3 Circuit Board Identification

Note: *Removal and handling of the circuit boards used in the 950 Flow Meter requires knowledge of ESD (Electrostatic Discharge) precautions and the CMOS circuit components used in the meter. Static electricity can damage the CMOS components of the meter when the boards are unplugged and removed from the case. Precautions must be taken to assure a static-free work area prior to handling the circuit boards.*

The 950 Flow Meter contains two main circuit boards: the Base Board and the CPU Board. The CPU board is located on the front panel assembly and the Base Board is located inside the back section of the case.

In addition, a liquid crystal display (LCD) circuit board is located behind the CPU board. The LCD board is an integral part of the LCD screen and contains no user serviceable components (see Figure 17).

9.4 Fuse and Connector Locations

Four fuses are provided to protect the 950 Flow Meter electronics from damage due to short circuits or excessive current draw. Three fuses are located on the Base Board (Figure 19) and one fuse is located on the CPU Board (Figure 20). Table 30 through Table 33 list the functions associated with the connectors and the fuses and their ratings for both circuit boards.

Figure 19 Base Board

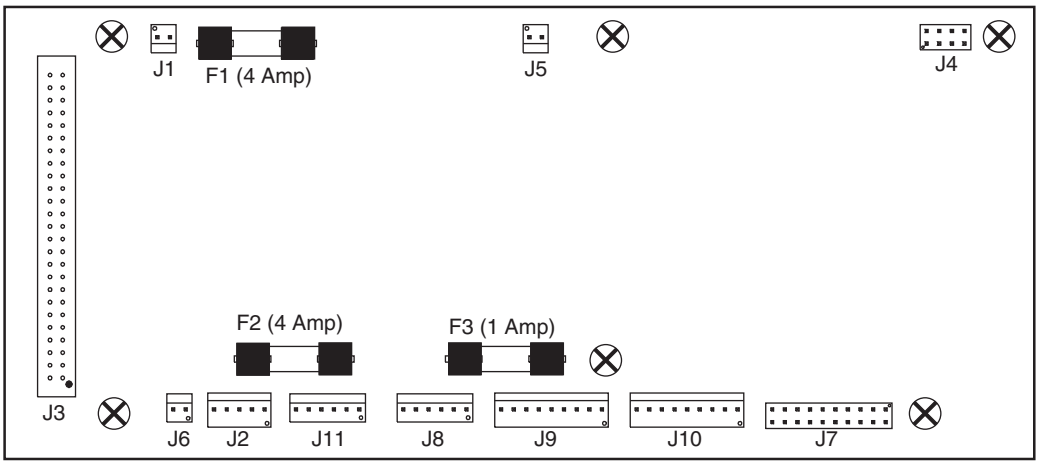


Table 30 Base Board Fuses

ID	Description	Type & Rating
F1	+12 VDC Interface Connector Main power input to meter Pin A (ground), Pin B (+12 VDC)	4 Amp, 125 V ac Slow-blow 5 x 20 mm (P/N 2604)
F2	+12 VDC Sampler interface connector Pin A (+12 VDC), Pin B (ground)	4 Amp, 125 V ac Slow-blow 5 x 20 mm (P/N 2604)
F3	Analog Input Option Interface connector (if so equipped) Pin A (+12 VDC), Pin B (ground)	1 Amp, 250 V ac Fast-blow 5 x 20 mm (P/N 2536)

Table 31 Base Board Connectors

ID	Description
J1	+12 VDC - Main Power Input
J2	Relay Option
J3	CPU Circuit Board
J4	4–20 mA Output Option
J5	Display push-button
J6	Rain Gauge Option
J7	Bubbler Assembly
J8	pH/ORP Option
J9	Submerged Pressure Sensor
J10	Analog Input Option
J11	Sampler Interface Connector

Figure 20 CPU Board

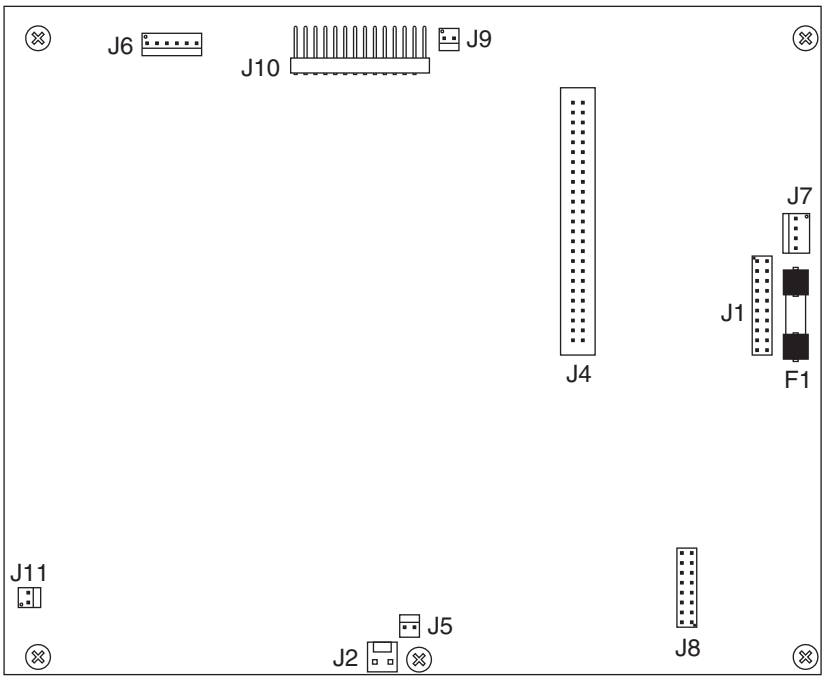


Table 32 CPU Board Fuse

ID	Description	Type & Rating
F1	RS485 Interface Connector	2 Amp, 250 V ac Fast-blow, 5 x 20 mm (P/N 2605)

Table 33 CPU Board Connectors

ID	Description
J1	Liquid Crystal Display (LCD) Board
J2	Mechanical Totalizer
J3	not used
J4	Base Board
J5	Memory Backup Battery Pack
J6	RS232 Serial Port
J7	RS-485 - Submerged Pressure Probe - (not used on bubbler 950)
J8	Modem Option Module
J9	Liquid Crystal Display (LED back-light)
J10	Keypad
J11	not used

9.4.1 Fuse Removal and Inspection

To remove a fuse, pull it straight out of the clips that hold it in place. Usually a close look will tell you if a fuse is blown. The wire strand inside the glass tube will be broken. Occasionally it may take an ohmmeter to verify if a fuse is good or not. You may need to remove plug J1 to access fuse F1.

Always replace any fuse with the exact same size and type rating. Over-rating or bypassing a fuse could lead to severely damaged equipment.

9.4.2 Working with Wiring Connectors

All inter-connect wiring plugs and receptacles are mechanically polarized to assist in proper insertion. Always note where a connector belongs and what orientation it was in prior to removal. This will assure that you get it back in the right place during reassembly.

Locations and descriptions of each fuse and connector on the Base Board and CPU board are shown in Figure 19 and Figure 20.

9.5 Replacing the Internal Desiccant Module

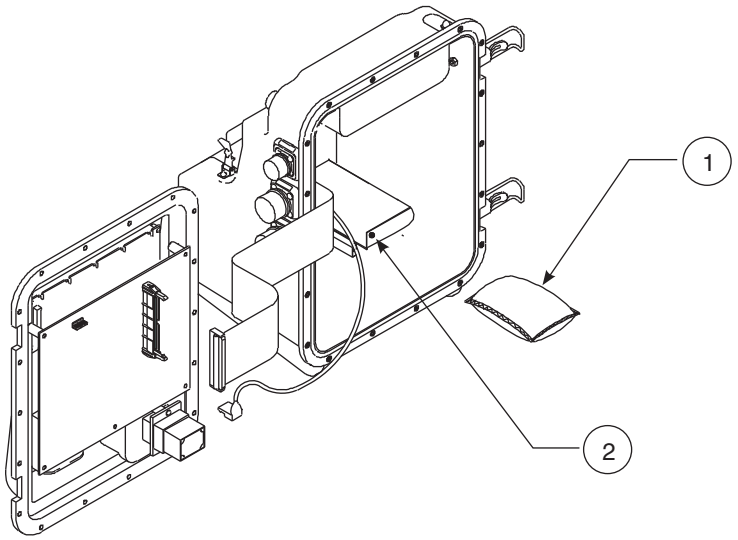
The Internal Desiccant Module (P/N 787) consists of a moisture absorbing material inside a poly bag. The module should be replaced if the Internal Case Humidity Indicator on the front panel turns pink.

To replace the desiccant module, proceed as follows:

1. Remove the screw holding the desiccant door in place and remove the door (Figure 21).
2. Slide out the old desiccant module and slide in a fresh one
3. Reattach the desiccant door.

The desiccant module cannot be recharged by heating. Do not attempt to bake the desiccant module in an oven to remove the moisture because this could be a fire hazard.

Figure 21 Replacing Internal Desiccant Module



1	Internal Module (P/N 787)	**2**	Remove desiccant access screw and door.

9.6 Replacing the Internal Case-Humidity Indicator Disc

After replacing the desiccant module and re-sealing the case, the Internal Case Humidity Indicator Disc (P/N 2660) will return to its original blue color within 24 hours.

If the indicator disc fails to return to blue after replacing the desiccant module, replace the disc. The indicator disc is held in place by a small clip and screw. To gain access to the indicator disc you must first remove the CPU board. Be sure to observe proper handling for static sensitive CMOS devices.

9.7 Memory Batteries

Random Access Memory (RAM) is a very reliable data storage medium for microprocessor applications; however, RAM requires power at all times to store its data. If power is removed, the data stored in the RAM chip is lost. Therefore, it is not feasible to power the RAM chips from the meter power supply because you would lose your data and program settings every time you unplugged the power cord. A separate battery pack located inside the flow meter powers the RAM chips and the real time clock.

The memory batteries (P/N 2709) keep the program entries and logged data stored in RAM memory when the main power fails or is removed for transport or replacement.

The memory batteries consist of two 1.5 VDC C cells. They are located below and behind the CPU circuit board, which is attached to the inside of the front panel assembly. They are easily replaced without having to remove the CPU board assembly. Use only good quality alkaline C cells as replacements.

If the memory battery voltage falls too low to properly maintain the program settings, a warning: “MEMORY BATTERY” will flash in the lower right corner of the display to alert you to replace the batteries. The meter uses a very small amount of energy from the memory batteries during normal operation.

To replace the memory batteries, refer to Figure 17 and proceed as follows:

1. Download all data before removing the batteries.

Important Note: *All data will be lost from the meter when the batteries are removed.*

2. Pull back on and open the Velcro® retaining strap.
3. Remove the old batteries and insert the new ones.
4. Refasten the Velcro retaining strap.

Section 10 Contact Information for U.S.A. and Outside Europe

Ordering Information for the U.S.A.

By Telephone:
(800) 368-2723

By Fax:
301-874-8459

By Mail:
Hach Company
4539 Metropolitan Court
Frederick, MD 21704-9452, U.S.A

Ordering information by E-mail:
hachflowsales@hach.com

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 an e-mail to: hachflowsales@hach.com or visit ww.hachflow.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 hachflowservice@hach.com or call 1-301-874-5599.

Repair Service

Authorization must be obtained from Hach Company before sending any items for repair.

To send the monitor to the factory for repair:

1. Identify the serial number of the monitor unit.
2. Record the reason for return.
3. Call the Customer Service Department (1-800-368-2723) and get a Service Request Number (SRN) and shipping label.
4. Use the shipping label provided and ship the equipment in the original packaging if possible.

Note: *Do not ship manuals, computer cables, or other parts with the unit unless they are required for repair.*

5. Make sure the equipment is free from foreign debris and is clean and dry before shipping. Sensors returned without cleaning will be charged a fee.
6. Write the SRN number on the shipping box.
7. Make sure that all return shipments are insured.
8. Address all shipments to:

Hach Company
5600 Lindbergh Drive - North Dock
Loveland, Colorado, 80539-0389 U.S.A.
Attn: SRN#XXX

Section 11 Contact information for Europe

For technical support, repair service and ordering information please refer to the contact information below.

For all countries except France, Spain and Great Britain:

Flow-Tronic
RUE J.H. COOL 19a
B-4840 Welkenraedt
Belgium
Ph: +-32-87-899797 or 899799
Fx: +-32-87-899790
Email: sales@mmi-europe.com
www.flow-tronic.com

For France, Spain and Great Britain:

France

HACH LANGE FRANCE S.A.S.33, Rue du Ballon93165 Noisy-le-Grand
Telephone: ++33 (0)1 48 15 68 70
Fax.: ++33 (0)1 48 15 80 00
Email: info@hach-lange.fr

www.hach-lange.fr

Spain

HACH LANGE, S.L.U
C/ Larrauri, 1C, 2ª Pl.
48160 Derio, Bizkaia
Telephone: 902 131441 94 6573388
Fax: 94 6573397
E-mail: info@hach-lange.es
www.hach-lange.es

Great Britain:

HACH LANGE LTD
Pacific Way
Salford
Manchester
M50 1DL
Telephone: 0 161 872 1487
Fax.: 0 161 872 7324
Email: sales@hach-lange.co.uk
www.hach-lange.co.uk

Figure 22 Overview of Basic Program Menus

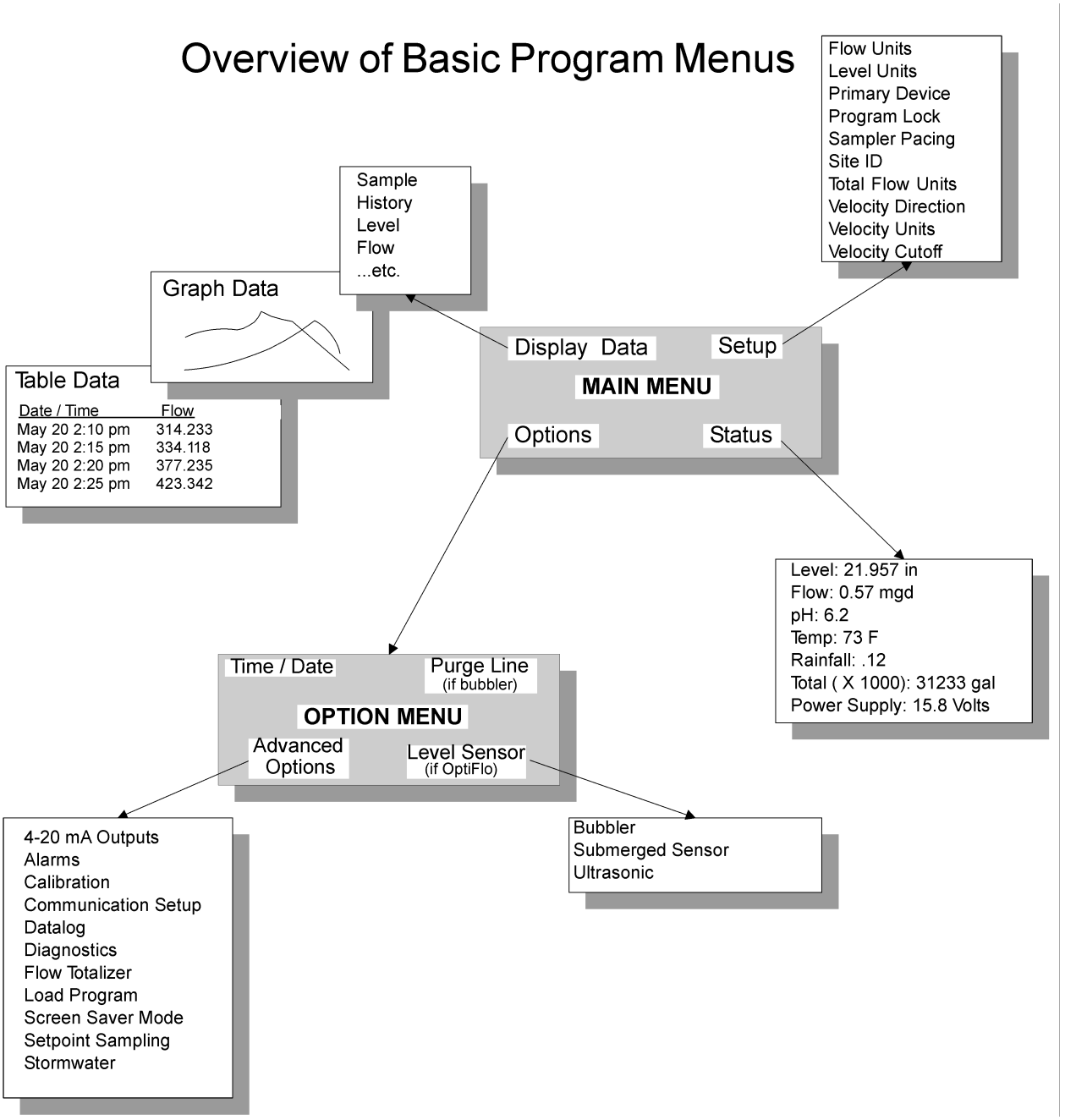


Figure 23 Setup Flow Chart

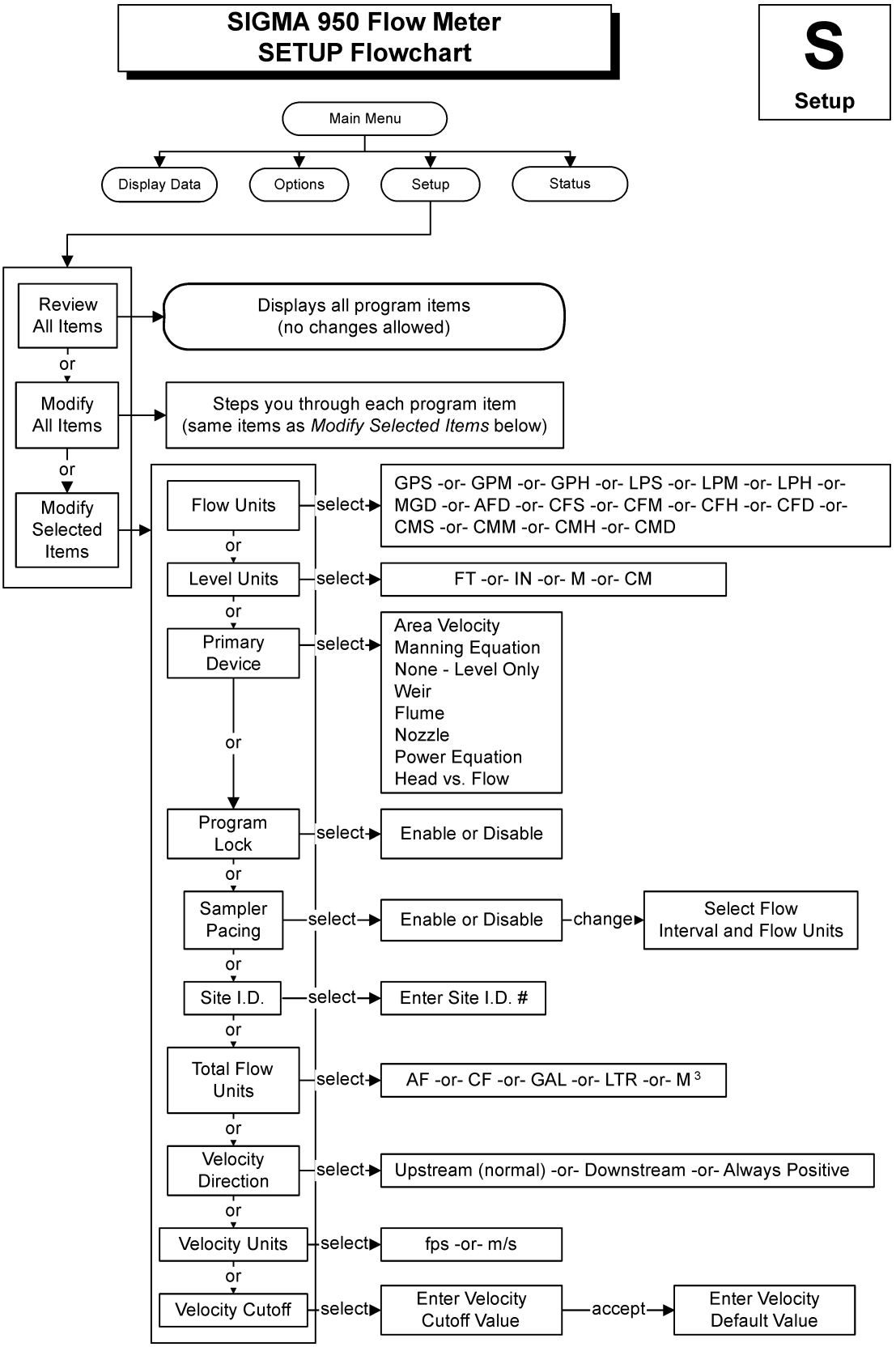


Figure 24 Options Flow Chart

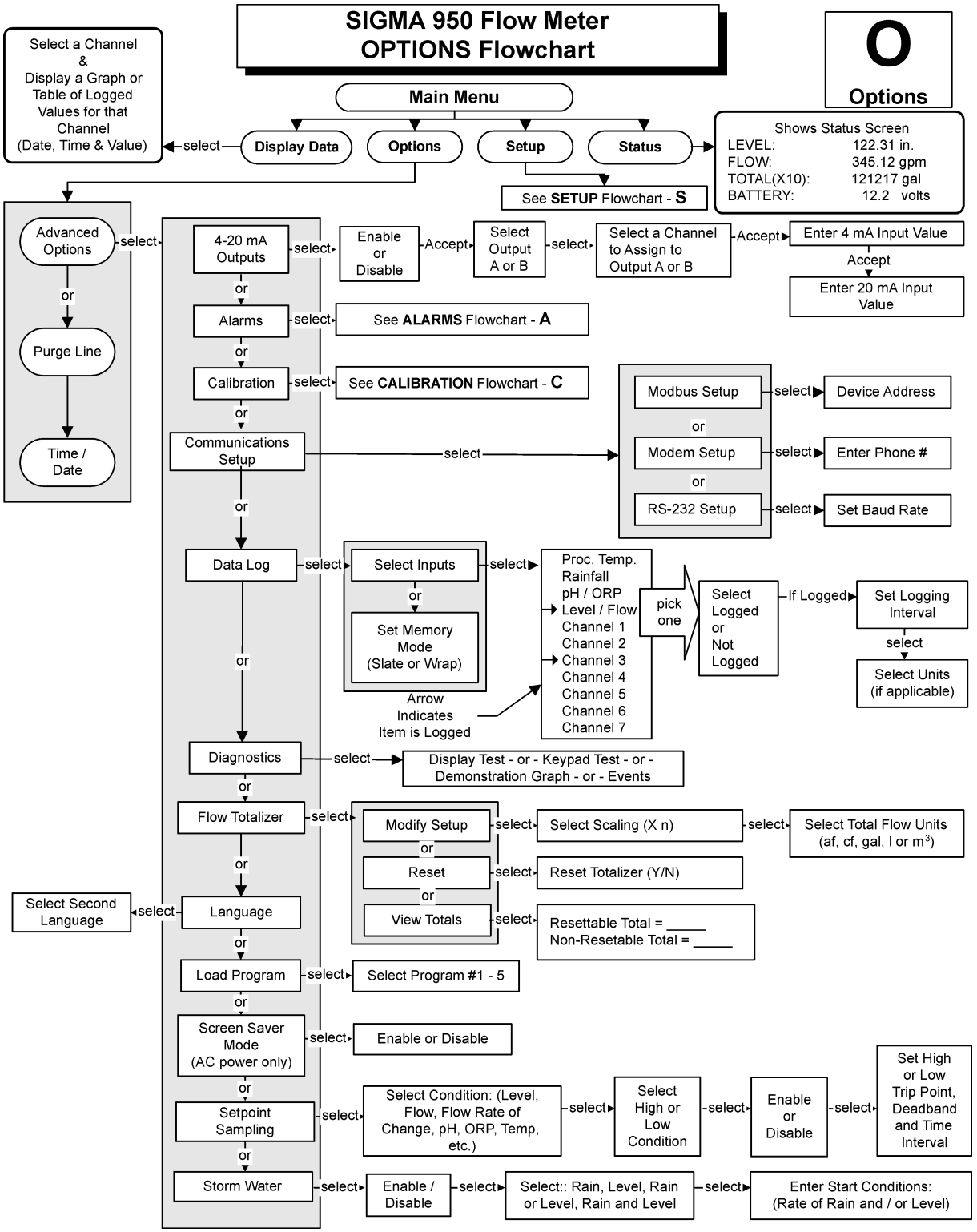


Figure 25 Alarms Menus Flow Chart

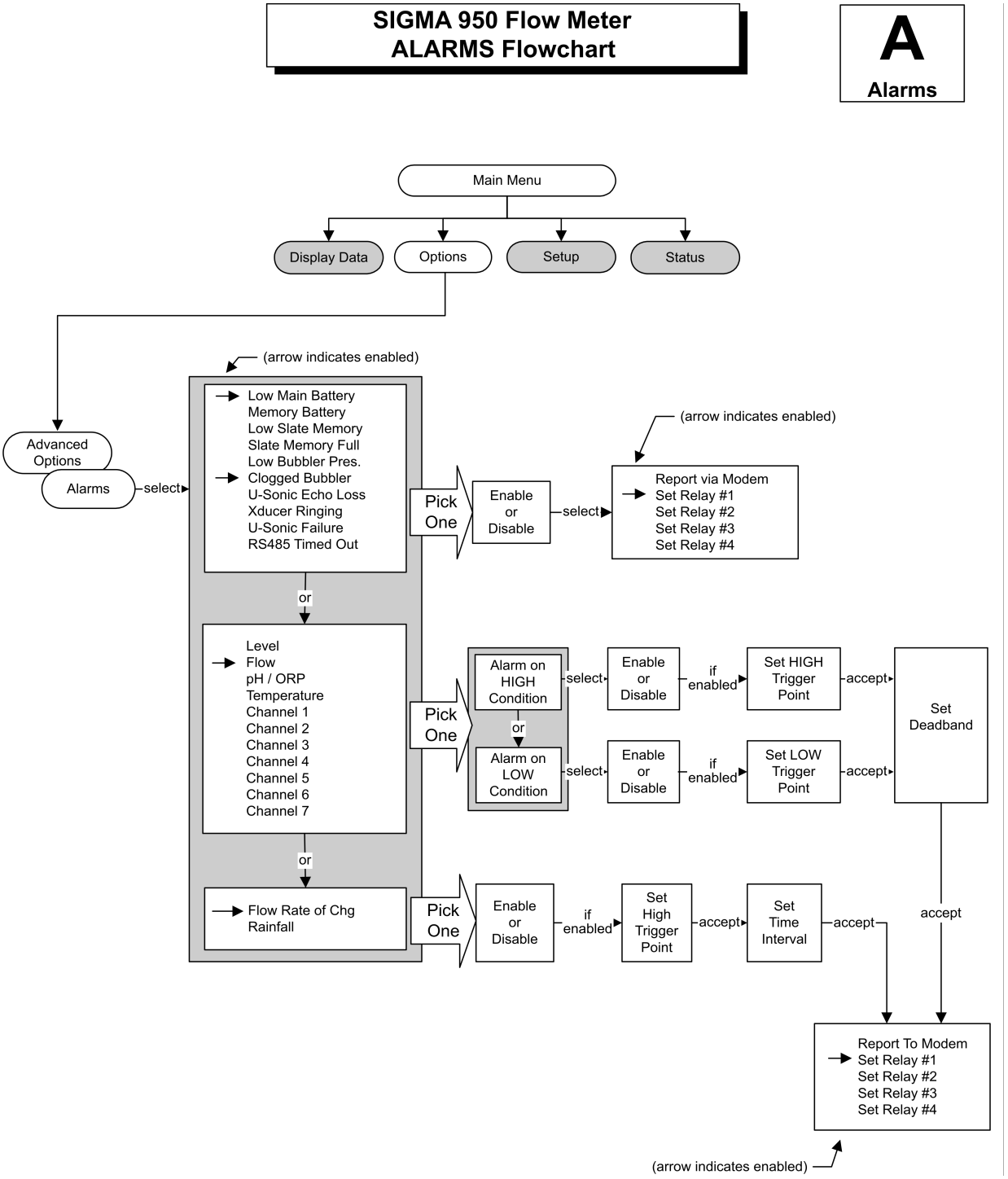
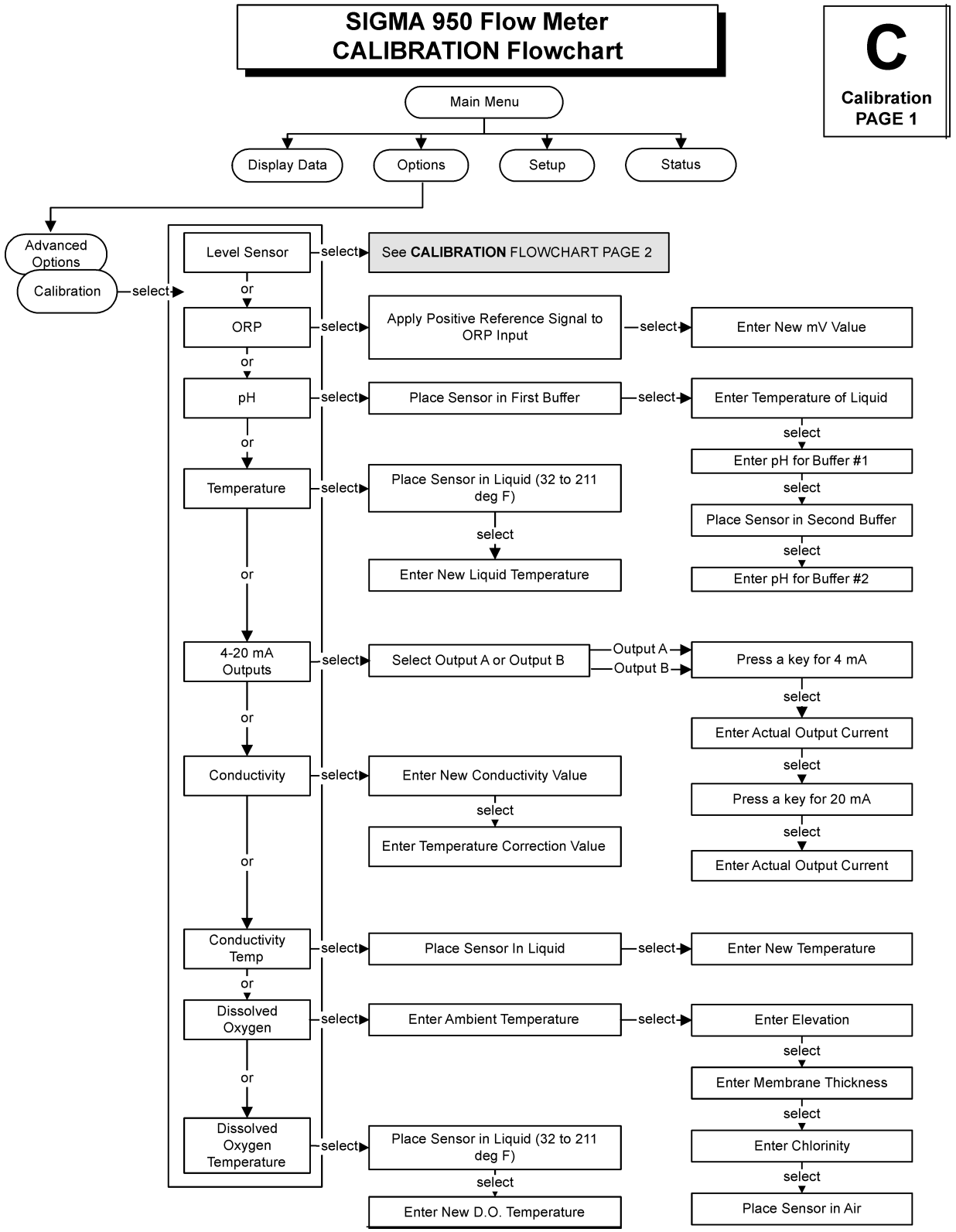


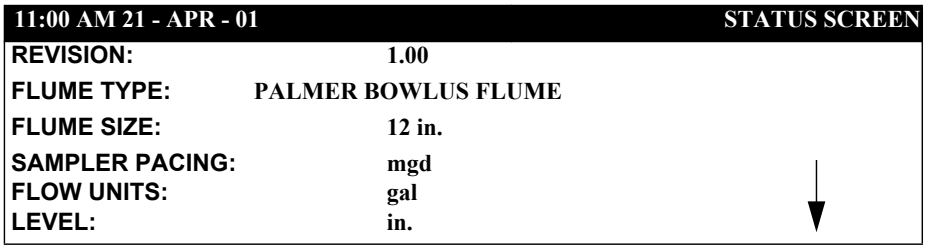
Figure 26 Calibration Menus Flow Chart (Page 1)



Appendix B Programming Features

B.1 Review All Items

To view programmed entries without changing any of the information, select the Review All Items from the Setup menu. Use the arrow keys to scroll through the setup information. Press the **MAIN MENU** key to exit.



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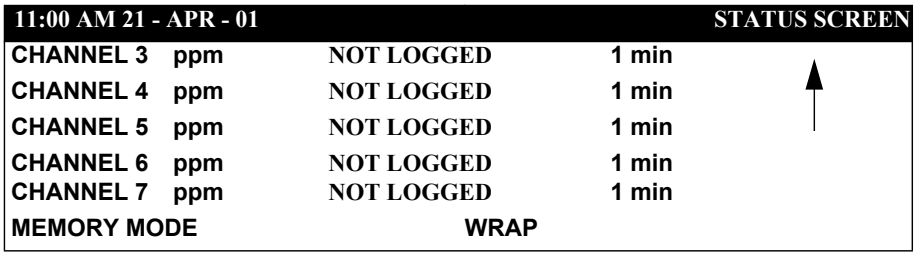


B.2 Displaying Data

The Display Data function provides the recorded data for any channel being logged in a tabular report or a graph.

In addition, for tabular reports, the data can be viewed from the beginning, from the end, or from a specific point in time. A graph can display any 24-hour period, zoom in to any portion of the 24-hour period for finer detail, or center the graph on a specific point in time.

B.3 Selecting the Channel

Note: *Only the channels for which logging has been enabled will be listed.*

1. Press **DISPLAY DATA** from the Main Menu to display a list of logged channels.
2. Highlight the desired channel using the **UP** and **DOWN** arrow soft keys then press **SELECT**.

B.4 Tabular or Graph Format

1. Highlight the desired display method using the **UP** and **DOWN** soft keys, then press **SELECT**.

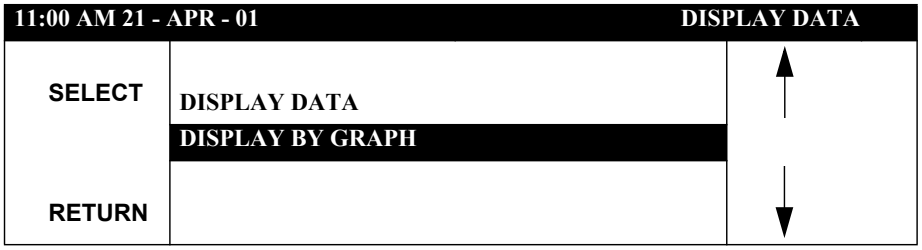


Table 34 Display Data Functions and Descriptions

Function	Description
Display Data by Table	
	View from start: Displays the data for the selected channel beginning with the first (oldest) data point in memory.
	View from end: Displays the data for the selected channel beginning from the most recent point in memory.
	View from time/date: Displays the data for the selected channel beginning from any desired time and date. Enters a new desired time and date.
	Note: *Totals displayed are calculated by summing the logged data. If the date selected precedes available logged data (memory has wrapped), the total will be incorrect.*
Display Data by Graph	
	Graph day: Displays data for a specified date. Data for the selected date is graphed from midnight to midnight.
	Graph point in time: Displays data for a specified time and date. The graph displays three hours of data with the selected point in time at the corner of the graph.
	Graph partial day: Zooms in on a portion of the logged data.

Table 35 Graphing Functions and Descriptions

Functions	Description
Status Bar	
	Displays the time, date, measured value, and unit of measure at the intersection of the data cursor. Placing the cursor's data on the status bar eliminates the need for X or Y axis labels and provides a larger viewing area.
Moving the Data Cursor with the Arrow Keys	
	The data cursor appears as a vertical line in the center of the graph. Move the data cursor to the left or right by using the soft keys or the numeric keypad.
Moving the Data Cursor with the Numeric Keypad	
	The keys 0–9 represent a percentage of full scale. Pressing a numeric key on the keypad while a graph is displayed causes the data cursor to jump to the location on the graph that is represented by that key. For example, pressing the 0 key moves the data cursor to the far left end or 0% position on the graph. Pressing the 5 key moves the data cursor to the middle or 50% position of the graph. Pressing the 9 key moves the cursor to the 90% position.
Next Channel Soft Key	
	Graphs data from the next logged channel. For example, if the 950 is logging Level, Flow, and pH and the Level graph is currently displayed, the **NEXT CHANNEL** soft key causes the Flow channel to be graphed. Pressing Next Channel again will create a graph for pH channel. Pressing **NEXT CHANNEL** again returns to the Level graph, selects a time period of interest and compares different graphs.

B.5 Graphic Display Averaging

The Sigma 950 Flow Meter can display a graph that consists of a maximum of 180 individual dots. Since a 24-hour period could contain as many as 1,440 data points (assuming a one-minute recording interval, one reading each minute) it would be impossible to plot every data point on the graph.

When more than three hours (more than 180 minutes worth) of data is graphed the data points must be averaged. When graphing a partial day of three hours or less, all data points are graphed with no averaging.

When viewing a graph with more than 180 data points, zoom in to the area of interest (using the Graph Partial Day option) so all of the individual data points are displayed.

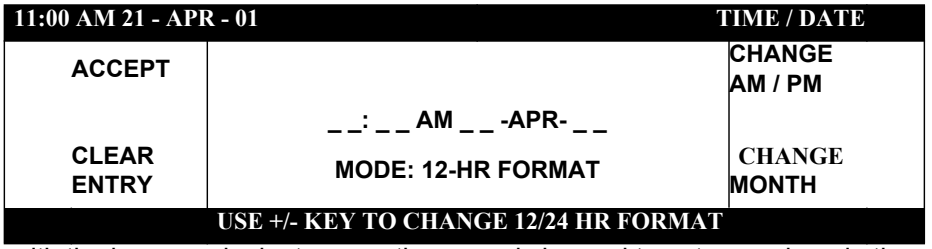
B.6 Options Features

The Options menu can set the:

- Time and Date for the real time clock in the Sigma 950 Flow Meter.
- Program the advanced features of the flow meter.
- Select level sensor when multiple sensors are installed.

B.7 Setting the Time and Date

1. From the Main Menu, select **OPTIONS > TIME/DATE.**



2. Starting with the hours and minutes, use the numeric keypad to enter numbers in the flashing cursor.
3. Use the +/- keys to toggle between 12-hour and 24-hour formats.
4. Use the soft keys on the right of the display to toggle the AM/PM and month fields to the desired selection.
5. Press **CLEAR ENTRY** to clear all numeric fields.
6. When complete, press **ACCEPT** to save the changes.

B.8 Purge Line (Applies to Bubbler Depth Only and Bubbler Area/Velocity Modes Only)

Note: *The Sigma 950 Flow Meter can be programmed to automatically purge at a present interval. For more details, see* *Depth Only and Bubbler Area/Velocity Calibration on page 50**.*

1. From the Main Menu, select **OPTIONS>PURGE LINE.**

2. A solenoid valve opens for approximately one second, temporarily connecting the bubbler line to the full reservoir air pressure.
3. This causes a high pressure air purge of the bubbler line to blow out any silt or debris that may clog the line and impede the normal flow of air.

B.9 Advanced Options

1. From the Main Menu, select **OPTIONS > ADVANCED OPTIONS.**
2. Use the up and down arrow soft keys to highlight the choice, then press the **SELECT** soft key to pick that item.
3. Proceed through the series of screens to configure the parameters for the selected item.

Advanced Options include the following:

- 4–20 mA Outputs (section 8.3.1 on page 68)
- Alarms (section 8.4 on page 72)
- Calibration
- Flow Totalizer (Flow Totalizer on page 103)
- Diagnostics (Diagnostics on page 101)
- Data Log (Data Log on page 99)
- Storm Water (Stormwater on page 106)
- Set Point Sampling (Set Point Sampling on page 105)
- Languages (English, Czech, Danish, French, German, Italian, Portuguese, Swedish, Dutch, and Spanish. (The 950 supports English and one other selected language).

B.10 Alarms

Setting the Deadband
After entering the trip point, enter a “deadband” value. The deadband is the area between alarm “turn on” and “turn off.”

Note: *Rainfall and Flow Rate of Change alarms are High Set Point conditions; they take no deadband, and they are time dependent.*

The purpose of setting a deadband is to eliminate alarm relay chatter which can occur if the turn-on and turn-off values are too close together. Small fluctuations that occur when the reading is at or near the trip point can toggle an alarm relay on and off very rapidly.

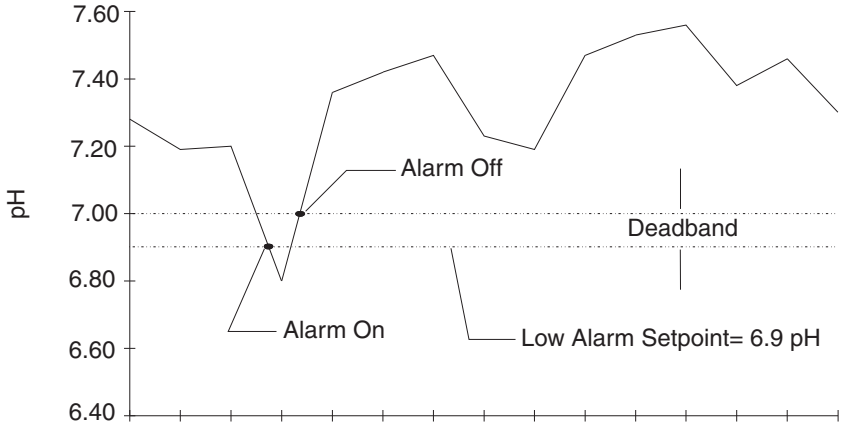
Note: *You must log rainfall to use an alarm on a rainfall condition. You must log flow in order to implement an alarm on a flow rate of change. If you forget, you are reminded when the program begins.*

In the pH example (Figure 27), the deadband is set to 0.10 pH. When the pH reached 6.9 (lower dashed line), the alarm tripped, but the alarm did not turn off until the pH came back up to 7.00. This difference is the deadband setting which should be set to the characteristics of each measured item.

Four alarm relays are provided with SPDT (Form C) contacts. The normally open, normally closed, and common contacts are on the terminal wiring board.

Multiple alarms can be enabled one at a time. Multiple alarms can be assigned to individual trouble conditions, to individual relays, or assigned to all the same relay.

Figure 27 Deadband Concept



B.11 Data Log

From the Main Menu, select **SETUP > ADVANCED OPTIONS > DATA LOG.**

The Sigma 950 Flow Meter can record up to 115,630 readings from any or all input channels and store them in solid state, battery-backed memory for later viewing or retrieval.

This option selects logged input channels, the frequency of logged channels (Logging Interval), and explains what to do when the memory becomes full.

B.12 Logging Intervals

Logging Intervals are designed to optimize the available memory so that readings can be logged for a longer period of time. A Logging Interval is the time period over which readings are taken and then averaged.

The Sigma 950 Flow Meter has three data logging modes; extended power mode, power save mode, and continuous mode:

Extended Power Mode
When operating in extended power mode, the microprocessor spends most of its time asleep, conserving battery power. Once per logging interval, the flow meter wakes up, logs the readings from all enabled input channels, performs any other necessary duties required, and then goes back to sleep. This mode will give the longest battery life but the least resolution.

If you select one-minute logging interval in extended power mode, a reading will be taken once per minute, at which time a reading is logged.

If you select a five-minute logging interval, a reading will be taken once every five minutes, at which time that reading is logged.

Note: *The Sigma 950 Flow Meter will assume it is battery operated if it measures less than 14.2 volts and DC powered in its power supply.*

Power Save Mode
Power save mode is automatically initiated upon power up if a battery is installed on the flow meter. When operating in power save mode, the microprocessor spends most of its time asleep conserving battery power. Once per minute the flow meter wakes up, logs the readings from all enabled input channels, performs any other necessary duties, and goes

back to sleep. This mode will give a quicker battery consumption but better resolution with longer logging intervals.

If a one-minute logging interval is selected in power save mode, a reading will be taken once per minute, at which time that reading is logged.

If a five-minute logging interval is selected, readings are taken every minute but the data is not logged until the five minute logging interval ends. At the time the readings are averaged over the previous five minutes; that average is logged.

Note: *The Review All Items selection from the Setup menu indicates the maximum available logging hours for the channels and recording intervals you selected. The flow meter calculates this information when the program is run using the* **RUN/STOP** *key.*

Continuous Mode

When a one-minute logging interval is selected, a reading will be taken approximately every second but data is not logged until the logging interval ends. At that time, the readings are averaged over the logging interval; that average is logged.

When a five-minute logging interval is selected, readings are still taken every second but the data is not logged until the five-minute logging interval ends. At that time, the readings are averaged over the previous five minutes; that average is logged.

Longer logging intervals result in a longer total recording time. Lower resolution also occurs since more averaging is done at higher logging intervals. Choose the shortest logging interval possible, while still making data collection convenient. Pick a logging interval that almost fills memory over the course of one month if data will be collected monthly.

Table 36 Logging Intervals vs. Total Recording Time for Each Memory Configuration[1]

Logging Interval	With 128K Bytes of RAM (Standard) (approx. 17,280 readings)	With 512K Bytes of RAM (Optional) (approx. 115,630 readings)
	Total recording time (days) before memory is full	
1	12	80
2	24	160
3	36	240
5	60	401
6	72	481
10	120	803
12	144	963
15	180	1204
20	240	1606
30	360	2409
60	720	4818

[1] Assuming **one** logged channel.

B.13 Data Logging Memory Allocation Options

The Sigma 950 Flow Meter uses a management scheme called “Dynamic Memory Allocation.” All readings are logged in battery-backed Random Access Memory (RAM). RAM memory is allocated to each channel dynamically during operation. If one channel is logging at 5-minute intervals and a second channel is logging at 1-minute intervals, the meter automatically configures memory so that both channels fill memory at the same

time. Five times as much memory is assigned to the channel that is logging at 1-minute intervals than the channel that is logging at 5-minute intervals.

Memory can be configured in slate or wrap mode.

Note: *When slate memory mode is used and becomes full, the 950 will enter program complete mode and stop logging data.*

Slate Memory Mode—Slate mode causes logging to stop when memory becomes full. The flow meter continues to operate but no more data is logged. Use this mode so no data is lost from the beginning of the logging period.

Wrap Memory Mode—In wrap mode, when memory becomes full, the oldest reading is discarded each time a new reading is taken. When memory becomes full, the flow meter continues to operate and log data. This mode is best used to receive the most recent data readings.

Memory Mode Configuration

1. Select **DATA LOG** from the Advanced Options menu.
2. Select **MEMORY MODE** using the **UP** and **DOWN** soft keys. Press **ACCEPT**.
3. Press **CHANGE CHOICE** to pick either Slate or Wrap. Press **ACCEPT**.

B.14 Datalogging Configurations

1. From the Main Menu, select **OPTIONS>ADVANCED OPTIONS> DATA LOG**.
2. Highlight **SELECT INPUTS** using the **UP** and **DOWN** soft keys. Press **SELECT**.
3. Highlight the channel to log using the **UP** and **DOWN** soft keys. Certain channels require more information.
4. Press **CHANGE CHOICE** to select Logged or Not Logged. Press **ACCEPT**.
5. Enter a logging interval using the numeric keypad, then press **ACCEPT**. Valid logging intervals are shown on the status bar along the bottom edge of the display.
6. Select another channel to configure or press **RETURN** to back up one step.

Table 37 Setup Parameters for Specific Channels

Channel Name	Configuration Options
Process Temperature	1. Select Logged or Not Logged using the **CHANGE CHOICE** soft key. 2. Press the **ACCEPT** soft key to continue. 3. Enter the Logging Interval using the numeric keypad. 4. Select Temperature Units, °F or °C (this is the only place where temp. units can be changed).
Rainfall	section 7.1.2 on page 53
pH/ORP	section 7.2.2 on page 54 and section 7.3.2 on page 55
Level / Flow	Flow Units on page 29 and Level Units on page 30
Analog Inputs	section 8.3.2.2 on page 71

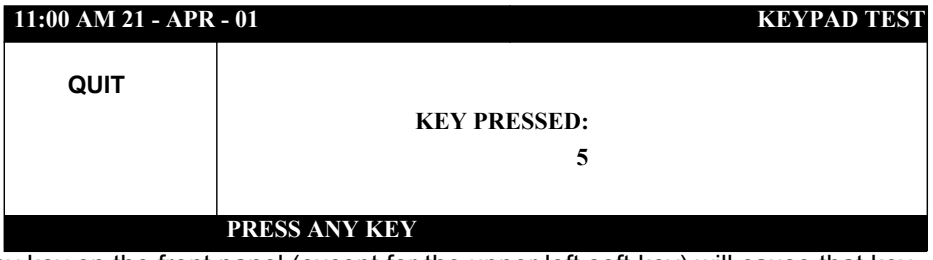
B.15 Diagnostics

From the Main Menu, select **OPTIONS > ADVANCED OPTIONS > DIAGNOSTICS.**

In addition to the automatic diagnostics that are performed upon power up, a keypad test, LCD test, demonstration graph, velocity analysis, and events (log) are available.

B.15.1 Keypad Test

Keypad Test provides a simple means of verifying the operation of all front panel keys. Selecting **KEYPAD TEST** from the diagnostics menu will bring up the following screen:



Pressing any key on the front panel (except for the upper left soft key) will cause that key label to appear in the center of the display. All numeric keypad keys, soft keys, and function keys may be tested in this manner. To end, press **QUIT** (this also verifies the upper left soft key operation).

B.15.2 LCD Test

LCD Test verifies all the pixels in the Liquid Crystal Display (LCD) are functional. The LCD is made up of 14,400 pixels that are turned on and off as needed to create the display of graphics and text. Each individual pixel is turned on and off by its own transistor. If a transistor fails, the pixel will not turn on, potentially causing an unreadable or confusing display.

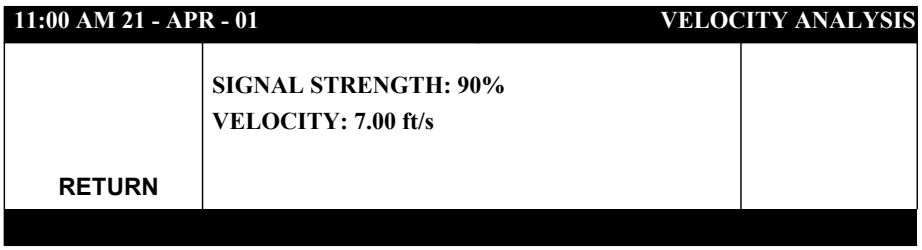
Select **LCD TEST** from the Diagnostics Menu. The display will become black for 3 seconds to verify that all pixels are functional. A defective pixel will stand out as a white dot in the field of black dots. A message, “THE DISPLAY WILL REMAIN INVERTED FOR 3 SECONDS” is shown for 2 seconds followed by a 3-second period with all dots turned on.

B.15.3 Demonstration Graph

The demonstration graph provides a small portion of demonstration data to use when learning how to use the graphing screen for the first time or for training others on its operation. No data logging is required to use the demonstration graph.

B.15.4 Velocity Analysis

A velocity probe must be installed in the flow stream and must be connected to the meter in order for this diagnostic to work. This diagnostic allows the viewing of ‘real time’ readings directly from the Submerged Depth/Velocity Probe. It shows the current velocity Signal Strength (percentage of Doppler signal returning to the probe) and a ‘real time’ velocity measurement of the flow stream. Use this diagnostic to determine that the probe is mounted for optimal velocity measurement. The closer to 100% the Signal Strength is, the more stable the velocity reading will be. If the signal seems low (50% or less), it may be due to improper installation of the probe or a lack of particulate in the flow stream.



B.15.5 Event Log

The event log diagnostic provides a time/date stamped list of significant events occurring in the flow meter. Review these events to find out when an event occurred and what events preceded or followed the event of interest. Events may be viewed in chronological order from the beginning or end of the event list by selecting **VIEW FROM START** or **VIEW FROM END** respectively.

Fixed Alarms
Fixed alarms (Table 38) show the On/Off status associated with the alarm. For instance, U-sonic Echo Loss On at some time/date will appear. When the condition ends, U-sonic Echo Loss Off will appear.

Table 38 Event Log Fixed Alarms

Event	Explanation
MEMORY BATTERY	Internal memory battery is low.
MODEM FAILURE	Modem chip/modem board failure.
U-SONIC ECHO LOSS	No return signal detected.
XDUCER RINGING	The return signal is detected too soon.
U-SONIC FAILURE	Ultrasonic board detects an error.
RS485 TIMED OUT	Communication problem with RS485.

Channel Alarms
Channel alarms show the value that caused the alarm to occur or go away, and show a status ON/OFF to indicate if the alarm occurred or went away at that time/date:

Event Log Channel Alarms:

- LEVEL
- FLOW RATE OF CHG
- RAINFALL
- CH1
- CH2
- CH3
- CH4
- FLOW
- pH
- CH5
- CH6
- CH7
- VELOCITY
- TEMPERATURE

B.16 Flow Totalizer

From the Main Menu, select **SETUP > ADVANCED OPTIONS > FLOW TOTALIZER.**

The Flow Totalizer is a series of up to three numeric counters that keep track of the total flow being measured. Two software totalizers are standard; a third mechanical totalizer is available as an option. The two software totalizers consist of a resettable totalizer and a non-resettable totalizer. Both software totalizers are set to zero upon program start.

Scaling multipliers are provided to allow you to tailor the totalizer response to meet the requirements of the application. Some applications with high flow rates will require a high scaling factor, while low flow rates will require a low scaling factor.

The scaling factor is displayed whenever a total flow number is displayed. As indicated in the Status Screen below, the total flow is displayed as “TOTAL (x1000): 465 gal.”

Multiplying the displayed total flow by the scaling factor (1000) gives you an actual total flow of 465,000 gallons.

11:00 AM 21 - APR - 01		STATUS SCREEN
LEVEL:	8.688 in.	
FLOW	71.39 mgd	
TOTAL (x1000):	465 gal	
pH:	7.2 pH	
BATTERY	16.9 volts	
RUNNING		

Selecting **FLOW TOTALIZER** from the Advanced Options menu causes three choices to be displayed:

- Modify Setup
- Reset
- View Totals

Modify Setup
Modify Setup allows you to select a totalizer scaling factor and a flow unit of measure.

To access the totalizer setup menu, highlight **MODIFY SETUP** using the **UP** and **DOWN** soft keys, then press **SELECT** to continue.

All three totalizers are scaled with one of seven scaling factors: X1, X10, X100, X1000, X10,000, X100,000 or X1,000,000. The selected scaling factor always applies to all totalizers. Press the **CHANGE CHOICE** soft key to cycle through the available scaling choices and then press the **ACCEPT** soft key to continue.

Totalizer Flow Units
The next screen will allow you to select a flow unit of measure (acre-feet, cubic feet, gallons, liters, and cubic meters). This selection is independent of the flow units selected in the Setup Menu.

Press **CHANGE CHOICE** to cycle through the available choices then press **ACCEPT** to continue.

Reset (Totalizer)
Selecting **RESET** from the Totalizer menu will allow you to reset the resettable totalizer only. The non-resettable totalizer will only be reset if one of the following conditions occur

- Change in totalizer scaling
- Change in totalizer units of measure
- Change in primary device
- Start of new program

If any of the above conditions occur, both the resettable and the non-resettable totalizers are reset.

The resettable totalizer can be used to total flow over a finite period and can be reset as often as desired without affecting the other totalizers. The optional mechanical totalizer cannot be reset.

To reset the resettable totalizer only:

Select **RESET** from the **TOTALIZER** menu. A confirmation message will appear. Press the **YES** soft key to reset the totalizer or press the **NO** soft key if you do not wish to reset the totalizer.

To reset both software totalizers at once:

Start a program with the **RUN/STOP** key.

View Totals
To view the current totals of both the resettable and non-resettable totalizers, press **VIEW TOTALS** from the Totalizer menu. Both totalizer values will appear.

B.17 Screen Saver Mode

From the Main Menu, select **SETUP > ADVANCED OPTIONS > SCREEN SAVER MODE.**

The power required to properly light the LCD can consume valuable battery life. Screen Saver Mode is a power saving feature.

B.18 Battery Power

When the flow meter senses that it is operating on battery power, Screen Saver Mode conserves battery life by automatically turning the LCD display off after 3 minutes of keypad inactivity. Pressing any key will turn the LCD display back on. No configuration is required; the meter automatically senses ac or battery operation on power up.

B.19 ac Power

When operated under ac power, Screen Saver Mode can be enabled or disabled manually. Enabling the Screen Saver when operating on ac power will prolong the life of the LCD display by minimizing its use.

To change the Screen Saver mode:

1. Highlight **SCREEN SAVER MODE** on the Advanced Options Menu using the **UP** and **DOWN** arrow soft keys, then press **SELECT**.
2. Press **CHANGE CHOICE** to select a new Screen Saver Mode (Enabled or Disabled). Press **ACCEPT** to save the changes.

B.20 Set Point Sampling

Set point sampling allows the control of an automatic liquid sampler from up to 14 different sources individually or simultaneously. Upon reaching a user-defined set point trigger, the flow meter provides an output signal at the Sampler Interface. This signal can be used to tell a sampler such as the Model SD900 Sampler that a set point condition has been reached and samples should be taken.

Set Point sampling defines a set of limits that inhibit sampling until an upset condition occurs, causing the limits to be exceeded. In this manner, time, money and collecting and testing samples that are within limits is not wasted, because sampling is enabled only when the waste stream falls outside the set points. Table 39 shows all possible sampling triggers and appropriate settings.

Table 39 Sampling Triggers

Sampling Trigger	Settings
Level	High and/or Low condition, deadband
Flow	High and/or Low condition, deadband
Flow Rate of Change	High condition within time interval
Temperature	High and/or Low condition, deadband
pH	High and/or Low condition, deadband
Rainfall	High condition within time interval

Table 39 Sampling Triggers

Sampling Trigger	Settings
Analog Input Channel 1	High and/or Low condition, deadband
Analog Input Channel 2	High and/or Low condition, deadband
Analog Input Channel 3	High and/or Low condition, deadband
Analog Input Channel 4	High and/or Low condition, deadband
Analog Input Channel 5	High and/or Low condition, deadband
Analog Input Channel 6	High and/or Low condition, deadband
Analog Input Channel 7	High and/or Low condition, deadband

To enable Set Point Sampling:

1. From the Main Menu, select **OPTIONS> ADVANCED OPTIONS > SETPOINT SAMPLING.**
2. Highlight **SETPOINT SAMPLING** using the **UP** and **DOWN** soft keys, then press **SELECT**.
3. Highlight the desired sampling trigger (see Table 39), then press **SELECT**.
4. Highlight either **SAMPLE ON HIGH CONDITION** or **SAMPLE ON LOW CONDITION.**
5. Press **CHANGE CHOICE** to enable or disable the sampling trigger for this condition.

Note: *You must log rainfall to use set point sampling on a rainfall condition; likewise, you must log flow in order to implement set point sampling on a flow rate of change. If you forget, you are reminded when the program begins.*

6. Enter the desired high or low trigger point using the numeric keypad, then press **ACCEPT**.
7. Enter a deadband value (see Setting the Deadband on page 98) or, if programming for Flow Rate Of Change or Rainfall, enter a time interval within which the flow or rainfall change must take place.

Sample on High Condition and Sample on Low Condition can be enabled at the same time. There is no limit to the number of sampling triggers that can be enabled at one time.

B.21 Stormwater

A stormwater monitoring program designed specifically to meet the NPDES stormwater requirements is built in to the Sigma 950 Flow Meter. Rainfall is monitored with an optional Rain Gauge. A connection is then made from the flow meter Sampler Interface to an automatic liquid sampler.

A typical stormwater program might be configured to activate when a storm causes a level of at least 3 in. (7.6 cm) in the outfall channel and 0.10 in. (2.5 mm) of rainfall within 30 minutes. Or, it might be desirable to activate the program if either the rainfall occurs or the channel level exceeds the limit. Any combination of rainfall and level conditions can be used to activate a stormwater program. Specific requirements can vary, however, from state to state. Consult state regulatory groups for recommendations on stormwater permit requirements for specific applications.

1. To configure the Stormwater program in the flow meter, proceed as follows:
2. From the Main Menu, select **OPTIONS > ADVANCED OPTIONS > STORM WATER.**
3. Highlight **STORM WATER** on the Advanced Options Menu, then press the **SELECT**.
4. Press **CHANGE CHOICE** to enable Storm Water, then press **ACCEPT**.
5. Select a Start Condition:

- Rain
- Level
- Rain and Level
  (both conditions must be met for the program to begin)
- Rain or Level (either condition must be met for the program to begin)

6. Enter the Start Condition limits:

- For Rain, enter the amount of rainfall and the time period within which it must fall.
- For Level, enter the level limit.
- For Rain and Level and Rain or Level enter the amount of rainfall and the time period within which it must fall, and the desired level limit.

Appendix C Primary Devices & Head Measurement Locations

These primary device illustrations are provided as a general guide to proper head measurement locations in commonly used primary devices. Please contact the manufacturer of your primary device for detail.

Figure 28 Parshall Flume's Head Measurement Location

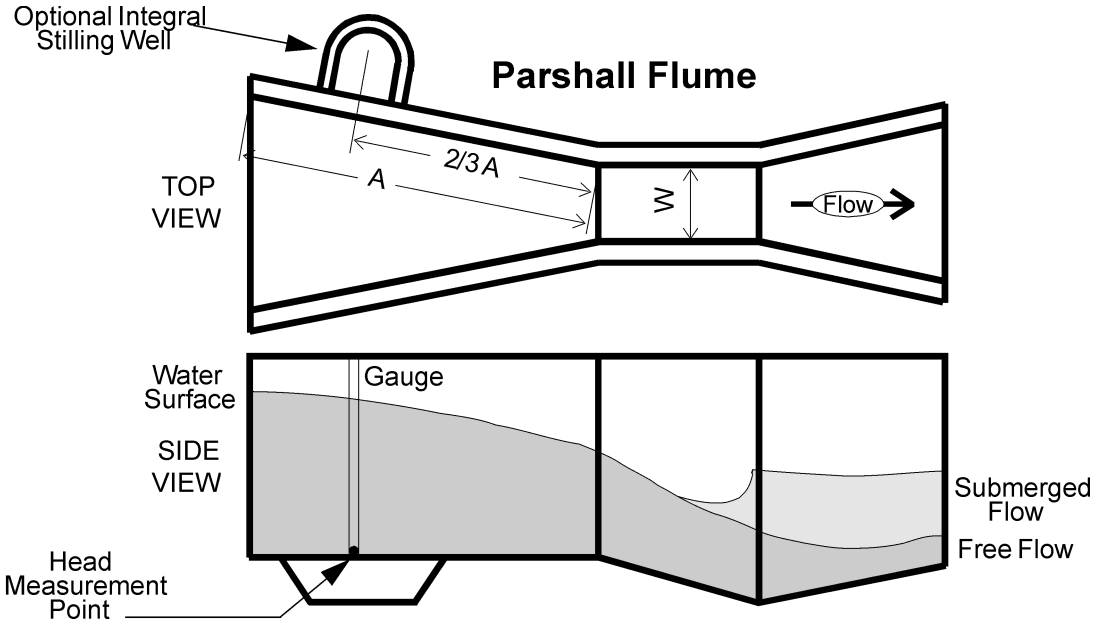


Figure 29 Palmer Bowlus Fume's Head Measurement Location

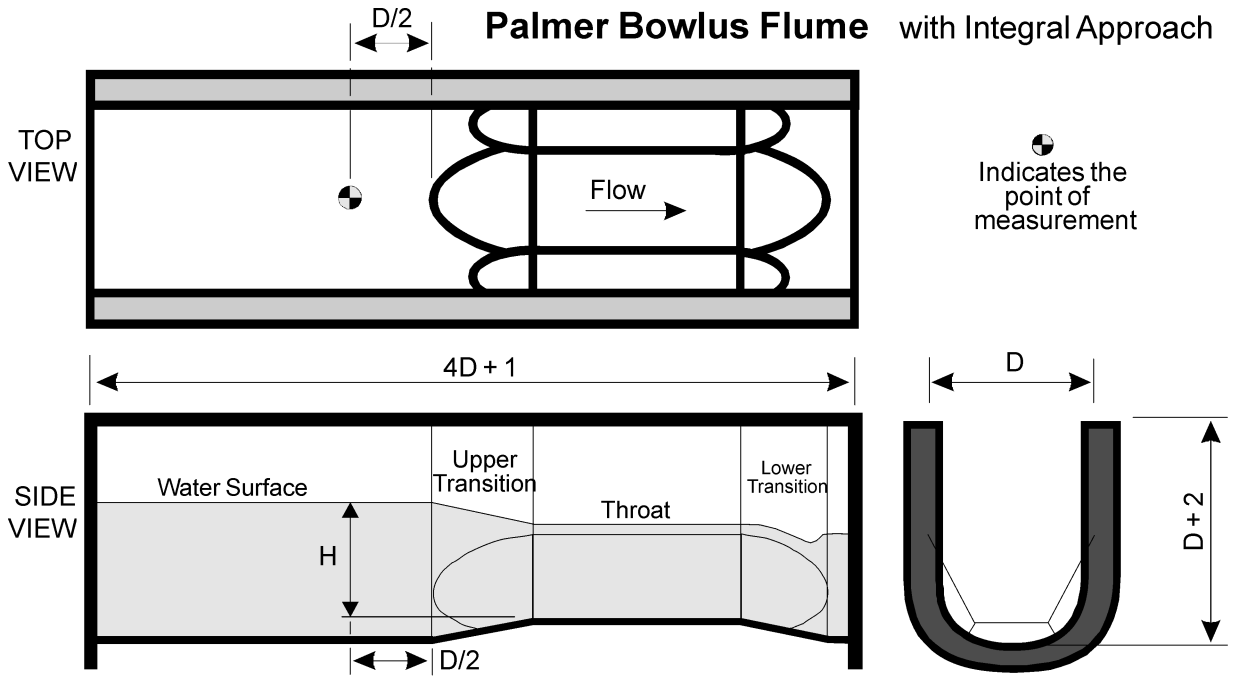


Figure 30 Leopold-Lagco Flume's Head Measurement Location

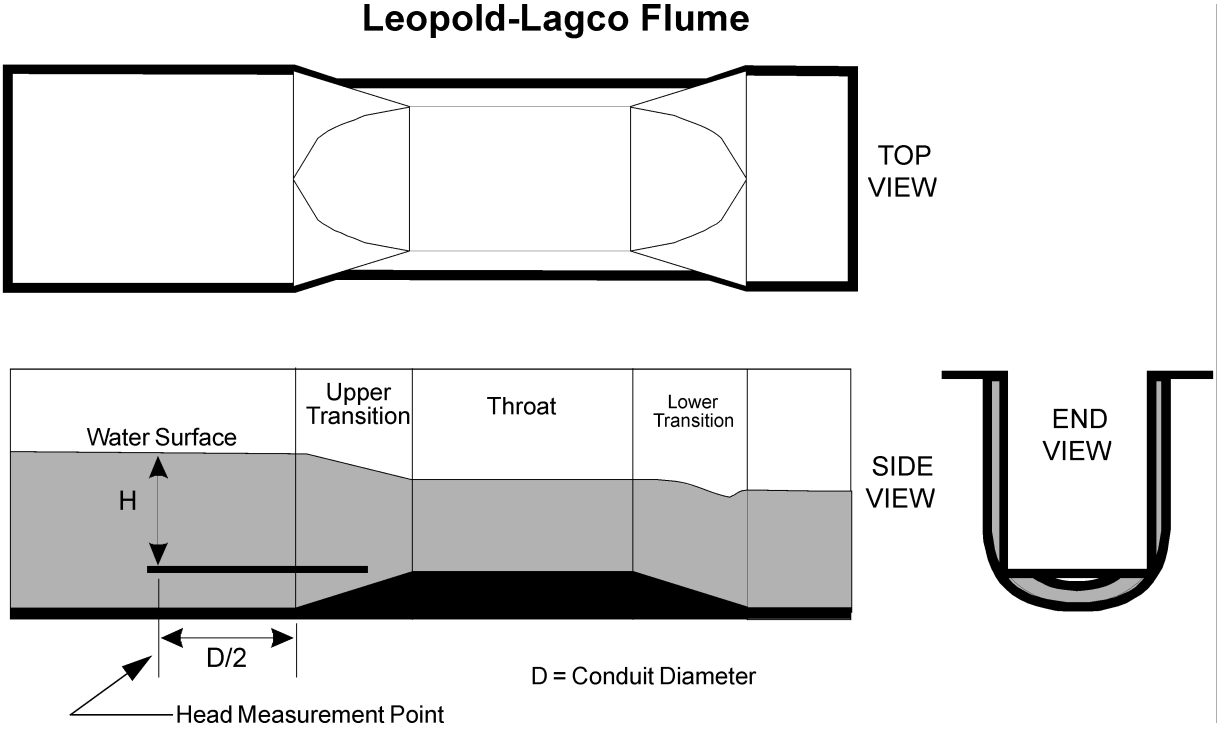


Figure 31 Flume's Head Measurement Location

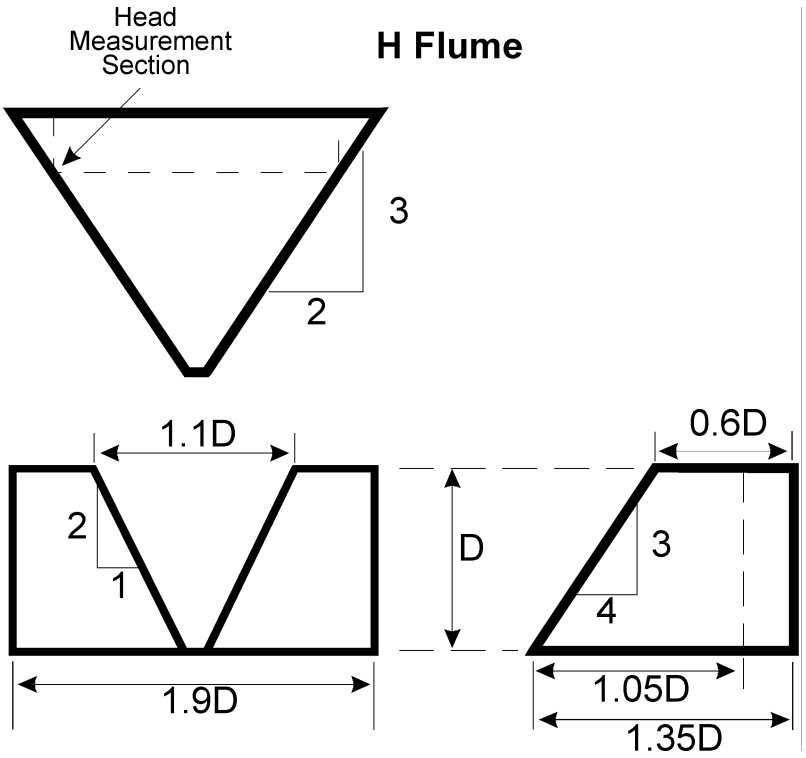


Figure 32 Weir's Head Measurement Location

Weir

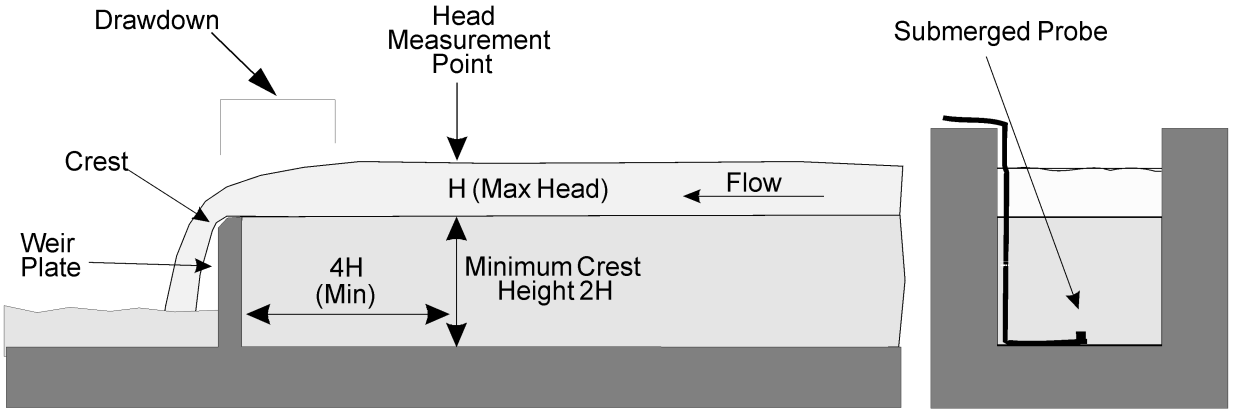
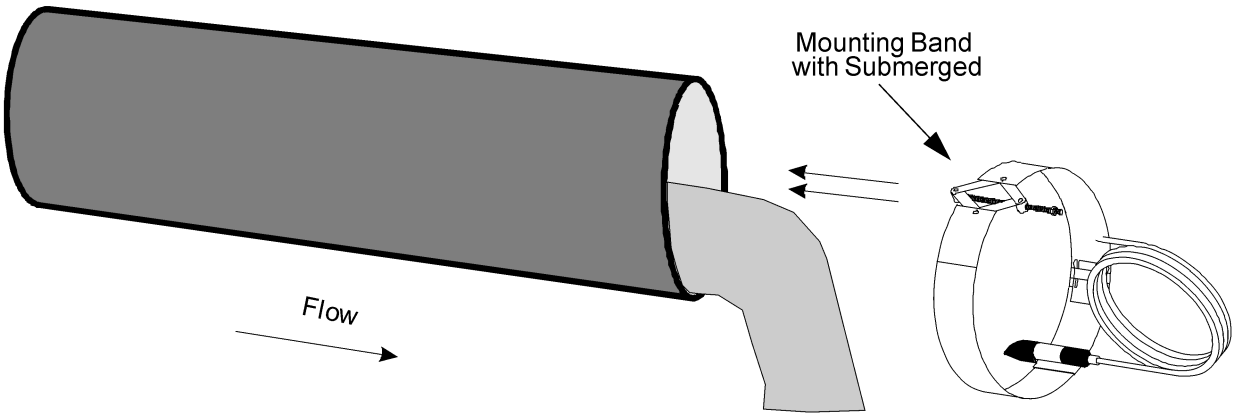


Figure 33 Probe and Band Orientation in a Round Pipe

Round Pipes



Appendix D Programming Worksheet

Name:	Date:		Serial No.:	ID No.:
Program Software Versions for:				
Flow Meter:	**DTU:**	**InSight**	**Flo-Center**	

Basic Programming Guidelines

- Go through all Setup menu items and configure each.
- Next, review the items in the Advanced Options menu and configure any items needed.
- Always check Data Logging and Totalizer Setup. Data logging channels must be enabled if you want to record the data in memory. Also, the totalizer should be configured with an acceptable scaling factor for the flow rate at each site.
- Go to the options menu and set the time and date if not already set.
- When finished, press the **RUN/STOP** key to start the program.
- Photocopy the following worksheets to record your program settings at each site for easy reference.

SETUP MENU

From the Main Menu, select **SETUP**, **MODIFY ALL ITEMS.**

1. Select FLOW unit of measure (gps, gpm, gph, lps, lpm, lph, mgd, afd, cfs, cfm, cfh, cfd, cms, cmm, cmh, cmd): _____
2. Select LEVEL unit of measure (cm, m, in., ft): _____
3. Select a PRIMARY DEVICE:_____

   Flume: Type_____, Size_____

   Weir: Type_____, Size_____

   Nozzle: Type_____, Size_____

   Manning Formula:

   Slope_____, Roughness_____, Pipe Diameter_____

   Power Equation:

   K_1=_____, n_1=_____, K_2=_____, n_3=_____

   Head vs. Flow

4. Enable PROGRAM LOCK password: (Y / N) (**Password is always 9500**)
5. Enable SAMPLER PACING: (Y / N):

   Flow interval:_____, Flow unit of measure:_____

6. Enter a SITE IDENTIFICATION:_____
7. Enter unit of measure for TOTAL FLOW (acre-feet, cubic feet, gallons, liters, cubic meters):_____

Applies to velocity models only:

8. Enter the VELOCITY DIRECTION (Upstream (normal), Downstream or Always Positive):_____
9. Enter the VELOCITY UNITS (ft/s or m/s):_____
10. Enter the VELOCITY CUTOFF:
11. Cutoff value = _____, Default Value = _____

OPTIONS MENU

From the Main Menu, select **OPTIONS**.

1. Set Time & Date: _____
2. Level Sensor (Ultrasonic or Submerged Sensor): _____

ADVANCED OPTIONS MENU

From the Main Menu, select **OPTIONS > ADVANCED OPTIONS**.

1. Setup 4–20 ma Outputs (if desired):_____
2. Setup ALARMS (if desired):_____

Alarm Name	High Trigger	Low Trigger	Deadband	Time Interval	Relay # Set
Low Mem Battery					
Level					
Flow					
Flow Rate of Change					
pH					
Temperature					
Rainfall					
Channel 1					
Channel 2					
Channel 3					
Channel 4					
Channel 5					
Channel 6					
Channel 7					

3. Calibrate inputs (as needed): _____chk
4. Communications Setup: (If modem is enabled) ACCEPT any baud rate displayed. [Modem will independently establish actual baud rate between 1200 and 14,400.]

   Pager Phone Numbers (if enabled): Pager Service:_____

   Pager #1: _____ Pager #2: _____ Pager #3: _____

   Select Baud Rate for RS232 (1200, 2400, 4800, 9600, 19200):_____

5. Configure DATA LOGGING for each desired channel:

Channel Name	Analog Channel Signal Description	Logged (Y/N)	Units	Logging Interval (min)
Process Temperature				
Rainfall				
pH				
Level / Flow				
Analog Channel 1				
Analog Channel 2				
Analog Channel 3				
Analog Channel 4				
Analog Channel 5				
Analog Channel 6				
Analog Channel 7				

6. Configure Flow Totalizer:

Scaling: _____ (X, X1, X10, X100.... X1,000,000)

Flow Units (Acre-feet, cubic feet, gallons, liters, cubic meters):_____

7. Configure SETPOINT SAMPLING if it is desired to trigger a sampler based on one of the following conditions:

Channel Name	High Trigger	Low Trigger	Deadband	Time Interval
Level				
Flow				
Flow Rate of Change				
pH				
Temperature				
Rainfall				
Channel 1				
Channel 2				
Channel 3				
Channel 4				
Channel 5				
Channel 6				
Channel 7				

8. Configure STORM WATER if desired:

Start Condition:_____ (Rain, Level, Rain & Level, Rain or Level)

Rain Trigger: _____, Rain Time Limit:_____

Level Trigger_____

Check one:

____ Head Vs Flow Worksheet

____ Level Vs Area Worksheet (velocity units only)

Head / Level (units =_____)	**Flow / Area (units =_____)**

Appendix E SCADA-Modbus® System Guidelines

E.1 Introduction to SCADA - Modbus Communications

Use this section as a guide when using the Modbus ASCII protocol to communicate directly with the 950 Flow Meter through an RS232 or modem connection.

This guide assumes that the user has a working knowledge of Supervisory Control and Data Acquisition (SCADA), its components, and the different topologies used to construct the communications network. Because a basic understanding of the Modbus ASCII protocol is necessary, a description of key pieces of the protocol will be described.

This section will guide you through the setup process by describing key points that need to be addressed for successful communication. This section will not outline specific implementation details of any particular Man Machine Interface (MMI) or controller, although examples may reference certain manufacturers for illustrative purposes. The description of the Modbus ASCII protocol is provided for reference only and is not intended as a tutorial. The scope of this section is limited to the description of Modbus ASCII as it pertains to the 950 Flow Meter.

Modbus, an open protocol, determines how each instrument will know its device address, recognize a message addressed to it, determine the type of action to be taken, and extract any data or other information contained in the message. The flow meter and MMI communicate using a master-slave technique in which only the master can initiate queries to a slave (950). The 950 will always be considered the slave, never a master. The master can address individual 950 Flow Meters or can broadcast a message to instruments within its scope. Responses are never returned to broadcast queries from the master. The Modbus protocol establishes the format for the master's query by placing into it the device address, a function code defining the requested action, any data to be sent, and an error-checking field. The flow meter's response message is constructed using the Modbus format which confirms the action to be taken, any data to be returned, and an error checking field.

E.2 ASCII Transmission Mode

The 950 Flow Meter is designed to communicate on standard Modbus networks using Modbus ASCII. In ASCII mode, messages start with a colon ':', and end with a 'carriage return-line feed' pair. The allowable characters transmitted for all fields are hexadecimal 0–9, and A–F. When a message is transmitted over a Modbus ASCII communication link, each character or byte is sent in the order of Least Significant Bit to Most Significant Bit. A typical message frame looks like the following:

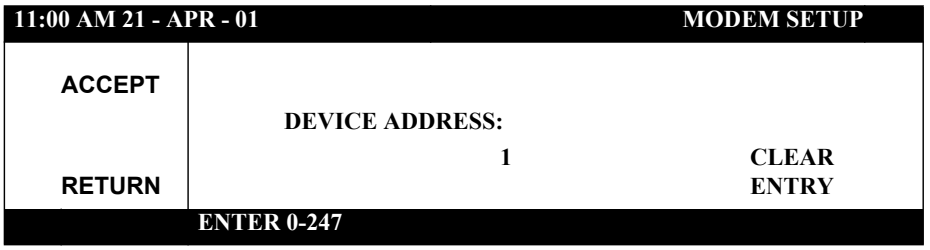
START	ADDRESS (HEX)	FUNCTION (HEX)	DATA (HEX)	LRC (HEX)	END (HEX)
1 Char ':'	2 Chars	2 Chars	n Chars	2 Chars	2 Chars 'CRLF'

E.3 Address Field

The address field of an ASCII message frame, ranging from 0 to 247 decimals, consists of two characters that represent the slave address. Individual slaves are assigned values between 1 and 247. A master addresses a slave by putting the slave's address in the address field of the message frame. When the slave sends its response, it places its own address in the address field of the message frame to let the master know which slave is responding.

The device address of the 950 Flow Meter is set via the front keypad in the 950 Communications menu.

1. From the Main Menu select **OPTIONS > ADVANCED OPTIONS > COMMUNICATIONS SETUP > MODBUS SETUP**
2. Enter a value between 0 and 247.



E.4 Function Field

The function code field of an ASCII message frame, ranging from 1 to 255 decimals, consists of two characters that represent the type of action the master is requesting from the slave. Of these functions, the 950 Flow Meter currently supports function 3 (Read Holding Registers). When a message is sent from the master to a slave device, the function field tells the slave what kind of action to perform. For example, this may include reading the channel values of Level and Velocity. When the slave responds to the master, it echoes the function code field to indicate a normal response. In the event of an error, such as parity error, LRC error, or a request that cannot be handled, the slave will not respond and the master will eventually process a time-out condition.

E.5 Data Field

The data field of an ASCII message frame consists of *n* pairs of ASCII characters that represent data sent to or from a slave device (flow meter). The data field contained in the master request contains additional information that is required by the slave before any action takes place. This may include channel register addresses, the number of registers to read, and the actual byte count in the data field. For example, if a master requests that the flow meter read the current status of a group of channels (function code 03), the data field specifies the starting register and how many registers are to be read. If no error occurs, the data field of the response from the meter to the master contains the data requested.

E.6 LRC Field

The LRC field of an ASCII message frame consists of two ASCII characters that provide an additional level of error checking to verify the integrity of the communication media. The LRC field is one byte that contains an 8-bit binary value. The LRC value is calculated by the transmitting device, which appends the LRC to the end of the message. The receiving device recalculates the LRC and compares it against the LRC value of the incoming message. If the two values are not equal, an error condition occurs. The LRC is calculated by adding together successive 8-bit bytes of the message, discarding any carries, and then complementing the result. The LRC is calculated by summing all values in the ASCII message except for the leading ‘colon’ and ending <CR><LF>.

E.7 Communication Parameters

To successfully communicate with the 950 Flow Meter using Modbus ASCII, the communication parameters of the master device must be set at 7 bits, Even Parity, and 1 Stop bit. The baud rate may be configured to any value offered by the 950 Flow Meter.

With the exception of baud rate, the communication parameters must not vary from this format.

E.8 User Memory Customizing

The most familiar component of existing SCADA networks today is the Programmable Logic Controller (PLC). Because the network integrator is most familiar with this type of device, the flow meter emulation of an existing PLC simplifies the process of integrating the manufacturer's instrumentation into the SCADA network. Modbus ASCII uses a referencing system to identify the various types of memory inputs and outputs. Each reference number has a leading digit that identifies its data type (discrete input, discrete output, register input, register output) followed by a string of digits that indicates its location in RAM (Table 40).

Table 40 Modbus ASCII Memory Input/Output Referencing System

Reference Indicator	Reference Type	Meaning
0xxxx	discrete output or coil	binary
1xxxx	discrete input	binary
3xxxx	input register	real
4xxxx	output holding register	real
6xxxx	extended memory register	real

The memory data is stored in 16-bit words. Within the predefined function codes of the Modbus ASCII protocol, the data fields are subject to interpretation by the device manufacturer. For example, the 950 Flow Meter places temperature information in registers 40001-40002.

E.9 Modbus ASCII Function Codes Supported

Currently, the 950 Flow Meter is capable of a read-only function to retrieve channel and total flow information. All data addresses in the Modbus ASCII message are referenced to zero. Therefore, a reference to holding register 40001 is addressed as register 0000. The function code field specifies the type of register accessed; therefore, the 4XXXX is implicit.

Function 03: Read Holding Registers
Reads the register (4X reference) contents of the 950 Flow Meter as defined in the tables that follow.

Table 41 Channels' Read Holding Register Addresses

Name	Type	Size (bits)	# of Registers	Start Address Hi	Start Address Lo	Registers
Temperature	Float	32	2	00	00	40001-40002
Rainfall	Float	32	2	00	02	40003-40004
pH (or ORP)	Float	32	2	00	04	40005-40006
Level 1	Float	32	2	00	06	40007-40008
Velocity 1	Float	32	2	00	08	40009-40010
Channel 1	Float	32	2	00	0A	40011-40012
Channel 2	Float	32	2	00	0C	40013-40014
Channel 3	Float	32	2	00	0E	40015-40016
Channel 4 (D.O.)	Float	32	2	00	10	40017-40018
Channel 5 (D.O. Temp.)	Float	32	2	00	12	40019-40020
Channel 6 (Conductivity)	Float	32	2	00	14	40021-40022
Channel 7 (Cond. Temp.)	Float	32	2	00	16	40023-40024
Flow 1	Float	32	2	00	20	40033-40034
Power	Float	32	2	00	26	40039-40040

Table 42 Channels' Units of Measure Read Holding Register Addresses[1]

Name	Type	Size (bits)	# of Registers	Start Address Hi	Start Address Lo	Registers
Temperature	Integer	16	1	00	31	40050
Rainfall	Integer	16	1	00	32	40051
pH (or ORP)	Integer	16	1	00	33	40052
Level 1	Integer	16	1	00	34	40053
Velocity 1	Integer	16	1	00	35	40054
Channel 1	Integer	16	1	00	36	40055
Channel 2	Integer	16	1	00	37	40056
Channel 3	Integer	16	1	00	38	40057
Channel 4 (D.O.)	Integer	16	1	00	39	40058
Channel 5 (D.O. Temp.)	Integer	16	1	00	3A	40059
Channel 6 (Conductivity)	Integer	16	1	00	3B	40060
Channel 7 (Cond. Temp.)	Integer	16	1	00	3C	40061
Flow 1	Integer	16	1	00	41	40066

[1] The addresses shown above return a code that represents the appropriate unit of measure.

Table 43 Flow Totalizer Read Holding Register Addresses

Name	Type	Size (bits)	# of Registers	Start Address Hi	Start Address Lo	Registers
Total Flow 1	Float	32	2	00	4A	40075-40076
Total Flow Units	Integer	16	1	00	50	40081
Total Flow Multiplier	Float	32	2	00	52	40083-40084

Table 44 SCADA-Modbus Units of Measure Codes

Unit	Code	Unit	Code
ML	1	GPH	26
AF	2	LPS	27
CF	3	LPM	28
GAL	4	LPH	29
L	5	MGD	30
M3	6	PH	31
IN	7	ORP	32
CM	8	PPM	33
FT	9	PPB	34
M	10	MGL	35
CM2	11	PCTSAT	36
FT2	12	MSIEMENS	37
IN2	13	MICROSIEMENS	38
M2	14	GRAMSPERKG	39
AFD	15	PCTPERDEGC	40
CFS	16	DEGREE_C	41
CFM	17	DEGREE_F	42
CFH	18	MILS	43
CFD	19	VOLTS	44
CMS	20	ft/s	45
CMM	21	MPS	46
CMH	22	PCT_O2	47
CMD	23	PCT_H2S	48
GPS	24	PCT_LEL	49
GPM	25	VDC	50

Query

The Modbus ASCII query must take the form shown below that specifies the starting register and number of registers to be read:

Start ':'	Slave Address	Function (03)	Start Address High	Start Address Low	No. of Pts. High	No. of. Pts. Low	LRC	<CR>	<LF>

For example, to read the level channel of the 950 Flow Meter, the query must be as indicated in Table 45.

Table 45 Channel Query to Read Level (Example)

Start	':'
Slave Address	01
Function	03
Starting Address High	00
Starting Address Low	06
No. of Registers High	00
No. of Registers Low	02
LRC	F4
Stop	<CR><LF>

The master queries the flow meter using a Read Holding Registers request, which implies a 4XXXX register reference, to slave device address 01. The message requests data from holding registers 40007–40008 to obtain the level information, which requires two registers to store the floating point value. Note that registers are referenced from zero in the data field.

Response

The 950 Flow Meter responds with the following transmission reflecting a level reading of 15.0 inches:

Table 46 Transmission Response that Reflects a 15 in. Level Reading

Start	':'
Slave Address	01
Function	03
Byte Count	04
Data High	00
Data Low	00
Data High	41
Data Low	70
LRC	47
Stop	<CR><LF>

The flow meter response echoes the address and function code, which indicates that no problems exist in the communication between the master and 950. The 'Byte Count' field specifies how many 8-bit data items are being returned in the data field. With Modbus ASCII, this is one-half the actual count of ASCII characters transmitted in the data portion of the response. The contents of 40007 are shown as two byte values of 00 00 hex, and the contents of register 40008 are shown as two byte values 41 70 hex. Together, these values represent the floating point IEEE representation of the level status.

950 Flow Meter Response Time

As a result of time lags associated with data acquisition, instrumentation could conceivably take up to 12 seconds to respond to a SCADA RS232 request. Therefore, the SCADA system must be designed to accommodate this potential communication lag. For example, in a Wonderware® application running a Modbus ASCII DDE server, the

com port reply time-out must be set to 12 seconds. This is the amount of time that the meter will be given to reply to Modbus queries via this serial port.

Communication Handshaking
The 950 Flow Meter contains minimal communication handshaking. For the meter to identify an RS232 connection from an outside source, and to keep the RS232 hardware active once communicating, the Data Terminal Equipment (DTE) must assert and hold high the DTR line of the DB9 connector (DSR of meter). The 950 Flow Meter does not support RTS/CTS hardware handshaking. Note that DTE must be capable of handling a 12-second maximum response lag.

Pin	Description	Pin	Description	Pin	Description
Pin 1	Data Carrier Detect (DCD)[1]	Pin 4	Data Terminal Ready (DTR)	Pin 7	Request to Send (RTS)
Pin 2	Received Data (RD)	Pin 5	Signal Ground (SG)	Pin 8	Clear to Send (CTS)
Pin 3	Transmitted Data (TD)	Pin 6	Data Set Ready (DSR)	Pin 9	Ring Indicator

[1] Not used.

E.10 Complications with Floating Point Values

The manufacturer's implementation of the Modbus protocol was based on the idea that we would enable our flow meters to emulate a Modicon®, Compact 984 PLC. Consequently, we follow the exact same format that Modicon uses for the storing and processing of floating point numbers. Additionally, the Modbus protocol does not define how floating point values are packed (stored) into the internal memory addresses or "Registers" of the flow meter. If you are integrating our Modbus-capable flow meters, be aware that these meters store and process floating point numbers in the exact same format as the Modicon Compact 984 PLC.

All current models of Modicon PLCs, including the Compact 984, pack two bytes of data into each register. This alone presents no problems. Unsigned two-byte (16-bit) integer values in the range of 0 to 65535 can be stored and retrieved from these registers without any problems or complications. The complications arise when the stored value is a floating point value, which by IEEE definition, require 4 bytes (32 bits). The IEEE standard for floating point values states in part that the 8 most significant bits represent the exponent and the remaining 23 bits (plus one assumed bit) represent the mantissa and the sign of the value.

Since a data "word" consists of two bytes, a floating point value is represented by two data words. Because a single Modicon register consists of one word (or 2 bytes), two consecutive Modicon registers are needed to store one floating point value.

The representation of a floating point value can be broken down into a "High Order" and a "Low Order" word. Additionally, each word can be broken down into a high order byte and a low order byte.

Table 47 and Table 48 depict how a IEEE floating point value is usually represented and how the Modicon stores a floating-point value.

The complications arise because Modicon doesn't store floating point values in this standard (IEEE) format. Modicon stores floating point values the opposite way with the “Low-order” word in the first register and the “High-order” word in the second register.

Table 47 IEEE Floating Point Representation

First Register (i.e., 4001)		Second Register (i.e., 4002)	
High Word, High Byte	High Word, Low Byte	Low Word, High Byte	Low Word, Low Byte

Table 48 Floating Point Values Representation

First Register (i.e., 4001)		Second Register (i.e., 4002)	
Low Word, High Byte	Low Word, Low Byte	High Word, High Byte	High Word, Low Byte

Since the Modbus protocol doesn't define how floating point values are handled or stored, some Modbus-capable servers incorrectly use the normal, “High word — Low word” format for converting the Modbus message response to the client application. Since Modicon stores the floating point values in the opp0odbus and floating point numbers.

E.11 Port Expanders and Protocol Converters

In some situations, there may not be a Modbus ASCII port available for use with the 950 Flow Meter. A good example might be where there is a need to install a flow meter at a remote pump site that already has a single Modbus line connected to a PLC that is used to control the pumps.

Port expanders are available from third party manufacturers; these allow several Modbus slave devices to be connected to a single Modbus Master device. Typically, a single port expander will have 3–5 separate Modbus ports on it. Depending on the manufacturer, the user may be able to configure each of these ports for different communications parameters. In essence, not only does this type of port expander allow multiple slave devices to be connected to a single Modbus master device, but it can also be configured to convert incompatible communications parameters such as Modbus ASCII to RTU (or vice versa), baud rate, parity, stop bits, etc.

In addition to the port expanders mentioned above, other protocol converters from third-party manufacturers, can be used to convert other industrial protocols to Modbus ASCII.

E.12 Other Reference Material

SCADA ANSI Specification. ANSI/IEEE Std. C37. 1–1994.

Boyer, Stuart A. *SCADA supervisory control and data acquisition.* Research Triangle Park, NC: Instrument Society of America. 1993.

MODICON. *Modicon modbus protocol reference guide.* North Andover, MA: MODICON, Inc., Industrial Automation Systems. 1996.

AEG Schneider Automation. *Modicon ladder logic block library user guide.* North Andover, MA: AEG Schneider Automation, Inc. 1996.

E.13 Troubleshooting Tips

Problem: 950 Flow Meter responds to some Modbus messages but not all

Response: Check the Register Addresses
The flow meter will only respond to valid Modbus message requests. If a Modbus message sent to the flow meter asks for stored register addresses for values that are outside of the address range currently supported by the meter, the meter will ignore the request.

The flow meter currently only supports register addresses 40001 through 40083. Consequently, a request to read the value in any register address greater then 40083 will be ignored. If a range of registers is requested and that range includes register addresses greater then 40083, the entire request will be ignored

Response: Check the number of registers being polled
Additionally, the 950 Flow Meter checks all Modbus messages to see if the correct number of registers is requested for the type of data being returned. The meter will ignore the request if the number of registers requested does not coincide with the correct number of registers needed to accurately display the data. For example, Velocity is a floating point value stored in register 40009–40010. Because all floating point values require two registers, the meter would ignore a request to read just the data in register 40009, yet it would respond correctly to a request to read the data stored in both registers 40009 AND 40010. Consequently, if the meter received a single request to read both Level 40007–40008 and Velocity 40009–40010, the request would have to be for an even number of registers for the meter to respond.

Problem: 950 Flow Meter does not respond to any Modbus message requests

Note: *It is imperative that the DTR be asserted prior to the communication session and that it remains asserted throughout the entire communication session.*

Response: Check the DTR Signal/Line
The 950 Flow Meter will not respond to any Modbus messages until the device connected to the RS232 port asserts (raises) the DTR line (DB-9, Pin 4 on the 1727 cable).

Response: Check the Baud Rate
The baud rate of the 950 Flow Meter is configured from 1200–19,200 and must match the baud rate of the device communicating with the meter.

Response: Check the Communication Parameters
The communications parameters of the 950 Flow Meter meter are fixed (except for the baud rate) and can not be changed. The device communicating with the flow meter must be configured with the exact same communication parameters as the meter. These parameters are as follows:

- 7 Data Bits
- 1 Start bit
- 1 Stop bit
- Even parity

Response: Check the Modbus Device Address assigned to the 950 Flow Meter
Modbus devices, including the 950 Flow Meter, have a unique configured device address in the range of 1 to 247. This address is embedded in the first two characters of the Modbus message. The flow meter will only respond to messages encoded with the same

address as the meter. If the meter receives a valid Modbus message with an encoded device address other than the address the meter is configured for, it will ignore that message.

Response: Check the Modbus mode
There are two different forms of Modbus: ASCII and RTU. Currently the 950 Flow Meter only support Modbus ASCII. Consequently the device communicating with the meter must be setup for Modbus ASCII. The meter will not respond to Modbus RTU messages.

Problem: The data values being returned by polling the meter with Modbus are not the same as the data values displayed in the current status screen of the meter.

Response: Confirm that the correct register addresses are being polled.
Check to make sure the register address being polled corresponds to the correct data channel. For example, if polling for FLOW, make sure the server or MMI is requesting data from registers 40033–40034.

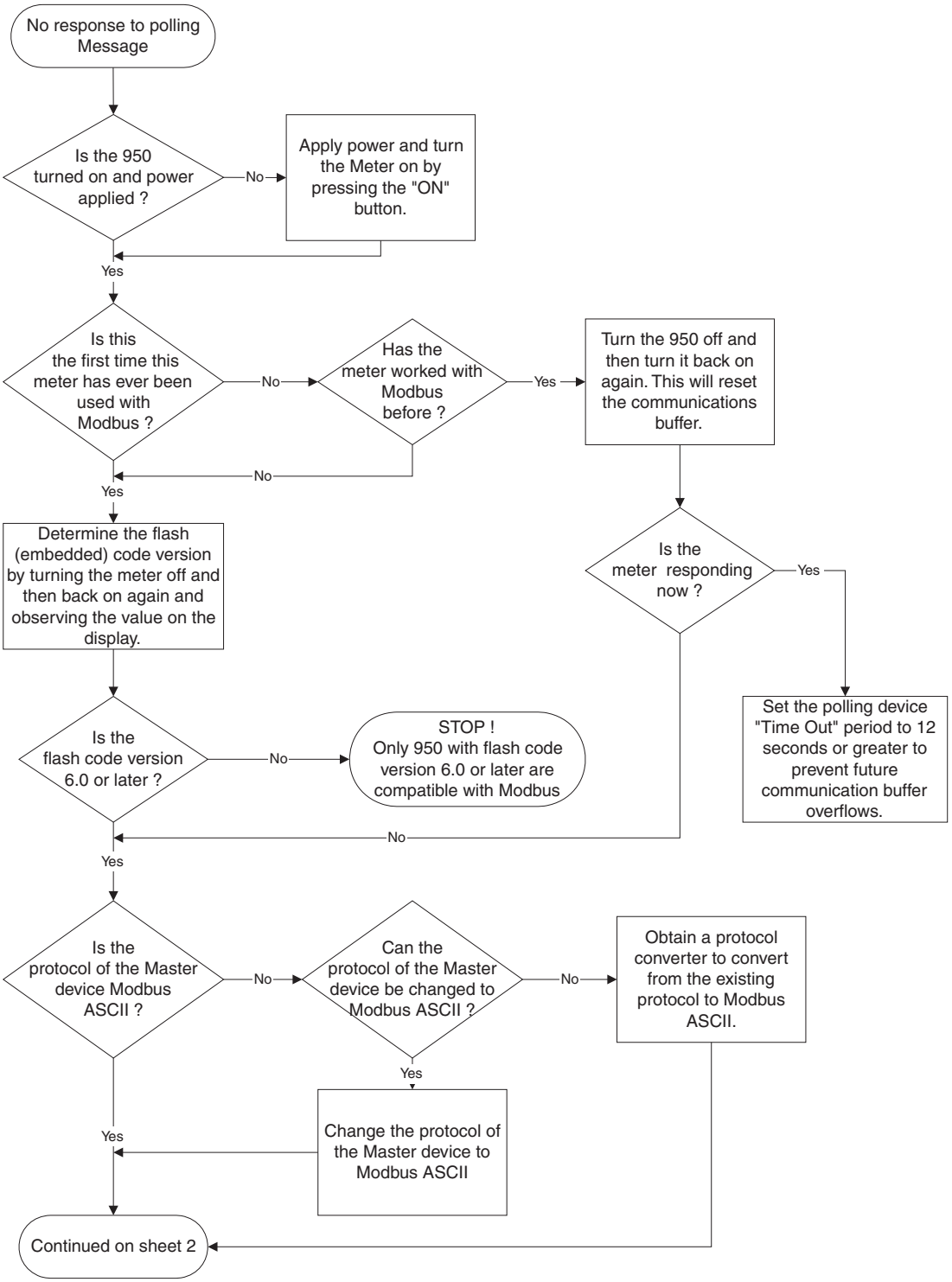
If polling for several values at the same time, try changing the polling so that only one value is polled at a time. Then check to see if the polled value matches a different data channel in the meter. For example, if polling for Level and it appears that you are getting the data for Velocity instead, you probably are polling the wrong registers.

Response: Check the data format of the Modbus server.
When configuring a Modbus server or MMI application to poll a 950 Flow Meter, it is absolutely essential that the correct data format is selected for that particular data channel (register). For example, when polling for Flow, Level or Velocity, which are all floating point values, the Modbus server or MMI must be configured to read these values as floating point values. If the server or MMI is formatting this data as a data type other then floating point, the values will not be read or displayed correctly.

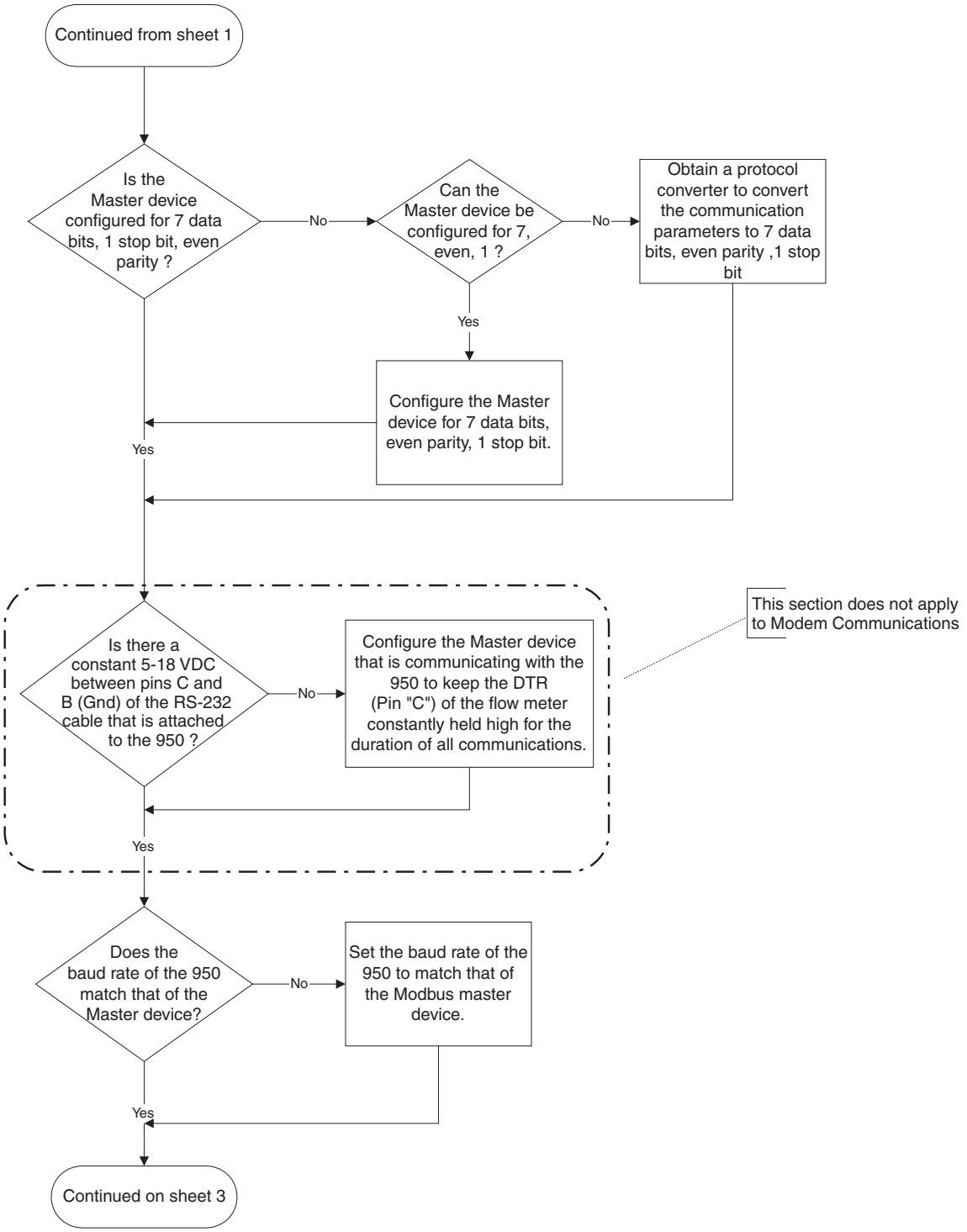
Likewise, if polling the meter for engineering units, which are represented by integer values, such as Flow Units of Measure or Level Units of Measure, the Modbus server or MMI must be configured to read these values as Integers. If the server or MMI is formatting this data as any data type other than Integer, the values will not be read or displayed correctly.

Different Modbus servers and MMI manufacturers have different methods for configuring the application to the appropriate data type contained within the register. Contact the server or MMI manufacturer for details on how to configure the application to read the data in the correct format.

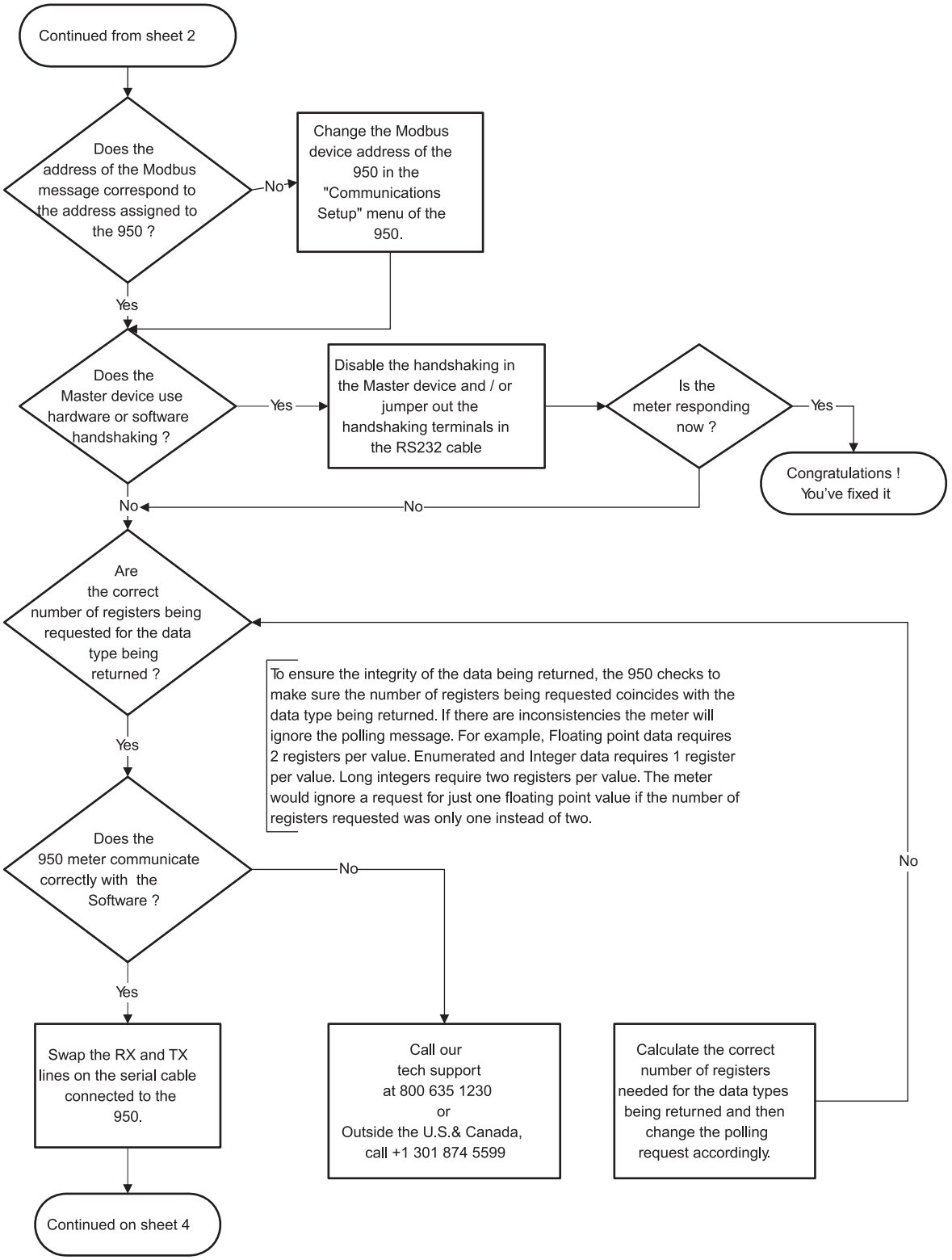
950 SCADA-Modbus "No Response" Troubleshooting Flow Chart (1 of 5)



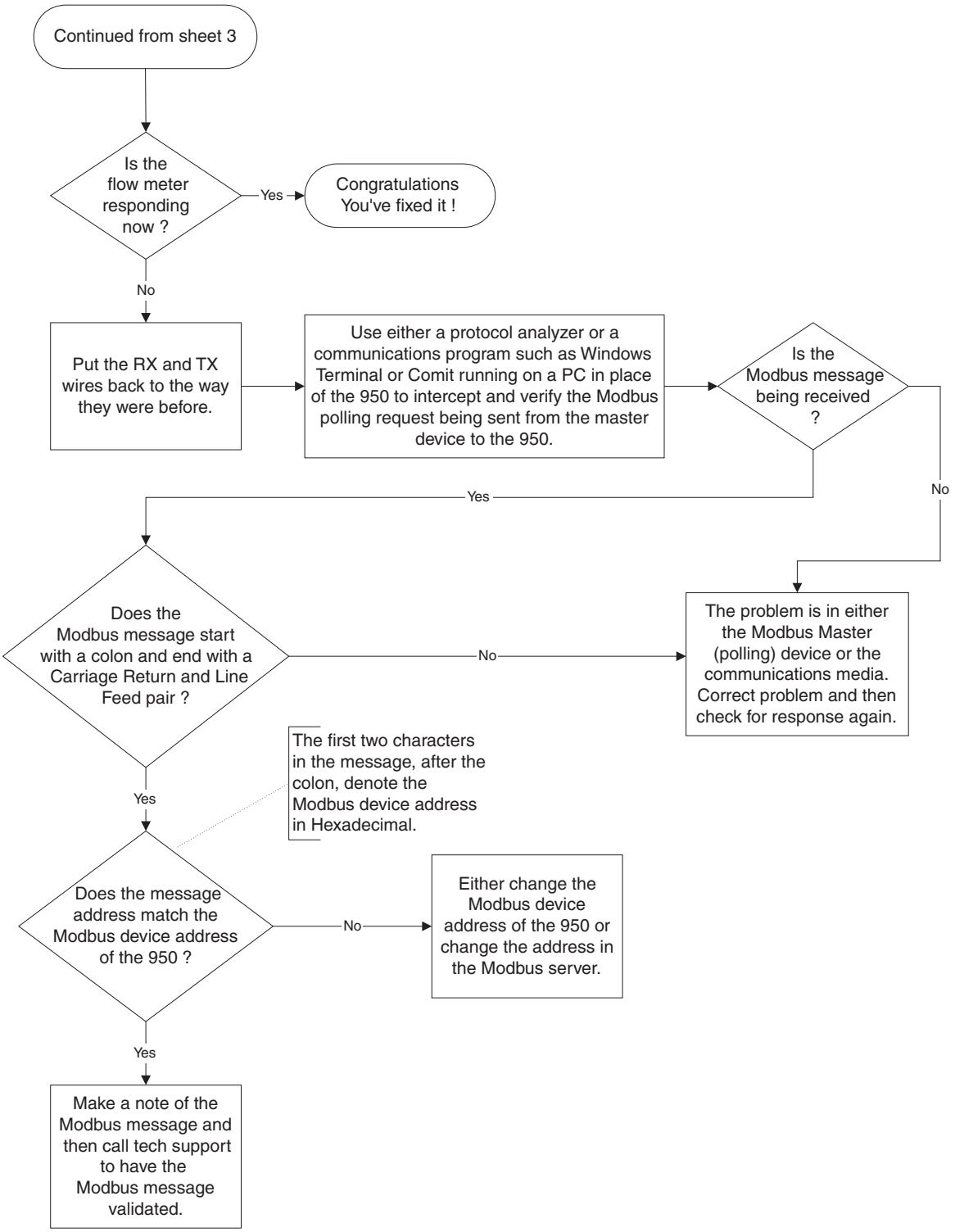
950 SCADA-Modbus "No Response" Troubleshooting Flow Chart (2 of 5)



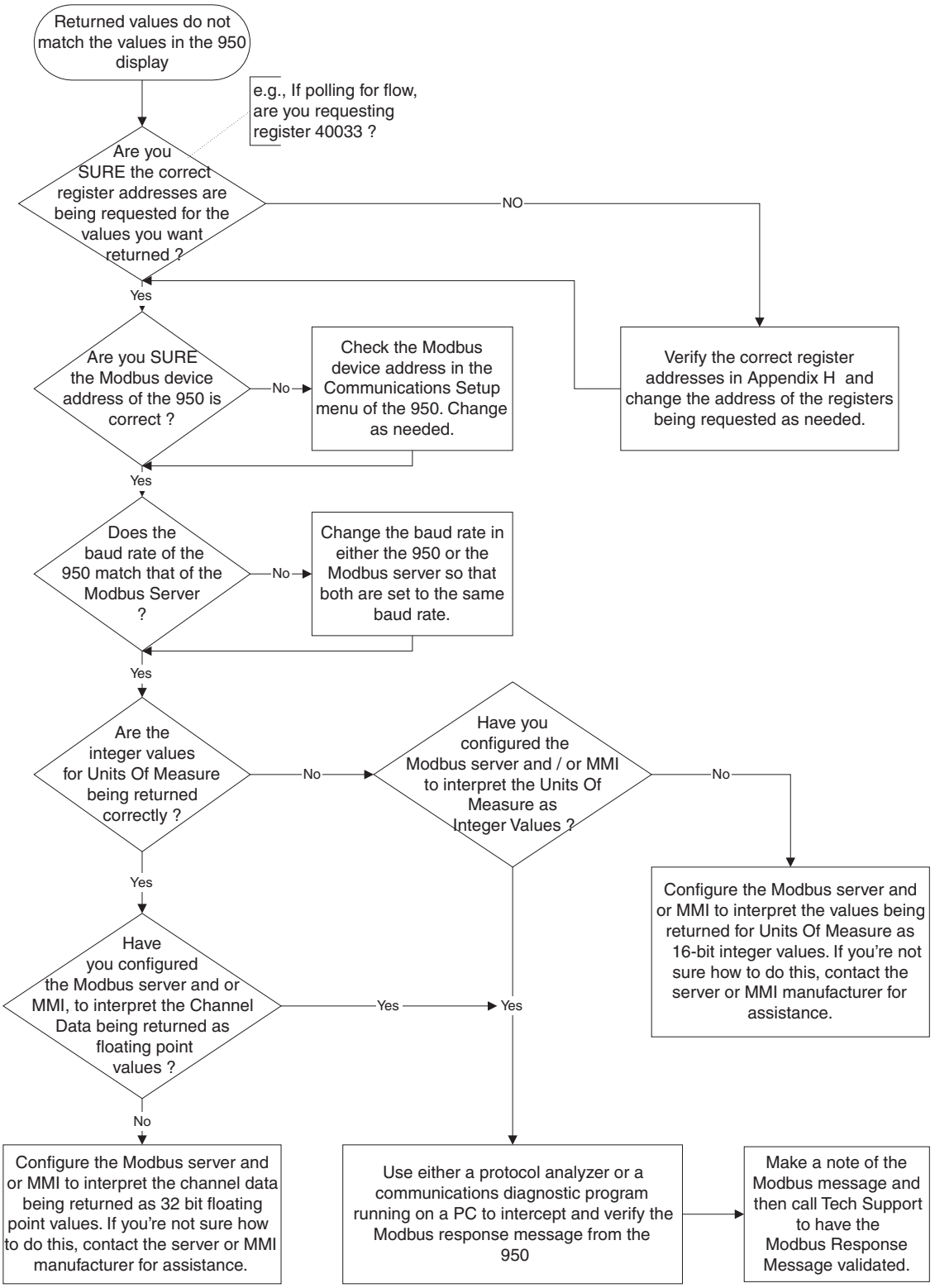
950 SCADA-Modbus "No-Response" Troubleshooting Flow Chart (3 of 5)



950 SCADA-Modbus "No-Response" Troubleshooting Flow Chart (4 of 5)



950 SCADA-Modbus "No Response" Troubleshooting Flow Chart (5 of 5)



Appendix F Batteries and Chargers

ATTENTION
Pour préserver la sécurité de l'utilisateur et éviter d'endommager l'équipement, rechargez exclusivement les accumulateurs avec les chargeurs Hach Company spécifiés.

CAUTION
To ensure user safety and prevent damage to equipment, use only the specified Hach Company battery chargers to recharge batteries.

F.1 Lead-Acid (Gel Cell) Batteries

The manufacturer's lead-acid batteries are designed to prevent electrolyte leakage from the terminals or case. The electrolyte is suspended in a gel, which ensures safe, efficient operation in any position. Gel cells are classified as "Non-Spillable" and meet all requirements of the International Air Transport Association.

Maintenance
The manufacturer's lead-acid batteries are maintenance-free.

Charging
The manufacturer's lead-acid cells are designed to be fully charged in 22 to 24 hours using their lead-acid battery charger. Do not exceed 24 hours or you may damage or shorten the life of the battery. The charge rate is 500 mA DC. LED is lit, indicating the battery is charging. The battery is fully charged when the LED indicator turns off.

Temperature
At higher temperatures, the electrical capacity that can be taken out of a battery increases. At lower temperatures, the electrical capacity that can be taken out of a battery decreases. However, excessive heat kills batteries. Avoid placing batteries near heat sources of any kind. To maximize battery life, operated the battery at an ambient temperature of 20 °C (70 °F). The permissible operating temperature range is -15 to 50 °C, however, use in the 5 to 35 °C temperature range is recommended.

Storage
Store lead-acid batteries in a cool, dry place. Their low self-discharge rate and excellent charging characteristics permit storage for up to one year without loss of efficiency or appreciable deterioration of battery performance.

Table 49 Lead-Acid Battery Storage Recommendations

Storage Temperature	Maximum Recommended Storage Time
0 to 20 °C	12 months
21 to 30 °C	9 months
31 to 40 °C	5 months
41 to 50 °C	2.5 months

F.2 Nickel-Cadmium Batteries

Nickel-cadmium batteries provide superior power capabilities when used at low temperatures. They also perform a higher number of charge/discharge cycles than lead-acid batteries.

Maintenance

Nickel-cadmium cells are sealed. They contain no free electrolyte, and in most cases require no service or maintenance other than recharging.

Charging

Charge new nickel-cadmium batteries prior to use due to their self-discharge rate. Nickel-cadmium cells are designed to be fully charged using a Hach Company nickel-cadmium battery charger within 14 to 16 hours. Do not exceed 16 hours or you may damage or shorten the life of the battery. The charge rate is 400 mA DC. The L.E.D. indicator is on continuously when charging a nickel cadmium battery.

Storage

At room temperature, the self discharge rate of nickel-cadmium batteries can be as high as 2% per day. When charged cells have been stored for a long period of time, or at an elevated temperature, a change starts to take place in the negative electrode. The structure changes so that it is less reactive than a fresh cell. This structure will return to normal after one or two charge/discharge cycles. Batteries which have been stored for extended periods of time (longer than 1 week) should be fully charged prior to use.

Nickel-cadmium cells can be stored for extended periods of time, in either a charged or discharged condition, without significant degradation in their performance (Table 50). However, after long storage periods, the battery pack may require a few charge/discharge cycles to restore its full capacity.

Table 50 Nickel-Cadmium Battery Storage Recommendations

Storage Temperature	Maximum Recommended Storage Time
20 to 30 °C	9 months
30 to 40 °C	5 months
over 40 °C	3 months

F.3 Alkaline Lantern Battery Pack

The Alkaline Lantern Battery Pack (P/N 3893) allows customers who are doing long-term flow studies or multi-site flow studies to use a disposable battery instead of a rechargeable battery. This allows you to log data for extended periods of time without having to check the battery or replace it with a charged one. The battery pack offers extended operating periods when used in conjunction with 950 Flow Meters.

Maintenance

The Alkaline Lantern Battery Pack requires little to no maintenance because it is not rechargeable and it is completely sealed and watertight. The only maintenance required is to replace the internal Alkaline Lantern Batteries when they expire. Keep the sealing gasket in the channel along the top of the battery base clean and clear of any debris that may prevent a good seal between the lid and the case.

Charging

Under no circumstances should the Alkaline Lantern Battery Pack be charged. There are no provisions for charging the battery pack and doing so will result in damage to the battery pack and possible injury to the user.

Proper Selection of Batteries

The proper selection of batteries for the Alkaline Lantern Power Pack is very important. The recommended battery for the battery box is the Eveready® Energizer® Model Number 529 or EN529-CAN. These are industrial grade, alkaline lantern batteries with

spring terminals. We only recommend these batteries for the battery box. Use of any other battery may cause damage to the battery pack assembly and/or decreased battery life.

When to Replace the Batteries
The circuitry associated with the Alkaline Lantern Battery Pack is designed to boost the working battery voltage to 12 VDC or higher while the alkaline batteries discharge and expire.

As the collective voltage of the alkaline batteries begins to drop, the booster circuitry of the Alkaline Lantern Battery Pack will begin to lose its effectiveness. As the batteries expire, the displayed voltage will begin to drop. When the displayed voltage gets to 11 VDC, the flashing “Low Main Battery” warning will appear on the lower right menu bar. The flow meter will continue to operate down to 10.5 volts but you should replace the batteries soon.

If the flow meter contains a bubbler module and/ or is operating in freezing to subzero climates, you should consider replacing the batteries when the displayed voltage reads 12 VDC.

Factors Effecting Alkaline Lantern Battery Life

Cold Temperatures:
If the ambient temperature drops between freezing and -20 °C, the battery pack will experience a 0 to 40% loss in life. Although this loss is extensive, as the temperature rises to above freezing, the battery will recover with an overall minimal degradation to battery performance. This, of course, is dependent upon the length of time the battery is exposed to these temperatures. The Alkaline Lantern Battery Pack is not recommended for these applications. Use of the Alkaline Battery Box in freezing or sub-zero weather may cause a premature ‘Program Complete.’ If the voltage drops to 10.5 VDC or lower, the meter may shut itself down and complete the program to protect stored data.

Steady Flow:
In conjunction with cold temperatures, constant flow in a seasonal climate will keep the air temperature in the manhole around 45 °F (7° C). If the flow stops, then the ambient temperature would tend to equalize with the temperatures experienced above the manhole. If the outside temperature is at freezing or less, then the effects of the cold conditions listed above may occur.

High Velocities:
Sites with velocities running at eight to twelve feet per second will tend to force the flow meter to “stay awake” longer to take a valid velocity reading of the flow stream. To “stay awake” means that the meter has gone from a powered down idle state, drawing only 1 mA, to being fully powered up in order to operate the circuitry involved in recording a reading. Normally, the unit will power up for four seconds or less to take a reading. Higher velocities cause the meter to stay on a few seconds longer before determining that the velocity reading is valid. Essentially, the meter may actually ‘stay awake’ twice as long per recording interval. This combined overall awake time can decrease battery life.

Improper Installation of Velocity Probes:
Any velocity probe that is installed incorrectly will cause the meter to process longer to determine a valid velocity. The probes must be mounted level and pointed straight or parallel in the flow stream. If possible, locate the probe in non-turbulent sites.

Improper Installation of Ultrasonic Probes:
Mount ultrasonic probes firmly and parallel with the flow stream surface. If the probe is mounted at an angle to the flow stream, the meter will increase the gain on the signal and

wait longer for a valid ultrasonic depth measurement. This will also equate to decreased battery life.

Options:
The following options will cause excessive current draw:

- Modem, if left enabled.
- Alarm Relays
- 4 to 20 mA outputs
- Analog Channels (If using 12 VDC internal supply)

Recording Channels:
Each channel added to the recording interval, adds additional awake time to the interval. Optimum recording is obtained logging two channels or less.

Downloading from the Data Transfer Unit:
The frequency at which the meter gets downloaded will also affect battery life. During an RS232 download to a Data Transfer Unit, the meter must power up to retrieve the data from memory, and also power the Data Transfer Unit. Download data only once per week or less when possible.

Selection of Batteries:
Using the wrong batteries in the Alkaline Battery Pack will result in less than expected battery life and could possibly damage the assembly.

The LED indicator located above each charging station functions differently, depending on the type of battery being charged.

Appendix G Troubleshooting

Basic Troubleshooting

Problem	Causes	Solutions
Instrument Will Not Power Up With ac Power	Blown fuse.	Check the fuse located on the base board (see section 9.4 on page 79).
	Circuit breaker issue.	Check the circuit breaker for the main power.
	Breaker is good, but still no power.	Check to see if the outlet is receiving power.
	Breaker and outlet is good, still no power.	Try using a battery or another power supply.
Instrument Will Not Power Up With DC Power	Blown fuse.	Check the fuse located on the base board (see section 9.4 on page 79).
	Battery is not charged.	Replace with a fully charged battery.
	Battery is dead.	Try using an ac power supply or a different battery.
	Gel or Nickel Cadmium battery has been submerged and internal corrosion has occurred.	Replace the battery pack.
	Incorrect battery usage.	Use manufacturer battery.
Short Battery Life	Voltage range is insufficient.	Ensure a gel cell or nickel cadmium voltage is in the 12.6 to 13.4 volts range when fully charged.
	Battery power is draining to quickly.	Fully charge the battery and let it sit for an hour before checking the voltage. Replace the battery if the voltage of the battery drops below 12 to 12.5 VDC within an hour.
	Modem is operating.	Check to see if the unit is using a modem. Flow Meters with a modem should always be on ac power, or scheduled when using the cell option.
Low Main Battery	Battery power is running low.	Change battery.
Memory Battery	Internal memory battery needs to be changed.	Replace the two c-cells inside the unit.
Low Slate Memory	Free slate memory is less than 20%. RAM memory is almost full and will stop recording soon.	Download data from unit, halt and restart the program or download data, halt, and change data to wrap mode.
Slate Memory Full	No more slate memory. Unit is in slate memory mode and cannot log any more data.	Download data and restart the program or download data then change the memory mode.
Program Complete	The program has completed and no more data will be logged.	If using slate mode, change to wrap mode.
	The power is interrupted for more than three hours due to a power outage or dead battery.	Use an ac power backup option. This is a customer purchased item when using ac mode. Download data and restart program.
Modem Failure	Problem with modem board.	Contact factory.
No 4–20 Output/Totalizer Stopped.	Program complete.	Enable 4–20.
	4–20 not enabled.	

Troubleshooting the Bubbler Depth Sensor

Problem	Cause	Solution
Low Bubbler Pressure	Bubbler does not turn on during initialization.	Power unit off for 10 seconds and power back on. Listen for the bubbler pump to turn on during unitization. If the pump does not run, contact the factory.
	Desiccant is pink.	Change the desiccant.
	Desiccant is blue.	Check the bottom of the cartridge for a blockage or coating.
	Kinks in the bubbler module airlines.	This is determined with the unit open. Remove kinks.
Clogged Bubbler	Blockage in the bubble tube.	Remove the vinyl bubbler tube from the bubbler port on the side of the flow meter case and check for obstructions.
		Visually check the end of the bubble tube port for solids blocking the line.
		Check the bubble line/cable for any tight bends that may cause a kink in the line.
No Change in Bubbler Depth Readings	Reference port desiccant is pink and is causing a blockage in the reference port.	Replace with new desiccant.
	The desiccant is blue and no change in depth readings.	Remove the tube connecting the desiccant cartridge to the reference port on the side of the meter. If the depth readings return to normal, the desiccant cartridge is plugged. Carefully remove the desiccant end caps and check the air intake area for debris. Make sure the membrane is not coated with grease.
Incorrect Flow Totals	Improper flume installation. Walls include bows or bends.	Reinstall the flume in a more appropriate site location.
	Incorrect depth on the AV meter.	Adjust the depth.
	Turbulence	The turbulence should be at least 5 pipe diameters behind the sensor and 10 diameters in front. For greatest accuracy it should be a smooth laminar flow near the sensor.
Inaccurate Bubbler Depth Readings	Bubbler needs to be calibrated.	Calibrate the Bubbler.
	Tubing is plugged.	Use the purge line in the options menu to clear line. Decrease the time for auto purge to 10 minutes. Also, clean out the bubble line with 40 to 50 psi of compressed air or replace the bubble line.

Troubleshooting the Submerged Area/Velocity Sensor

Problem	Cause	Solution
RS485 Time Out—Unit did not receive data with specified time.	CPU board is having trouble communicating with the velocity board.	Wait a few minutes and see if the condition disappears. If it continues there is a problem with the velocity, ultrasonic, or CPU board.
	Logging intervals are 1 or 2 minutes, conditions are poor, and the problem continues indefinitely.	Increase the logging interval to allow more time to capture the signal.
	Difficulty receiving a velocity reading.	Indicates an internal problem.
Zero Velocity or Velocity Drop Outs	Sensor is covered with sediment.	Clean the sensor.
	Low particulate levels in the channel.	Stir up the water in front of the probe and watch the signal strength. If the signal starts to vary this may be an indication of low particulate in the channel.
	Unusual events occurred.	Check the event log for unusual events that occurred around the time of the velocity problems.
	Radio Interference in the area.	Move the unit to a different location.
Loss of Area Velocity as Primary Device	Blown fuse on the CPU board—the prompt was there and then disappears.	Replace the fuse, located in position F1 under the gray ribbon cable that connects at position J1 (see section 9.4 on page 79).
Inaccurate Velocities	Obstructions	Obstructions should be a minimum of 5 pipe diameters downstream and 10 diameters upstream.
	Eddies and waves returning flow back into the pipe could be causing incorrect velocities.	Relocate the probe.
	The invert has an unusual construction such as a rounded section in the middle of the invert or drops that may cause a draw-down effect.	Relocate the probe.
	Mounting band and probe are not positioned correctly—it was working fine, then had trouble.	Check the mounting band and probe to see if it slipped out of poisiton.

Troubleshooting the Submerged Depth Only Sensor

Problem	Cause	Solution
Depth readings are inaccurate or no change in depth readings.	Incorrect calibration.	Check to see if the unit is calibrated. Re-calibrate the sensor to the unit.
	Sensors have been swapped between units and where not re-calibrated.	Sensors must be re-calibrated each time they are placed on another unit.
	Desiccant is clogged.	Replace if the desiccant has turned pink.
	Depth is trending upward because of water or debris in the atmospheric reference tube.	Clean and re-calibrate.
	Depth is trending downward due to debris in the diaphragm.	Remove the plate and carefully clean out the debris.
	Silt is covering the sensor.	Clean sensor.
Excessive Debris Collection	Improper use of sensor mounting band.	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. The cable should exit the tied area at, or near, the top of the pipe to keep it out of the flow stream.
Submerged Depth readings are inaccurate or no change in depth readings.	Improper calibration.	Check to see if the unit is calibrated. Re-calibrate the sensor.

Troubleshooting the Ultrasonic Sensor

Problem	Cause	Solutions
RS485 Time Out—Did not get a reading with the specified time allotted	CPU is having trouble communicating with the Ultrasonic board.	Wait a few minutes and see if the condition goes away. If it continues there may be a problem in the Ultrasonic, Velocity or CPU board, and you should contact the factory.
U-Sonic Echo Loss—Flow Meter Not Receiving a Return Echo from the Ultrasonic Transducer	Excessive foam on the water surface cause sound waves to be absorbed rather than reflected.	Check for excessive foam.
	Sensor is knicked or cut or improperly installed.	Check for knicks, cuts, and the sensor installation.
	Sensor must be level for proper return of signals.	Make sure the ultrasonic transducer is level.
	Convection currents are present which varies the speed of sound.	Try shielding the transducer from convection currents. Echo loss should not exceed more than two hours.
	Temperature calibration set up incorrectly. Extreme high or low temperature indicates a bad temperature transducer in the temperature sensor.	Go through the temperature calibration procedure and determine what temperature the unit is sensing. Replace transducer if necessary.
U-Sonic Failure—No Signal from the Ultrasonic Transducer	Transducer is not connected.	Check the ultrasonic sensor connection on the flow meter.
	Cut or broken cable.	Check for any knick or cuts in the cable.
	Unusual temperature or inability to read new calibrated level.	Re-calibrate the unit.
XDucer Ringing—False Return Echo mask Real Echoes	Liquid is too close to the transducer.	Try moving the transducer farther from the liquid—more than 15”.
	Obstructions under the transducer.	Check for obstructions on the front and sides of the transducer (see section 6.1.3.3 on page 39).
	Coating on the face of the transducer.	Clean the transducer face. If this is a constant problem, try coating the face of the transducer with a very thin film of silicone grease to keep the debris from collecting.
	The transducer resonates against steel mounting rails.	Use the proper rubber isolation washers.
No Change in Depth Readings or Inaccurate Depth Readings	—	Check the logged data to see when this started to occur. Go to the event log to see if anything happened during the same time.
	Calibration	Re-calibrate the unit.
	Echo loss or ringing occurs, but not enough for detection.	Check the trouble areas.
	Bad transducer.	Try a different transducer.
Loss of Ultrasonic as Depth Measuring Device	Blown fuse on CPU board.	Replace fuse. The fuse is located in position F1 under the gray ribbon cable that connects at position J1. (see section 9.4 on page 79).
	Problem with the ultrasonic board.	Contact factory.

Troubleshooting the Low Profile Velocity-Only Sensor

Problem	Cause	Solution
Zero Velocity Reading	The sensor is not covered with water.	Make sure the sensor is in water.
	Not enough suspended solids.	Throw dirt into the water, upstream of the sensor, to reset the sensor.
		Look at current status and watch for increased velocity signals. Re-evaluate application.
	The beveled face of the sensor is covered with sediment/algae growth, rags, etc.	Clean the sensor.
Erratic Velocity Readings	The sensor is not covered with water.	Make sure the sensor is in water.
	Not enough suspended solids.	Throw dirt into the water, upstream of the sensor, to reset the sensor.
	The beveled face of the sensor is covered with sediment/algae growth, rags, etc.	Clean the sensor.
	Occurs only when using a laptop.	Make sure the laptop is not running on a power inverter or malfunctioning serial port.
	Electromagnetic interference near the meter or sensor cable (i.e. a large pump motor).	Make sure there are no electromagnetic interferences. Remove interferences or move the meter and sensor cable away from the interferences.
	Problem occurs at the same time of the day because the sensor is not covered with water during certain times of the day.	Make sure the probe is covered at all times, especially during the early morning hours.
	Turbulence in front of the sensor.	Make sure there is no or little turbulence up to 20 ft away from the sensor.
	Probe is not facing the right direction.	Install the sensor facing the proper direction to the flow.
	Noise coming in on RS232, ac power lines, and 4–20 output lines.	Disconnect the RS232, ac power line, and/or 4–20 mA output. Power the unit off and on to reset it.
Velocity Reading Constant if 32 ft/s	The beveled face of the sensor is covered with sediment/algae growth, rags, etc.	Clean the sensor. After cleaning, it may be necessary to reset the unit by disconnecting power for a minute.
	Electromagnetic interference near the meter, sensor cable, or RS232 connection.	Make sure there are no electromagnetic interferences. Remove interferences or move the meter and sensor cable away from the interferences.
	Mild power surges.	Reset the unit by disconnecting power for a minute.

Troubleshooting the pH Probe

Temperature Swings—Severe temperature swings will affect probe response. Very high temperatures can cause the gel in the probe to expand and seep out through the porous Teflon® junction and when temperature drops, air is sucked in through the junction. If the temperature rises again, the air expands pushing more gel out the junction. This type of cycling will eventually cause probe failure.

Build-Up of Contaminants on Probe—Some sites coat the probe with contaminants such as grease. In these environments, mount the probe so that the water “scrubs” the probe. For example, mount the probe so that probe tip faces downstream; this lets the cable protect the probe tip. Alternatively, mount the probe with the tip pointing into the flow so that the flow scrubs the tip. Some sites require that the probe be mounted inside a short piece of perforated PVC pipe. At very poor sites, mount the probe inside more than one piece of perforated PVC with the holes offset.

Problem	Cause	Solution
Meter continuously reads pH 14 or drifts above 14	Open circuit in either glass or reference electrode.	• Inspect the cable and connector of the faulty electrode for evidence of a crushed or broken cable jacket or brittleness of the cable due to exposure to heat. Discard the electrode if damage is present. • Manipulate meter/electrode connections to check for intermittent continuity. Replace if faulty. • Inspect the bulb, making sure it is filled with solution. If not, shake down (like a clinical thermometer) to displace air in the pH bulb. Retest. • Inspect the bulb for signs of coating.
Slow response and/or erratic readings	Very high impedance in either glass or reference electrode.	• Inspect the pH bulb for coating or clogging. If present, clean thoroughly. • Keep the electrode wet at all times. If it dries out, the impedance will increase dramatically. To restore performance, soak in 0.1 N HCl (P/N 14812-53) for 30 minutes and rinse well with distilled water. • Chemical degradation of pH glass can occur rapidly in a high temperature or high pH environment, yielding sluggish response. Low temperature environments can double the impedance for every 8 °C drop below 25 °C. • A high impedance electrode is extremely sensitive to electrical noise, e.g., oscillating electrical fields generated by motors, generators or discharges from electrical thermostats. A free-hanging cable swinging due to air currents will also generate erratic signals. • Manipulate electrode cable and connections to check for intermittent continuity. Replace as necessary.
	Ground loop problem.	• Check to see if the ground wire is connected properly at the pre-amp junction box. • Check for continuity between the stainless steel lug on the electrode and the ground wire at the interface. • Check an isolated sample. Place the probe in a beaker filled with water. If the probe reads fine in the beaker, but not in the stream, connect the pre-amp ground directly to the earth ground.
	Temperature is incorrect.	See “Temperature” symptom in this table.
No response to pH change.	Cracked glass bulb.	If the electrode gives readings between 5.8 and 6.2 pH in all solutions, inspect the glass bulb. If damaged, discard.
	Short circuit.	If a constant reading of 7.0 pH or 0.0 mV is obtained, inspect the cable. If no visible damage exists, remove the connector and test for a short circuit. Replace if faulty.
	High impedance bridge.	Inspect the connector for moisture or corrosion. If wet, rinse well with distilled water and dry thoroughly. Determine the cause of wetness and correct it.
Temperature is constant or incorrect	Interface is wired wrong.	Check interface wiring.
	Thermistor is open.	Check interface wiring. Check for open at electrode RTD wire. Disconnect to make measurement. (Should read approximately 100–110 ohms.)
Electrode won’t calibrate	Gain or offset error.	• Ensure that solutions are fresh and labeled properly. • Confirm that electrode and buffer temperatures have stabilized. • Confirm that the wetting cap is removed. • Check bulb for cracks or other damage. • Confirm that interface wires are connected properly. • Check interface connections for corrosion.

Appendix H Manning Roughness Coefficients

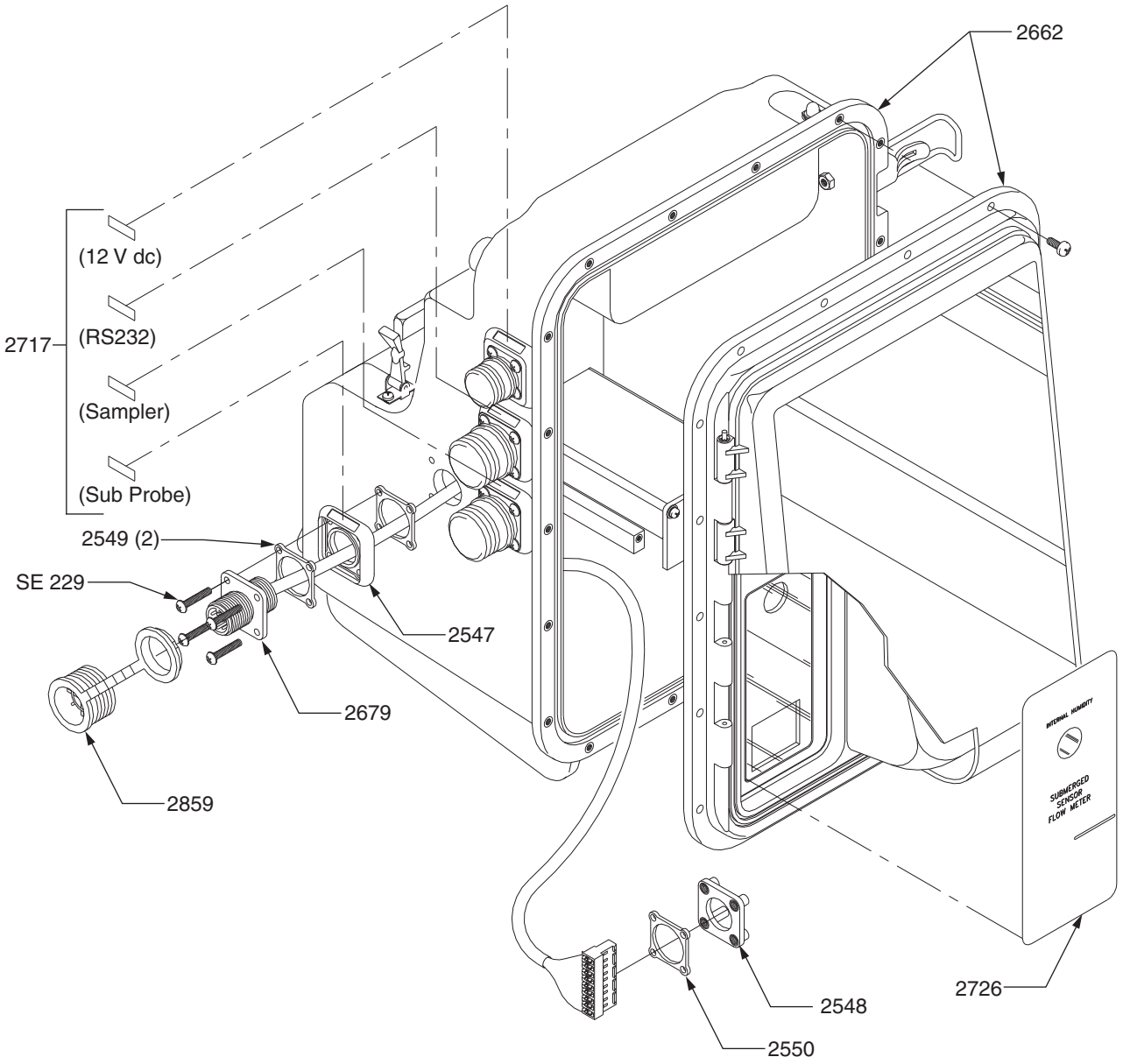
Closed Conduit - Partly Full				
Metal				
	Steel			
		Lockbar and welded	0.010	0.012	0.014
		Riveted and spiral	0.013	0.016	0.017
	Cast Iron				
		Coated	0.010	0.013	0.014
		Uncoated	0.011	0.014	0.016
	Wrought Iron				
		Black	0.012	0.014	0.015
		Galvanized	0.013	0.016	0.017
	Corrugated				
		Subdrain	0.017	0.019	0.021
		Storm drain	0.021	0.024	0.030
Non-metal					
	Acrylic		0.008	0.009	0.010
	Glass		0.009	0.010	0.013
	Wood				
		Stave	0.010	0.012	0.014
		Laminated, treated	0.015	0.017	0.020
	Clay				
		Common drainage tile	0.011	0.013	0.017
		Vitrified sewer	0.011	0.014	0.017
		Vitrified sewer with manholes, inlets, etc.	0.013	0.015	0.017
	Brick				
		Glazed	0.011	0.013	0.015
		Lined with cement	0.012	0.015	0.017
	Concrete				
		Culvert, straight and free of debris	0.011	0.011	0.013
		Culvert with bends, connections and some debris	0.011	0.013	0.014
		Sewer with manholes, inlet, etc., straight	0.013	0.015	0.017
		Unfinished, steel form	0.012	0.013	0.014
		Unfinished. smooth wood form	0.012	0.014	0.016
Non-metal					
	Concrete				
		Unfinished, rough wood form	0.015	0.017	0.020
		Sanitary sewers coated with sewage slimes	0.012	0.013	0.016
		Paved invert, sewer, smooth bottom	0.016	0.019	0.020
		Rubble masonry, cemented	0.018	0.025	0.030

Lined or Built-up Channels				
Metal				
	Smooth steel surface			
	Painted	0.011	0.012	0.014
	Unpainted	0.012	0.013	0.017
	Corrugated	0.021	0.025	0.030
Non-metal				
	Cement			
	Neat surface	0.010	0.011	0.013
	Mortar	0.011	0.013	0.015
	Concrete			
	Trowel finish	0.011	0.013	0.015
	Float finish	0.013	0.015	0.016
	Finished, with gravel on bottom	0.015	0.017	0.020
	Unfinished	0.014	0.017	0.020
	Wood			
	Planed, untreated	0.010	0.012	0.014
	Planed, creosoted	0.011	0.012	0.015
	Unplaned	0.011	0.013	0.015
	Plank with battens	0.012	0.015	0.018
	Brick			
	Glazed	0.011	0.013	0.015
	In cement mortar	0.012	0.015	0.018
	Masonry			
	Cemented Rubble	0.017	0.025	0.030
	Dry Rubble	0.023	0.032	0.035
Non-metal				
	Asphalt			
	Smooth	0.013	0.013	------
	Rough	0.016	0.016	------
	Vegetal Lining	0.030	------	0.500

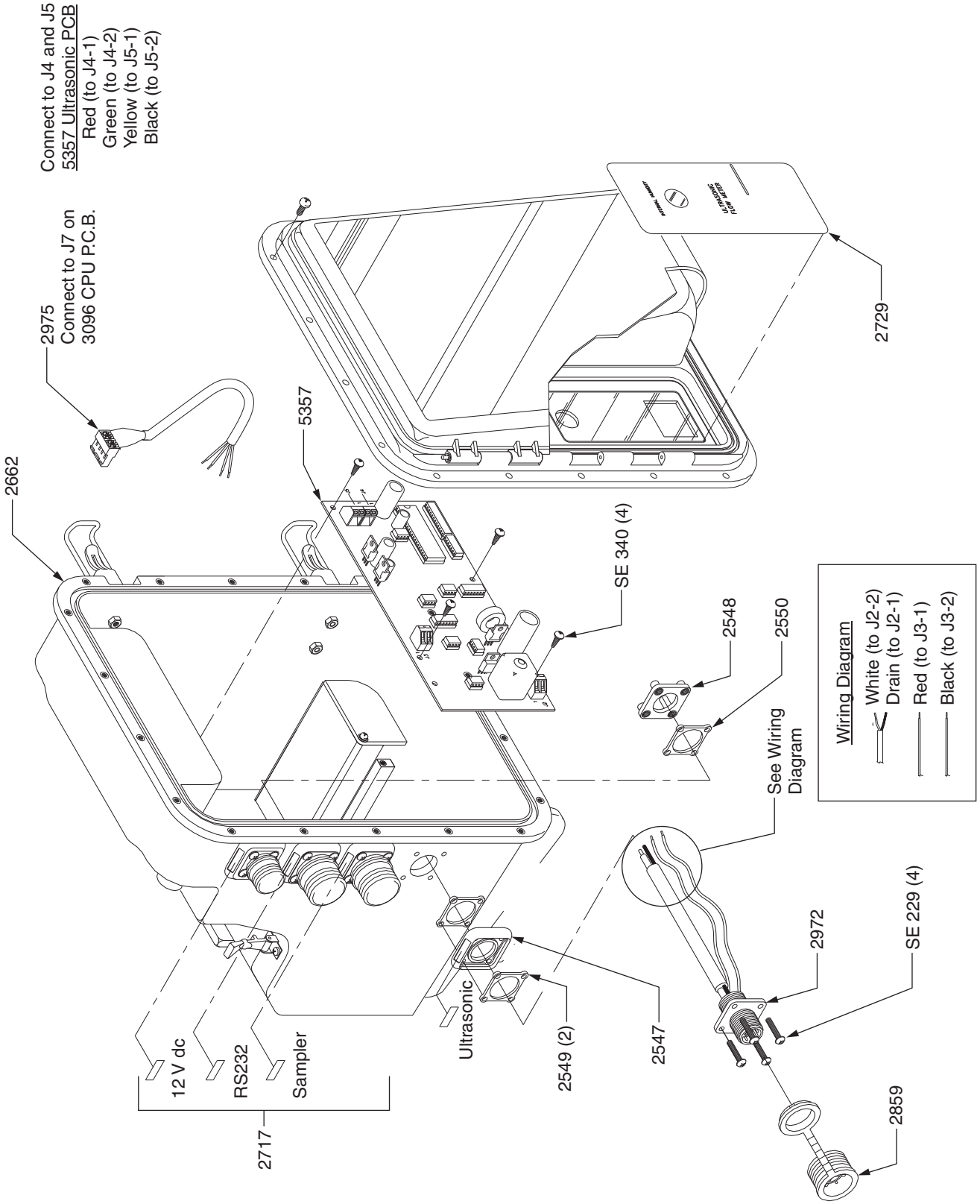
Excavated or Dredged			
Earth, straight and uniform	0.016	0.022	0.035
Earth, winding and sluggish	0.023	0.030	0.040
Rock cuts	0.030	0.040	0.050
Unmaintained channels	0.040	0.070	0.140

Natural Channels (Minor streams, top width at flood 100 ft.)			
Fairly regular section	0.030	0.050	0.070
Irregular section with pools	0.040	0.070	0.100

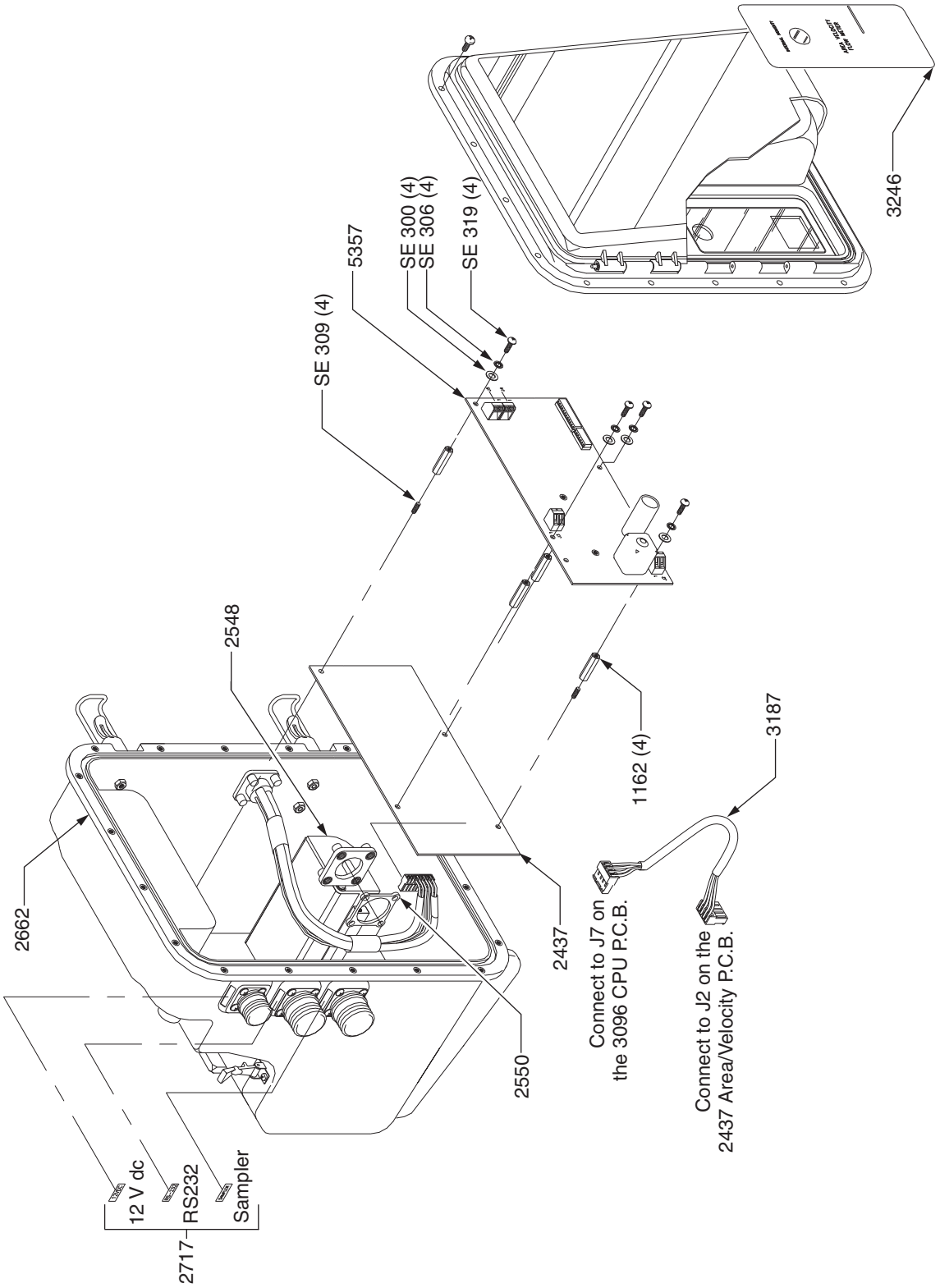
Submerged Flow Meter



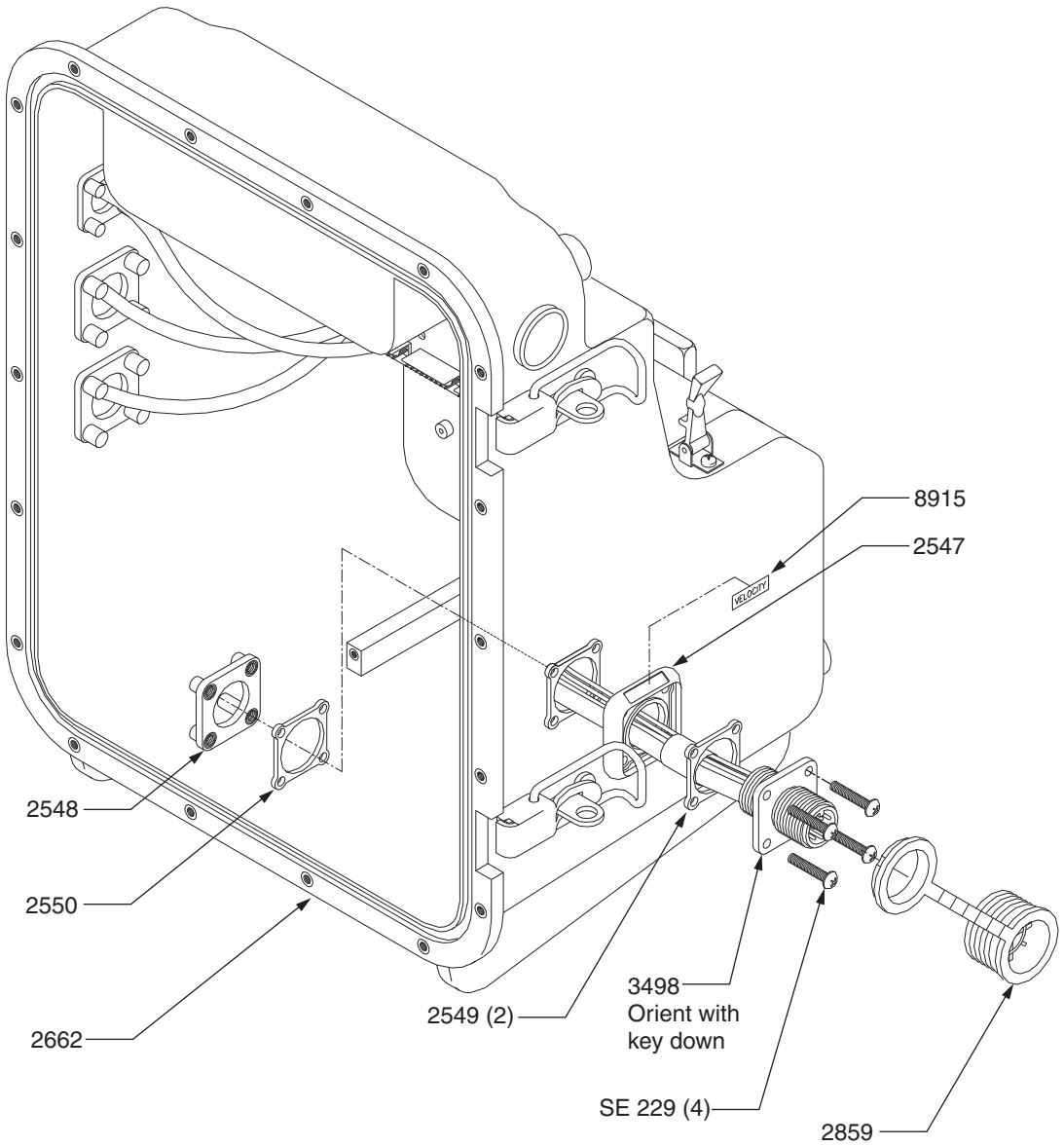
950 Flow Meter Ultrasonic Meter Assembly



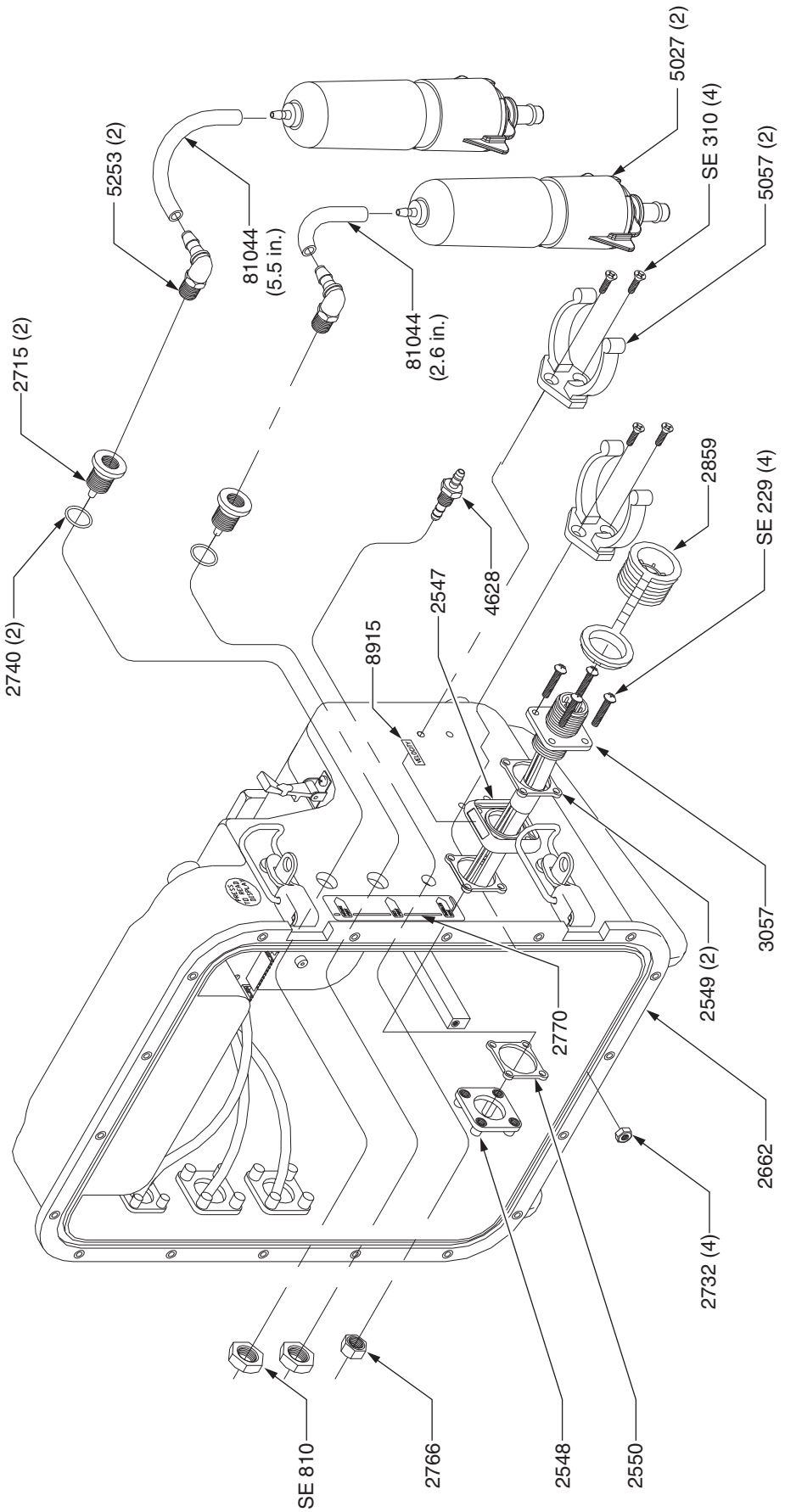
950 Flow Meter Area/Velocity (1 of 2)



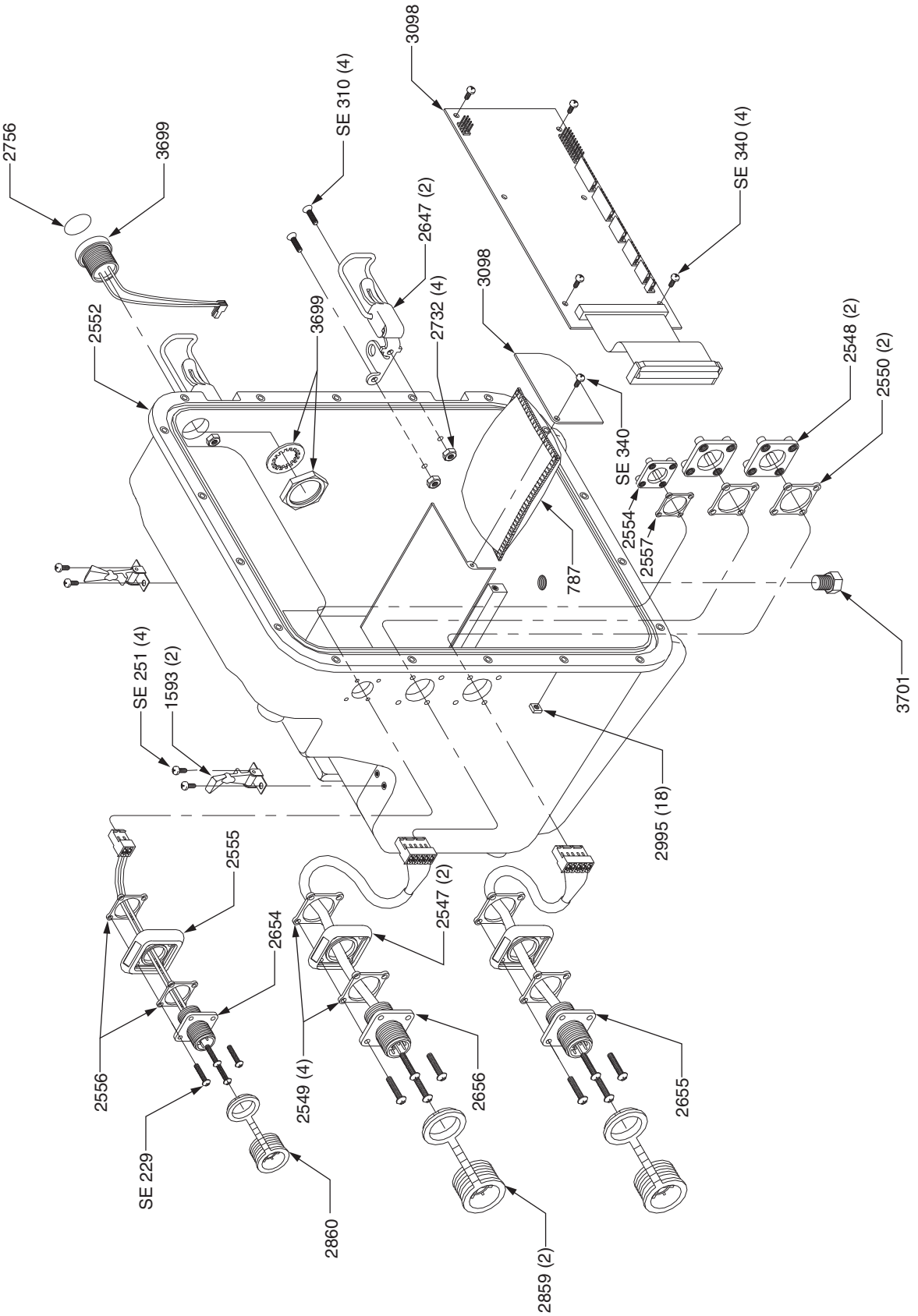
950 Flow Meter Area/Velocity (2 of 2)



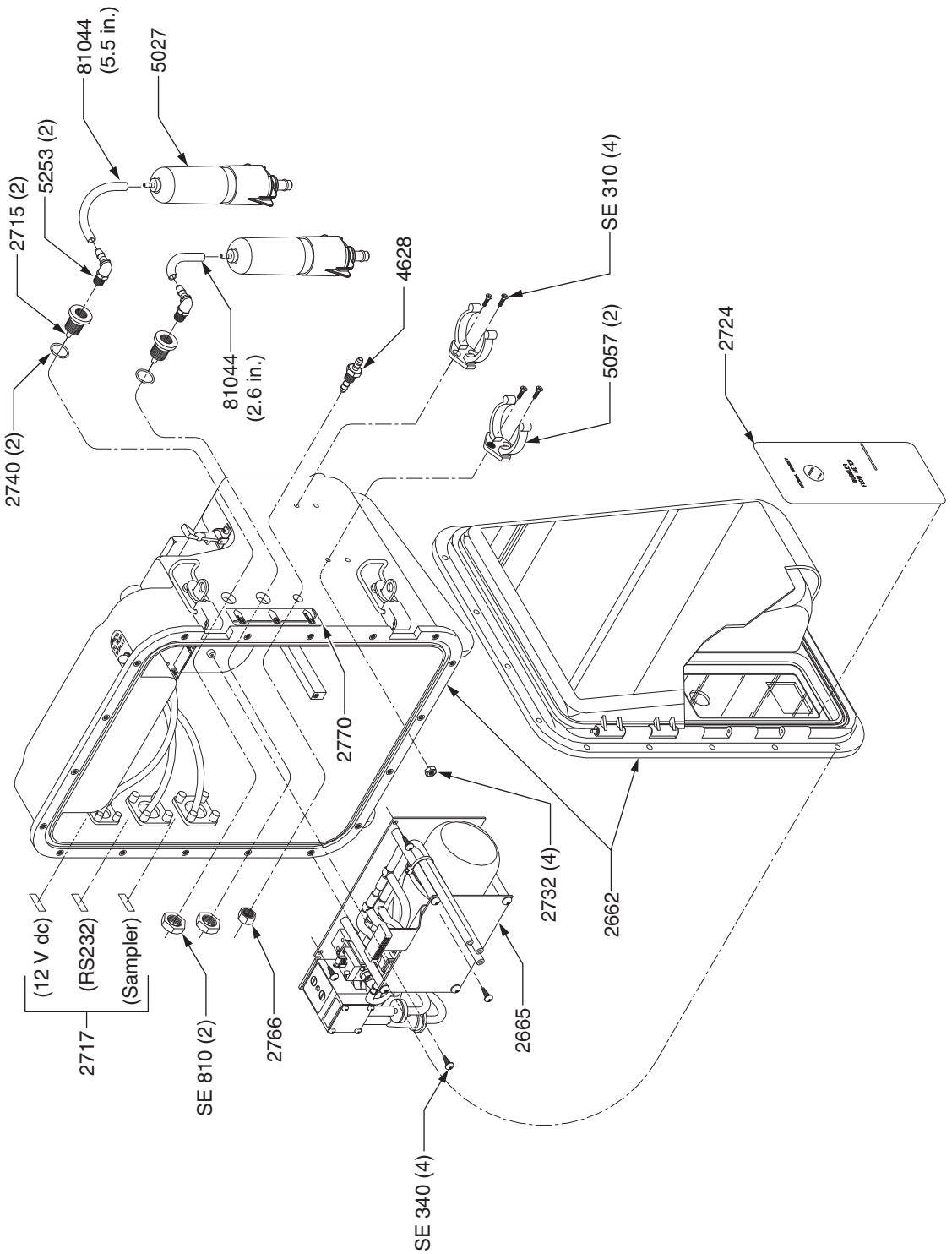
950 Flow Meter Bubbler Assembly



950 Flow Meter Optiflow Assembly



950 Flow Meter Bubbler Final Assembly



950 Flow Meter Base Assembly