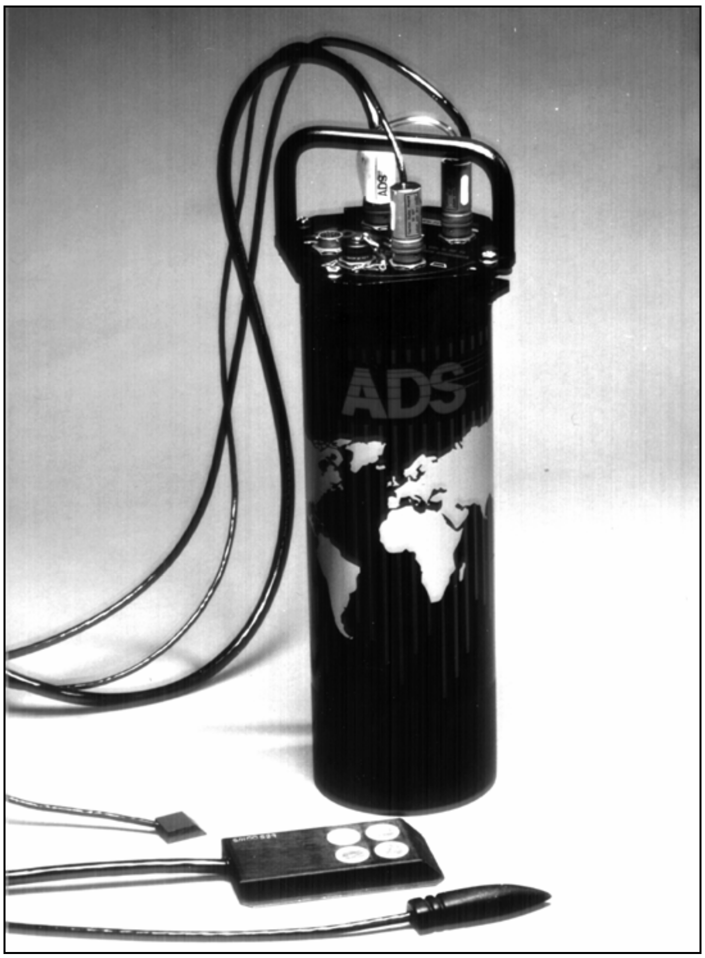
3600 Flow Monitor
Operation and Maintenance Manual

May 1998 **530002A2**

An introductory guide to the ADS® 3600 intrinsically safe flow monitor



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Notice of Proprietary Information

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CHAPTER 1

Introduction

The ADS® QuadraScan® 3600 (QS3600) flow monitor is a compact, microprocessor-based flow monitor that meets the requirements of intrinsic safety (IS) certification. (For more information on the QS3600 IS certification, see "Intrinsic Safety" on page 1-5.)

The QS3600 flow monitor is installed in a sewer manhole and is connected by telephone lines and a modem to a central computer. Installed on the central computer, ADS QuadraScan software configures and activates the monitor. The QS3600 flow monitor can then gather data electronically. Using the monitor and QuadraScan software, this data can be analyzed to measure sewer pipe flow rates and to generate reports.

The QS3600 flow monitor also performs sampler control, which outputs a discrete signal to a sampler, and event notification, which alerts you and prints a message when specified events occur. An additional capability is its capability to be connected to the rain gauge; a rain gauge records the amount of rain that falls during a specified time period and allows you to judge the severity of the effect that rain has on a mini-system.

Using a supervisory control and data acquisition (SCADA) system, the QS3600 flow monitor can also be configured to measure open channel flow in sewage collection systems to allow real time monitoring and control of the system.

The QS3600 flow monitor plays an important role in the ADS complete flow monitoring system. Read "The ADS Flow Monitoring System" on page 1-3 for a brief explanation of the QS3600's role in this system.

This manual explains how to install, operate, maintain, and troubleshoot the QS3600 flow monitor. You can find supplemental information on the monitor's specifications in Appendix A of this manual.

To learn about: ***See page:***

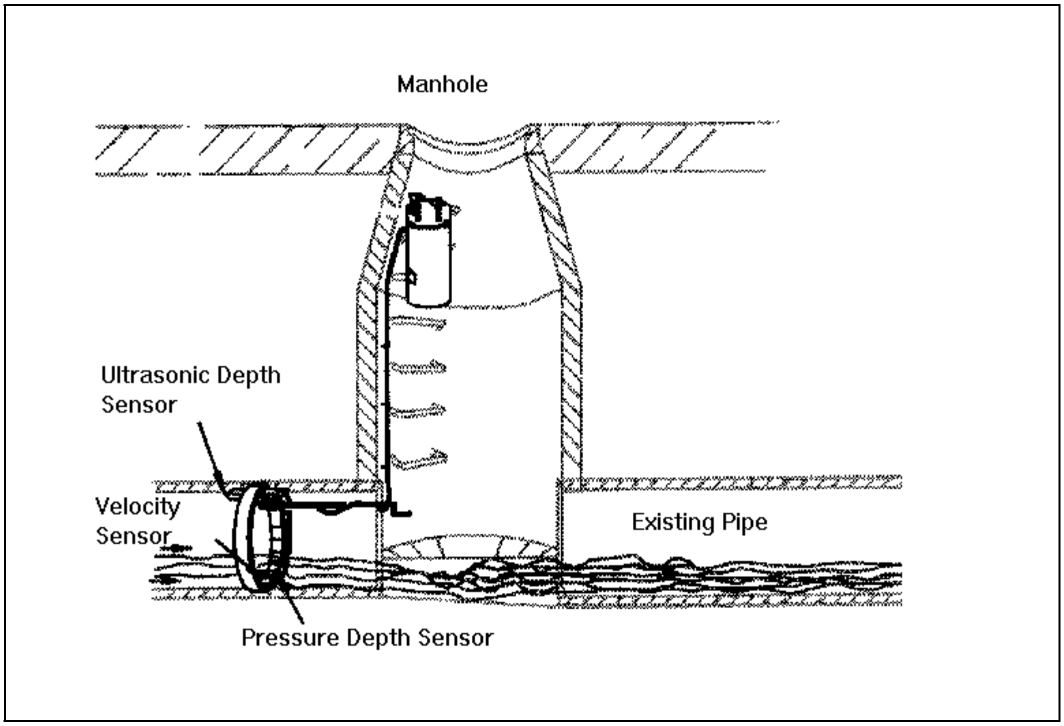
The ADS Flow Monitoring System

The ADS flow monitoring system is a comprehensive and sophisticated system that uses powerful scientific and engineering concepts to measure and monitor open channel flows. The system was initially developed in the late 1970s and has been used to address a variety of issues faced by municipal sewer systems, such as:

- planning sewer systems (for example, sewer sizing, and sewer rehabilitation),
- reducing infiltration and inflow (I/I),
- monitoring combined sewer overflows (CSO),
- monitoring surcharges,
- calculating billings, and
- monitoring sewage handling facilities (such as wastewater treatment plants and pump stations).

Flow Monitoring with the QS3600

The main role of the QS3600 flow monitor in the ADS flow monitoring system is to measure the flow rates in sewer lines. In this application, readings are taken by flow sensors installed in the sewer pipe, then gathered and processed by flow monitors connected to the sensors and installed in the manhole. Using a telephone line, the data is transmitted to the central computer via a modem and then processed by QuadraScan software. QuadraScan uses the data to generate reports on the quantity of flow.



Typical 3600 Flow Monitor Installation

Typically, the monitor is attached to the inside wall of a manhole using bolts. Depth and velocity flow sensors are installed in the sewer pipe to gather flow data. The sensors are mounted on a stainless steel ring, usually placed upstream in the sewer pipe. Cables connect the monitor in the manhole to the sensors in the sewer pipe. The QS3600 flow monitor is linked to a central IBM-compatible personal computer with a voice-grade telephone line and either an IS modem or an external modem unit (EMU). (Data can also be acquired serially directly from the monitor with an internal IS modem). This link allows you to communicate with the monitor, configure the monitor, activate the monitor, collect data, and perform monitor diagnostics from a remote location.

In order to measure the flow rate in a sewer pipe, the QS3600 flow monitor gathers data on the depth and/or velocity of the flow. The monitor gets this data by periodically scanning the sensors which are installed in the pipe. The monitor uses two types of sensors to determine the depth of flow: the ultrasonic depth sensor and the pressure depth sensor. The monitor has a Doppler velocity sensor to measure flow velocity. See Chapter 2 for information on the monitor's key hardware components. See Chapter 3 for a more detailed explanation of monitor operation.

Intrinsic Safety

Intrinsic safety (IS) is a special certification awarded to equipment when its design and manufacture meet the high standards of IS regulations . The main goal of IS regulations is to prevent the electronic equipment from causing explosions in potentially explosive environments. These environments are categorized as Class I, Division 1, Groups C and D in the USA and as Zone 0 in Europe; the QS3600 flow monitor is certified for use in these environments. IS regulations were created by local and international standards organizations to regulate all electronic equipment that operate in areas where hazardous gases are present (for example, in sewer systems).

ADS field crews are trained to test all manholes for the presence of explosive gases by sampling its atmosphere with a gas meter. When the amount of gas present exceeds certain limits, the crew does not enter the manhole.

However, a flow monitor is mounted in a manhole for extended periods of time. During this time, the amount of combustible gas may rise to dangerously high levels without the field crew's knowledge. As a result, many cities require that all electronic equipment installed in sewers be tested and certified as non-explosive. ADS produces the QS3600 IS flow monitor to meet these requirements.

Unique Features

The QS3600 flow monitor can be configured in two ways: by using a monitor with an internal IS modem or by using a monitor with an external modem unit (EMU). Country specific telecommunications standards and certifications will dictate whether the internal IS modem or EMU is required. The external modem unit (EMU) houses the modem and the power supply outside of the monitor and the manhole. The EMU contains special circuitry to protect the circuits entering the hazardous area.

Special features of the QS3600 flow monitor include the following.

- All QS3600 flow monitors are checked carefully before being shipped. Each component is guaranteed to meet specifications. The pre-shipping inspection is completed by internal quality inspectors.
- All QS3600 flow monitors connect to 3600 compatible sensor cables. The female connector is located on the flow monitor lid, while the male connector is found on the sensor cables (unlike other ADS monitors). This arrangement of connectors prevents mismatching with non-IS sensors. .
- The monitor can be equipped with either an internal IS modem and telephone interface box or with an external modem unit (EMU).
  - ❑ For the internal IS modem, cables are routed from the monitor to a phone line interface box located on a pedestal or on the telephone pole. The

monitor cables and the phone lines connect within this interface box because IS standards require that telephone lines not be routed *directly* into a manhole since it is a potentially explosive environment. An additional precaution can be taken by using an ADS lightning protection module that is located above the phone line interface box on the pedestal or telephone pole and which stops high voltages before they reach the interface box.

- ❑ An alternative to the internal IS modem is the external modem unit(EMU). Two types of EMUs are available: one with an internal battery power source and one which uses an external power source. The same IS standards apply to the EMU which houses both the monitor's modem and modem battery outside of the manhole. The EMU is either installed in an above-ground customer supplied box, in a specially dug pit, or in a pavement or sidewalk box. A cable then connects the EMU with the monitor to allow communications between the monitor and a central computer.

- Only limited field repairs to the QS3600 are allowed; all other repairs must be performed by an authorized technician. For information on allowable field repairs, see “Maintenance Restrictions” on page 1-7.

Installation and IS Considerations

When installing the QS3600 flow monitor, carefully follow any local regulations for the installation of IS equipment. For example, many cities only allow the use of IS-certified flash lights in manholes. Some cities will not allow the use of an electric drill–either battery powered or AC powered–in a manhole. In this case, air (pneumatic) tools must be used.

Maintenance Restrictions

As mentioned earlier, all ADS QS3600 flow monitors are manufactured to meet IS standards. The monitor's IS certification can be voided instantly if proper maintenance and service procedures are not followed. ADS must restrict certain maintenance tasks to ADS IS certified technicians.

ADS allows you to perform only those maintenance tasks which do not require opening the monitor housing. All other maintenance must be performed by ADS IS-certified technicians. ADS technicians carefully inspect and document their repairs to IS monitors. This inspection and documentation process provides legal protection should the monitor's performance or safety be questioned. It is important to understand that if the monitor's housing is opened by unauthorized personnel, the IS certification is compromised.

For your convenience, ADS allows you to

- install and swap monitors,
- install and swap sensors,
- clean sensors,
- calibrate and confirm monitors, and
- collect data.

> **Note:** Please note that in all applications, only ADS Service Technicians are authorized to perform component-level service on the QS3600.

This manual contains the correct procedures for performing routine installation and maintenance on the QS3600. If you have any question about the procedures, or regarding the level of service you are allowed to perform on a monitor, contact your regional ADS office.

Warnings, Certifications, FCC Compliance, and Conformity

Changes or Modifications Changes or modifications to the QS3600 flow monitor not expressly approved by the party responsible for compliance will void the IS certification.

Personnel performing installation of the QS3600 flow monitor should carefully follow the guidelines contained in this manual when installing and maintaining the monitor. Failure to strictly adhere to these guidelines can result in personal injury and can cause damage to the monitor, which would invalidate its warranty.

The QS3600 flow monitor is designed to be installed in combined and sanitary sewer lines and manholes. This installation work is inherently dangerous. All applicable safety guidelines should be followed and carried out by at least two fully trained and qualified persons.

Intrinsically Safe (IS) Certification

Only authorized technicians can make certain repairs to the QS3600 IS flow monitor. These repairs must be re-inspected by approved inspectors for continued IS certification. If individuals other than approved technicians make the repairs, they will void the monitor's IS certification. For more information on allowable field repairs, see "Maintenance Restrictions" on page 1-7.

FCC Compliance

To comply with the Federal Communications Commission (FCC), ADS Environmental Services provides the following information about installing and operating the 3600 internal modem DAA/3600 Monitor.

FCC Part 68 This equipment complies with FCC Rules, Part 68. It bears a label displaying, among other information, the FCC registration number and ringer equivalence number (REN). The user must provide this information to the telephone company if requested.

The REN identifies the number of devices that may be connected to the telephone line. Excessive RENs on the telephone line may prevent devices from ringing in response to an incoming call. In most areas, the sum of the RENs should not exceed five. To determine the number of devices you may connect to a line, as determined by the RENs, contact your telephone company.

This equipment uses standard RJ11C jacks/plugs for connection to the telephone network. These modular jacks/plugs are FCC compliant. They are designed for connection to the telephone network or premises wiring using compatible modular jacks/plugs and cabling that comply with FCC Part 68 rules.

The telephone company may make changes in its facilities, equipment, operations, or procedures that could affect the operation of this equipment. If this occurs, the telephone company will provide advance notice so you can make the modifications necessary to maintain uninterrupted service. In the unlikely event that this equipment harms the telephone network, the telephone company will notify you that temporarily discontinuing telephone service may be required. Notification will occur in advance of discontinuation, or as soon as practically possible. They also will inform you of your right to file a complaint with the FCC if necessary.

This equipment may not be used on public coin phone service provided by the telephone company. Connection to party line service is subject to state tariffs.

This equipment is not field repairable. If you experience trouble with this equipment, please refer to this manual for troubleshooting, replacement, or warranty information or contact:

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FCC Part 15 This equipment has been tested and found to comply with the limits for a Class A digital device pursuant to Part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception (which can be determined by turning the equipment off and on), you should try to correct the interference by one or more of the following measures:

- reorient or relocate the radio or television antenna,
- move and/or increase the distance between the computer and the radio or television, and
- plug the computer in an outlet different than the radio or television.

If these suggestions do not help, consult ADS Corporation or an experienced radio/television technician.

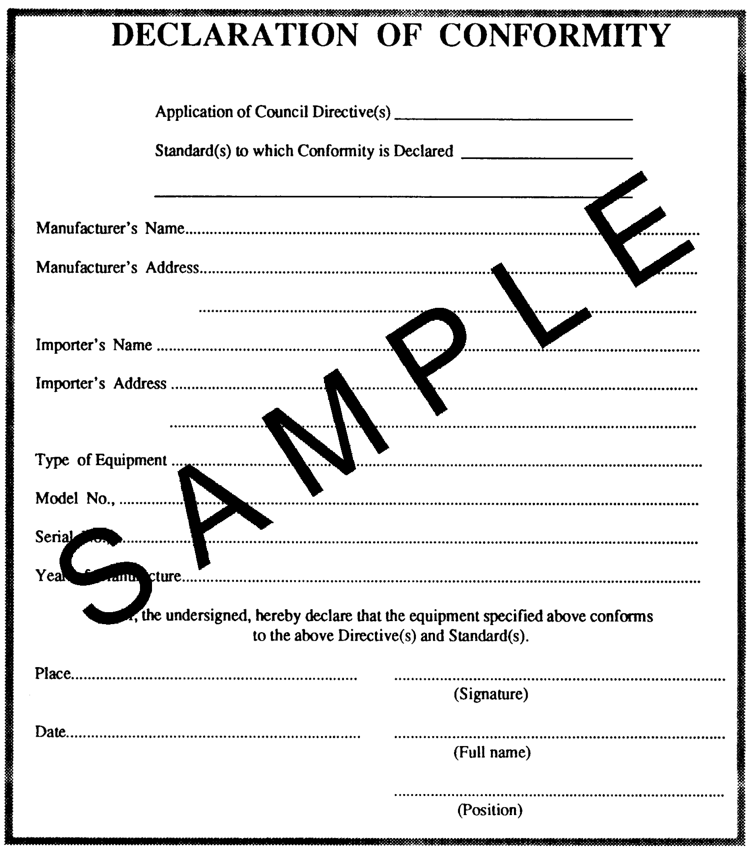
Additional Notice of Canadian Emissions Requirements

This digital apparatus does not exceed the Class A limits for radio noise emissions from digital apparatus, which were set out in the Radio Interference Regulations of the Canadian Department of Communications.

Le present appareil numerique n'emet pas de bruits radioelectriques depassant les limites applicables aux appareils numeriques (de la class A) prescrites dans le Reglement sur le brouillage radioelectrique edicte par le ministere des Communications du Canada.

Declaration of Conformity

For European (EC member country) applications, a Declaration of Conformity is required to be kept on file at the facility responsible for repair and maintenance of this equipment. If you have any questions about the Declaration of Conformity, contact your regional ADS representative.



DECLARATION OF CONFORMITY

Application of Council Directive(s) ____________

Standard(s) to which Conformity is Declared ____________

Manufacturer's Name..........

Manufacturer's Address..........

Importer's Name..........

Importer's Address..........

Type of Equipment..........

Model No.,..........

Serial No...........

Year of Manufacture..........

We, the undersigned, hereby declare that the equipment specified above conforms to the above Directive(s) and Standard(s).

Place.......... .... (Signature)

Date.......... .... (Full name)

.... (Position)

SAMPLE

Sample Declaration of Conformity

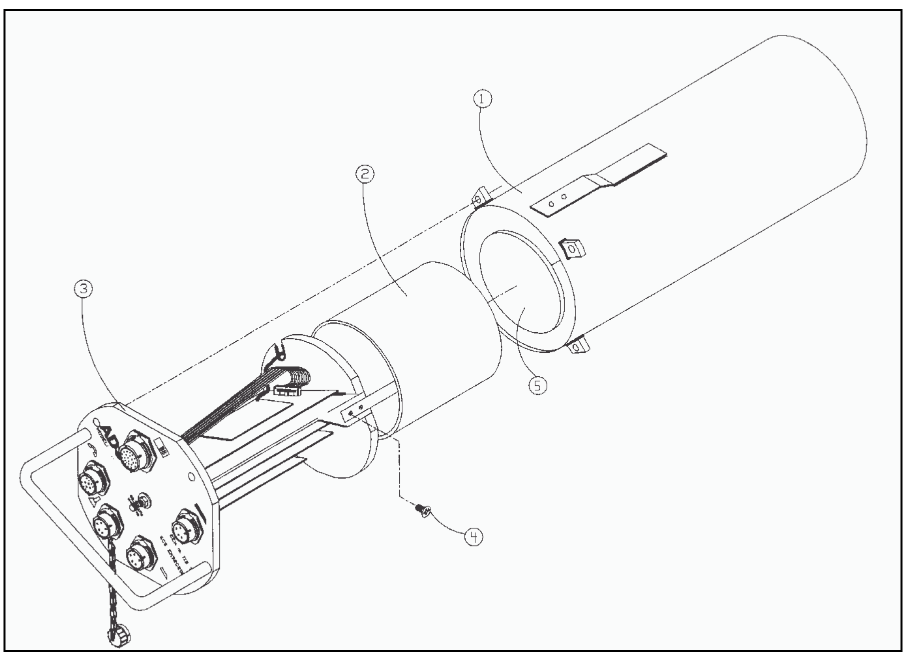
CHAPTER 2

Hardware

The QS3600 flow monitor is housed inside a cylindrical aluminum canister that is 62 cm (24 in.) long and 17 cm (6.6 in.) in diameter. The canister lid contains ultrasonic, pressure, velocity sensor, and communication cable connections as well as rain gauge and sampler communication cable connections. With the lid in place, the canister is airtight and waterproof.

> **Warning:** Only ADS Service Technicians are authorized to perform component level service on the QS3600. If the monitor's housing is opened by unauthorized personnel, its IS certification is compromised.

A one-piece chassis attaches to the inside of the monitor lid to provide a mounting surface for the central processing board (CPU board), the depth interface (for the ultrasonic level sensor and the pressure depth sensor boards), the velocity interface (for the Doppler velocity sensor board), and the power supply board (with the internal modem).



Assembly of the QS3600 IS Flow Monitor
(1) Aluminum Canister (2) Battery Pack
(3) Lid Assembly (4) Screw to Attach Battery Pack (5) Foam Insert

> **Note:** The depth board and velocity boards are also called the input/output (I/O) boards.

Opening the lid of the monitor and removing the lid assembly reveals the one-piece chassis. The processor board is mounted to the chassis on the bottom of one side. Two Doppler velocity boards are mounted on top of the processor board. The depth board is mounted to the other side of the chassis' frame. The IS modem is located on the power supply board which is mounted on top of the depth board. The processing, depth, and velocity boards are connected with a ten-conductor ribbon cable.

A 9 V battery pack is attached to the bottom of the chassis. Cabling connects the battery pack to the power supply board. The bottom of the housing is sealed. Connectors for the following cables are installed on the lid of the canister:

- the ultrasonic depth sensor cable,
- the Doppler velocity sensor cable,
- the pressure depth sensor cable,
- the communications cable,
- the rain gauge cable, and
- the sampler cable.

The monitor can be sealed after the lid assembly is securely placed in the monitor.

To learn about: ***See page:***

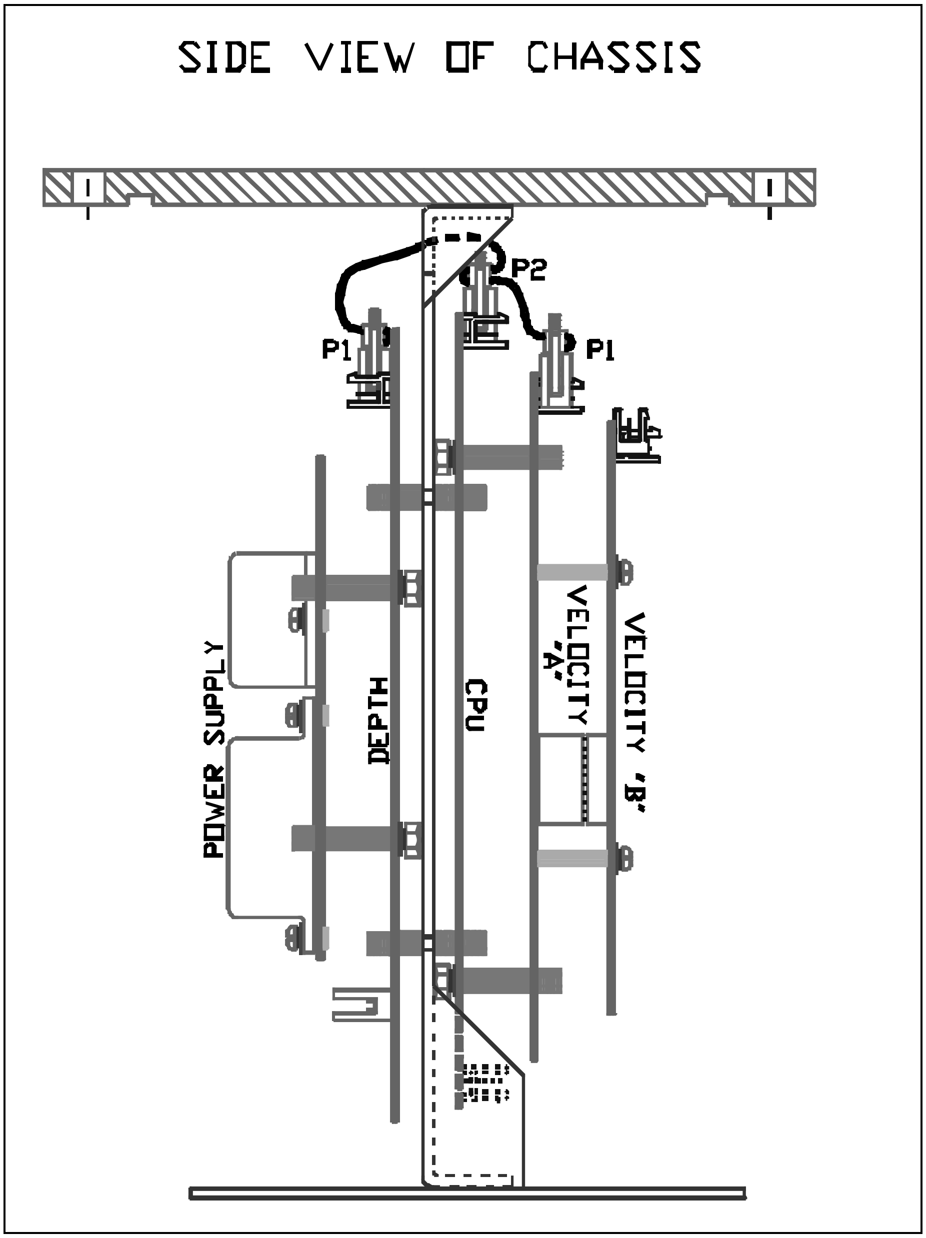
Major Components of the QS3600 Monitor

The major components of the QS3600 flow monitor include the processor board, the sensor interface boards, the battery pack, and the flow sensors. Refer to Appendix A for additional information regarding these components.

Processor Board

The processor board contains the central processing unit (CPU). It is mounted on the bottom of the chassis card frame plate which is installed on the lid assembly chassis. The processor board is the center of all monitor activity, and is responsible for all of the monitor's high-level functions, including

- communications with the central computer,
- communications with the sensor interface (I/O) boards,
- data storage, and
- time-keeping.



Side View of Flow Monitor Chassis and Assembly

The board allocates portions of memory to firmware (permanently stored software), data storage, and program manipulation and calculations. A light-emitting diode (LED) is located on the processor board and indicates the monitor's communication status. When the processor board is involved in external communications, the LED is *ON*. A second LED is used to indicate the current activity level of the processor board: the brighter the light, the more work the processor board is doing. Discrete input and output ports, a monitor clock, and a memory battery are also located on the board.

The processor board performs many functions; it

- powers up each input board and provides each board with the parameters required to carry out the appropriate operations,
- periodically scans the sensor interface boards and the optional rain gauge input to retrieve and store data readings,
- outputs a discrete signal to a sampler,
- transmits the stored data to the central computer for processing by QuadraScan software after data is collected, and
- maintains the date and time.

Sensor Interface Boards

The QS3600 flow monitor's chassis can hold up to two sensor interface subsystems:

- one Doppler velocity subsystem which consists of two boards and
- one depth subsystem which consists of one board that is used for both the pressure depth sensor and the ultrasonic level sensor.

Each sensor interface subsystem communicates with its particular sensor(s) in order to provide the instructions necessary to collect the appropriate data, collect sensor readings, and convert raw data to engineering units of measurement (instead of binary counts).

Flow Sensors

As mentioned earlier, a QS3600 flow monitor can have up to three flow sensors: one Doppler velocity sensor, one ultrasonic depth sensor, and one pressure depth sensor. These flow sensors are mounted on an expandable stainless steel ring that is placed in the sewer pipe upstream from a manhole. Cables connect each sensor to its interface board through connectors on the monitor's lid.

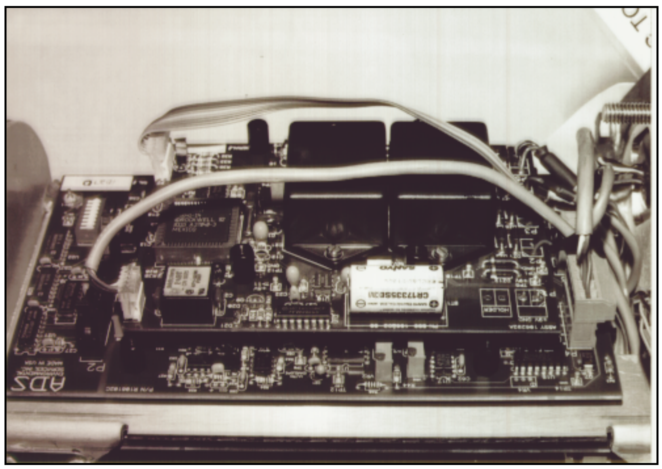
Battery Pack

The 9 V battery pack provides the power necessary to operate the monitor and maintain the monitor memory. The monitor measures the battery voltage and signals a warning when the power is low. The QS3600 battery pack (part number 106152) meets IS requirements.

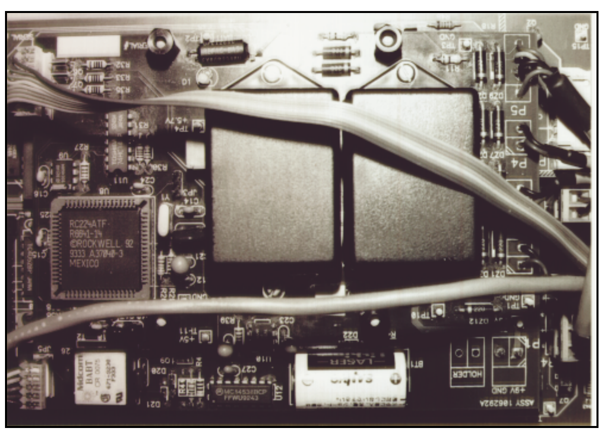
IS Modem and Telephone Interface Box

If the QS3600 flow monitor uses an IS modem instead of an EMU, it is located within the QS3600 monitor housing and complies with IS regulations. This modem communicates with the central computer via a telephone interface box, located on the telephone pole or on a nearby pedestal. (The IS modem does not require a separate battery for power; it uses the monitor's battery pack.)

Routing the electricity through the telephone interface box prevents voltage from going directly into the potentially explosive manhole environment. To protect the telephone interface box from dangerous lightning and high voltages, the telephone lines can first be run through a lightning protection module (ADS part number 103313A). The QS3600 flow monitor can be programmed to communicate at various baud rates. For more information on the modem's capabilities and installation, see Chapter 5, "Monitor Installation and Activation."



IS Modem on the Processor Board

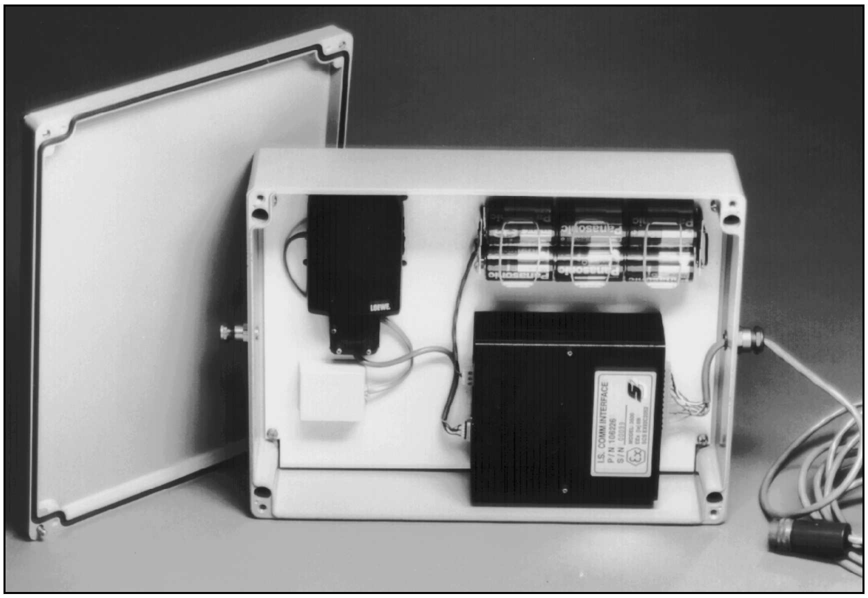


IS Modem on the Processor Board

External Modem Unit

An alternative way to communicate via a telephone line is to use an external modem unit (EMU), which houses the modem outside of the monitor. Two types of EMUs exist: one with an internal battery power source and one which uses an external power source. The EMU may be buried in a sidewalk or pavement box at the end of a trench dug away from the manhole, or the EMU may be bolted to a nearby wall.

The EMU functions similarly to the internal modem and can be programmed to communicate at various baud rates. For more information on EMU capabilities and installation, see Chapter 5, "Monitor Installation and Activation."



EMU—Inside View

Internal Power Source

The internally powered EMU contains a set of alkaline batteries that supply power for the modem. This internally powered EMU is used in applications where an external power source is not available. An example of this application is the 3600 flow monitor that typically collects data at a set time period, such as once per week. The following standard EMUs provide battery-powered modem communication:

ADS Part Number	EMU Model
P/N 106223B	United States
P/N 106223C	British/German
P/N 106223D	French

External Power Source

Some model 3600 flow monitors may require a continuous power source, for example real time flow monitors used in SCADA applications. The external modem unit (EMU) supplied for SCADA applications has a provision for continuous power from an external power source. This can be accomplished in two ways: alternating current (AC) or direct current (DC).

> **Note:** For continuously powered applications, the external power cable within the monitor must be moved from a non-functioning connector and placed into connector P1, which is the connector to which the battery is normally connected. Additionally, the battery should be removed from the flow monitor housing.

Due to the diversity of electronics and telecommunications requirements abroad, ADS only manufactures SCADA EMUs to meet the specific requirements of the United States. United States versions of external-powered SCADA EMUs are available with a modem. However, International versions of external-powered SCADA EMUs are available without a modem. The user of an International version is responsible for configuring the unit with any telecommunication options and for obtaining any agency approvals for telecommunication equipment relevant to that country. ADS currently manufactures the following SCADA EMUs:

ADS Part Number	SCADA EMU Model
P/N 106328A	International, External AC-Powered
P/N 106328B	International, External DC-Powered
P/N 106328E	United States, External AC-Powered
P/N 106328F	United States, External DC-Powered

External AC Power Source (optional)

ADS can provide a cable assembly which includes a wall socket mount transformer to provide the low voltage power needed by the EMU. In this version of the EMU, the low voltage power sent to the EMU is used to operate and power the 3600 flow monitor, sensors, modem, and EMU and to charge an internal NiCad battery. The only SCADA EMU external AC power cable currently available through ADS is the United States version with the following part number:

ADS Part Number	External AC Power Cable
P/N 106330C	United States

The above cable is 20 m (8 ft) in length. A wall receptacle or socket must be provided within 20 m (8 ft) of the EMU location. A 25 m (10 ft) ground wire is also provided in this cable to provide earth ground for the intrinsic safety barriers inside the EMU.

Earth grounding is necessary to satisfy the intrinsic safety requirements of an installation involving a 3600 and SCADA EMU using external power. Therefore, when connecting the SCADA EMU to an AC power source using the ADS power cable with the three-prong wall plug transformer, make sure the power source is earth grounded.

> **Note:** Customers using their own power cables must pin the SCADA EMU connector according to the diagram displayed on the inside cover of the SCADA EMU to ensure proper earth grounding.

In the event of power loss, the NiCad battery, located in the EMU, can provide operating power for the 3600 flow monitor. The NiCad battery has been sized to provide about six to eight hours of operation when the flow monitor is taking readings once per five minutes and when the RTU is polling the monitor once per five minutes.

External DC Power Source (optional)

The EMU will also operate from a user supplied 12 Vdc power source. This power source should be provided with some form of battery backup that is sufficient to power the 3600 flow monitor during power outages. The external power source should provide from 11.5 V to 15.0 Vdc and a voltage ripple of 100 mV peak to peak. The user supplied power source should be able to support the EMU and 3600 flow monitor at a maximum of 450 mA although only 290 mA is typically needed for the required time period. No internal battery backup exists in this configuration. The cable for this configuration is different from the AC powered configuration. The following SCADA EMU DC power cable is available for use in the United States or Internationally:

ADS Part Number	External DC Power Cable
P/N 106132A	United States or International

This cable is 20 m (8 ft) long, with a 25 m (10 ft) wire to provide earth ground for the intrinsic safety barriers. The appropriate connector for mating this cable to the EMU is provided at one end of the cable. The bare end of the cable connects to the DC power supply [white wire to +12 V, black wire to ground(–)].

Earth grounding is necessary to satisfy the intrinsic safety requirements of an installation involving a 3600 and SCADA EMU using external power. Therefore, when connecting the SCADA EMU to a DC power source using the ADS power cable with the exposed wires, connect the ground wire to the earth ground associated with the power source.

> **Note:** Customers using their own power cables must pin the SCADA EMU connector according to the diagram displayed on the inside cover of the SCADA EMU to ensure proper earth grounding.

The EMU cannot tolerate external power source voltage dropouts or droops outside the specified range regardless of duration. The typical external power source would be a fully charged lead acid battery; however, no internal battery backup exists in this configuration. Therefore, if utilizing a battery as the external dc voltage source, the length of the unit operation is dependent on several factors, such as the battery amp-hour rating, the battery charge state, the monitor configuration, and the monitor sample interval. These factors cannot be predicted by ADS.

Data Access Arrangement (DAA) for 3601 Flow Monitors

ADS manufactures the following DAA and communication cable for use with the 3601 flow monitor:

ADS Part Number	3601 Hardware
P/N 106288A	DAA
P/N 106298A - cable length	communication cable

The communication cable connects the DAA to the 3601 flow monitor. Orders for this cable must include the specific cable length required (in feet).

CHAPTER 3

Flow Measurement

This chapter describes the QS3600's integral role in the ADS flow measurement process, including information on

- monitor operation,
- flow sensor operation,
- data scrubbing (filtering erroneous data out of the data collected),
- communications between the monitor and a computer, and
- confirmation of the monitor's accuracy.

To learn about: ***See page:***

Monitor Operation

A central computer communicates with the QS3600 using a telephone line and modem. QuadraScan software must be installed on the computer, and site configuration information must be defined before the QS3600 flow monitor can be activated (see Chapter 5, "Monitor Installation and Activation," and the *QuadraScan User's Guide* for more information on using QuadraScan software on the computer). Site information is entered on the LIF (Location Information File) configuration screens in QuadraScan. After the site information is defined, the monitor can be activated.

Monitor Activation

Activating the monitor involves two tasks. First, the computer uses site configuration information to build BASIC code and variable files for the site. Then, the computer downloads the BASIC code and variable files to the monitor. The monitor uses the instructions contained in these files to

- activate the depth and velocity sensors and read the values they gather,
- store data on the processor board for retrieval by the computer and QuadraScan software,
- record pulses from a rain gauge,
- send signals to a sampler, and
- monitor the status of selected events, initiate telephone calls to the event notification station, and report event status changes.

The computer and QuadraScan software

- activate the monitor,
- collect data from monitor memory,
- process the data to determine flow rates,
- generate graphical and tabular reports of the flow rates,
- store data on the computer's hard disk files,
- synchronize the monitor clock with the computer master clock upon activation,
- maintain a hardware log of all conversations between the computer and the monitor,
- maintain an exception log of computer/monitor conversations that have had problems, and
- perform diagnostics.

> **Note:** Refer to the *QuadraScan User's Guide* (version 5.01 or higher) for additional information and instructions on the interaction between the monitor and QuadraScan.

The QS3600 can be used in real time applications in which the flow monitor will interface with the remote terminal unit (RTU). For more information on using the QS3600 in real time applications, refer to *Using ADS Flow Monitors for Real Time Applications*, document number 530006**, or contact your regional ADS office.

Flow Sensor Measurement Techniques

The ultrasonic depth sensor, the pressure depth sensor, and the Doppler velocity sensor gather raw flow data. The ultrasonic and pressure depth sensors use independent measurement techniques to collect information about the depth of flow. The Doppler velocity sensor gathers flow velocity data.

Upstream Installation

The sensors are mounted on a ring that is installed in the sewer pipe upstream from a manhole. Upstream installation minimizes hydraulic effects and erroneous data readings.

The process of installing the sensors in the incoming pipe is patented by ADS. The system's hydraulics are much more stable and uniform in the incoming pipe than they are in the manhole invert or in the outgoing pipe. In addition, upstream installation minimizes monitoring errors caused by foamy waters, flow waves, sewer line noise, and non-laminar flow.

Quadredundancy

Each ultrasonic depth sensor contains four ultrasonic transducers. To take a reading, one transducer transmits a sound wave while a second transducer listens for the returning echo. Taking readings with four transducer pairs gives the sensor *quadredundancy*, which ensures greater sensor reading reliability.

In one firing of the ultrasonic depth sensor, each of the four sensor pairs takes thirty-two readings. All false and multiple echoes are discarded. The good readings are averaged to arrive at the final reading for each pair. The readings from each sensor pair are then averaged into one final value. Refer to Appendix A for a technical discussion of the ultrasonic depth system.

Ultrasonic Depth Sensor

The ultrasonic depth sensor, also known as a *bat*, is mounted at the crown (soffit) of the pipe. The ultrasonic depth sensor transmits sound waves from the top of the pipe to the surface of the flow. Then, it measures the time elapsed between transmission and reception of the sound signal. This distance between the sensor face and flow surface is the *range*. Using this elapsed time and the speed of sound, the ultrasonic depth sensor can calculate the depth of the flow by subtracting the range from the pipe diameter. The monitor compensates for air temperature by using the temperature recorded by one of two temperature sensors mounted inside the ultrasonic depth sensor.

Enhanced firmware (permanently stored software) for the ultrasonic level sensor has been added to the 3600 monitor to increase its capabilities. While the appearance and composition of the ultrasonic level sensor is unchanged, this firmware stores an algorithm that allows the updated sensor to filter out noise caused by bad signals that return from the apron, side connections, rungs, broken pipes, or drop connections.

With previous sensor data, the data analyst was required to examine and filter out noise readings that occurred when a sensor was not working properly. Now, the 3600 monitor uses this improved algorithm to filter out bad signals automatically. It also produces more accurate data, yields one final average, and decreases the amount of data that has to be stored.

Basically, each time the monitor fires the sensors and takes a reading, the algorithm triggers two separate processes. First, the algorithm automatically determines a *range window*, or set of standards, for good return echoes. The analog return signal is digitized, and the sensor fires all 12 pairs five times each for a total of 60 firings. (In earlier depth sensor design, only four pairs were fired.) The algorithm then takes an average of the pairs to use in determining the range. The range is set by scanning through the digital data and recording the strongest returning echoes, and a range window is created around these echoes. Thereafter, the sensor accepts echoes only within that range; bad signals are screened out.

Second, the monitor uses the standards set by the algorithm in the first sensor firing to process the return echoes and determine the range actually used to record depth of flow in the pipe. The monitor fires the sensors, which take 32 analog readings of each of the 12 pairs (384 firings) because the analog signals produce a greater resolution and are more accurate. The range window is then applied to each of the 32 readings, and the signals outside of that window are screened out; this process is called *scrubbing*. Interpair and intrapair averages are taken; the scrubbing routine is applied again, and the algorithm produces one final range. In order to save memory space, this single range is stored in memory rather than the four ranges used in previous designs.

Pressure Depth Sensor

The pressure depth sensor, or *pressure mouse*, is typically placed at the bottom of the pipe. This depth sensor can measure depths greater than full pipe (surcharges), whereas the ultrasonic depth sensor only measures depths up to full pipe capacity.

The pressure sensor contains a differential pressure transducer which transmits an output voltage corresponding to the difference between the water pressure and the air pressure in the sewer. Water pressure is measured through a port on the underside of the pressure sensor. Air pressure is measured using an integral vent tube which runs to the top of the manhole. By reading the difference in pressures, the depth board calculates the depth of flow. The pressure depth system also compensates for temperature, which is measured by a temperature sensor located inside the pressure sensor.

Doppler Velocity Sensor

The Doppler velocity sensor, called the *velocity mouse*, is placed at the bottom of the pipe next to the pressure depth sensor. It emits a wide, omnidirectional sound wave at a specific frequency upward into the flow. The sound wave bounces off particles in the flow and returns to the sensor.

The velocity sensor measures the change in the sound wave's frequency from transmission to reception. This change is used to determine the velocity of the flow based on the principle of the Doppler effect. The Doppler effect describes the shift in frequency of a sound wave emitted by a moving object in relation to a stationary point.

In this case of flow measurement, the moving objects are particles in the flow; the stationary point is the velocity sensor, and the sound wave is the reflection of the sound wave emitted by the velocity sensor off of the particles.

Ultrasonic Depth Data Scrubbing

There are a number of difficulties inherent to accurately measuring data in a sewer system, particularly at sewer manholes. Some of the common problems interfering with flow measurement are noise in the sewer, turbulent (non-laminar) flow, and flow that is not level or has foam on the surface.

To minimize the effects of these disturbances, bad data points can be eliminated (data *scrubbing*) at two different times. The first data scrubbing is done routinely as the monitor collects readings. This routine incorporates the following procedures.

- Multiple readings are taken by each sensor and averaged.
- Readings that are clearly erroneous (they are well outside the spectrum of the majority of the readings) are discarded.
- The percentage of all acceptable readings used to arrive at the average value is recorded.

The second opportunity to scrub data occurs when the data is transferred to the computer. The data analyst has the option to eliminate bad data points using parameters specified in QuadraScan. These operations are described in detail in the *QuadraScan User's Guide*.

Transmitting Data to the Computer

The monitor stores readings from the sensors at specified time intervals. These readings are stored until the monitor's memory is full; when the monitor's memory is full, new readings begin to overwrite previous ones. (Monitor storage capacity is discussed in Appendix A.) If the central computer is remotely collecting the data, a telephone line and a modem are used. If telephone capability is not available, an ADS certified technician could set up the monitor for direct collection with a portable computer using a cable attached directly to a serial communication port (also called a *direct connect*).

Data collection should be performed on a routine basis. When data is collected over the telephone, data should be collected a minimum of once a week (twice a week is recommended). When data is collected through an onsite direct connection, ADS recommends that data be collected once every one to two weeks. The data should be reviewed immediately to minimize errors.

QuadraScan software processes the data and generates graphical and tabular reports. These reports are used to plan improvements and additions to sewer systems, to improve the accuracy of billing information, and to provide information for the overall management of municipal sewer systems.

Confirmation

The accuracy of the flow sensor subsystems in a monitor must be confirmed on a regular basis. Monitor confirmation involves comparing manually-taken readings of depth of flow and velocity with the monitor's readings for the same values. In addition to checking monitor accuracy, this process verifies sensor calibrations. Refer to the *QuadraScan User's Guide* for more detailed information on confirmation procedures.

CHAPTER 4

Ring, Sensor, and Special Installations

This chapter contains instructions for installing the adjustable stainless steel ring and the sensors. These installation procedures require training and should not be attempted by inexperienced personnel. Because of the hazardous conditions that can exist in sewers and other places where the monitor is installed, a team of two or more people should be involved in the installation. Specific safety procedures are beyond the scope of this manual, but you should follow all company and governmental safety policies. Failure to strictly adhere to these guidelines can result in personal injury and can cause damage to the monitor (which would invalidate its warranty).

Changes or modifications to this unit not expressly approved by the party responsible for compliance could void your authority to operate the equipment and void the monitor's intrinsic safety certification. For more information on allowable field repairs, see “Maintenance Restrictions” in Chapter 1.

The last topic in this chapter, “Special Installations,” deals with installing equipment in non-standard environments. For example, pipes which are not round and pipes greater than 48 in. (a standard stainless steel ring cannot be used) require a special installation. Refer to page 4-20 for more information about special installations.

To learn about: ***See page:***

Preparing for Installation

The QS3600 flow monitor is delivered fully assembled and tested. The installation process includes

- assembling the ring,
- mounting the sensors,
- connecting sensor cables to the monitor,
- installing the ring in the sewer pipe, and
- installing the monitor in the manhole.

Note: Refer to Chapter 5 for information on installing the monitor and software, as well as on activating and confirming the monitor.

Before beginning installation, determine the types and quantities of installation supplies required, and obtain those items. See page 4-4 for a list of the required supplies. You should also conduct a thorough investigation of hydraulic and other site conditions. The hydraulics of a site directly affect the monitor's ability to accurately measure flow depth and velocity values. Measure the horizontal and vertical pipe dimensions carefully.

When installing the monitor, verify that the monitor is configured correctly for the applications being supported, verify that the correct baud rate has been set, and make any necessary changes to the configuration before mounting the unit.

Required Supplies

Obtain the following supplies before installing the ring, sensors, and monitor. You may not need all of the materials each time you install a monitor, but the materials should be available to prevent any costly delays. Supplies can be ordered from the ADS corporate office in Huntsville, Alabama. When ordering, specify QS3600 flow monitor ring-mounted installation hardware.

Quantity	Unit	Description	ADS Part Number
1	each	QS3600 flow monitor	QS3600
as required	roll	splicing or stretch tape	I45-0001
as required	can	Scotchkote® (electrical coating)	I20-0002
15	each	1/4 × 2 1/4 in. stainless steel anchor bolt	I01-0002
15	each	plastic push mount	I01-0006
15	each	11 in. cable tie *(28 cm)*	I05-0003
25	each	4 in. cable tie *(10 cm)*	I05-0001
15	each	8 in. cable tie *(20 cm)*	I05-0002
15	each	anchor cable ties	I05-0004
1	each	stainless steel ring (sized for pipe)	I25-0053—0063
1	each	sliding ultrasonic sensor bracket	I25-0001
1	each	stabilizer sliding bracket	I25-0002
1	each	spreader assembly	I10-0003
1	each	18 in. (*46 cm*) stainless steel crank handle	I10-0012

Note: Values and units that appear in *italics* are direct conversions only; these mechanical sizes may not actually exist. These values and units were converted only to enhance readability.

Ring Assembly

The flow sensors are mounted on a stainless steel ring which is installed in the sewer pipe. There are several different ring sizes. Each ring is adjustable within about three inches to fit different pipes. Rings are designed for the secure installation of ultrasonic, velocity, and pressure sensors.

> **Note:** The last topic in this chapter, "Special Installations," deals with installing equipment in non-standard pipes. For example, pipes which are not round and pipes greater than 48 in. (a standard stainless steel ring cannot be used) require a special installation. Refer to page 4-20 for more information about special installations.

Parts List The parts of the spreader mechanism come assembled. The ring assembly consists of

- one adjustable stainless steel ring,
- one ultrasonic sensor mount,
- one stabilizer sliding bracket, and
- one spreader assembly (which includes a spreader bolt, shoulder bolt, and spreader bar assembly; two spreader mechanism attachment screws; two hex nuts; and two large washers).

Tool List Ring assembly requires the following tools:

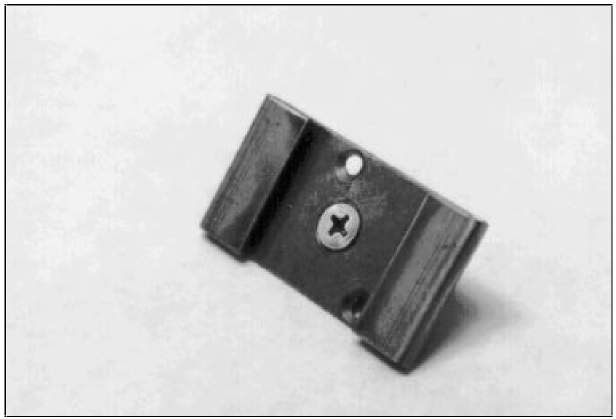
- a medium sized Phillips head screw driver and
- a 1/2 in. nut driver or wrench (ADS part number F35-0063).

> **Note:** The ring has a detachable crank handle. Any crew using the new ring will need to have two detachable crank handles, one with an 18 in. *(46 cm)* shaft, ADS part number I10-0012, and one with a 24 in. *(61 cm)* shaft, ADS part number I10-0013. You may substitute a 1/2 in. deepwell socket (ADS part number F35-0094) with a compatible ratchet.

Assembling the Ring

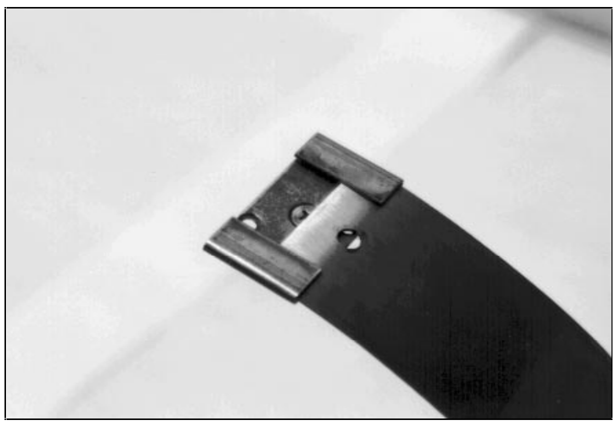
Perform the following steps to assemble an adjustable, stainless steel ring.

1. Insert the spreader mechanism screw through the hole in the center of the ring stabilizer. Ensure that the head of the screw fits into the counter sink hole.



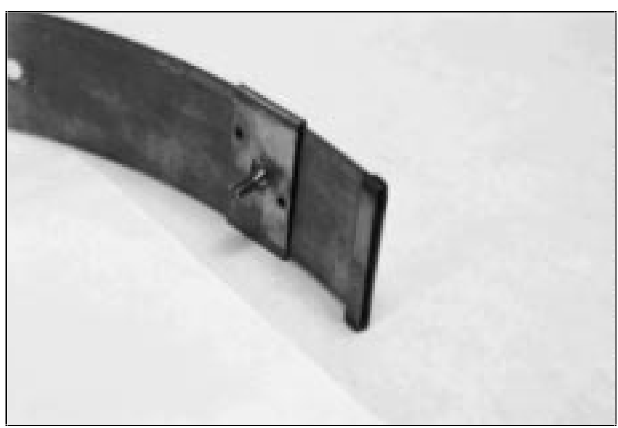
Ring Stabilizer With Spreader Mechanism Screw Inserted

2. On the open end of the ring (the end without a welded metal band), slide the ring stabilizer and spreader mechanism screw so that the ring stabilizer flanges are on the outside of the ring and the spreader mechanism screw is on the inside of the ring.



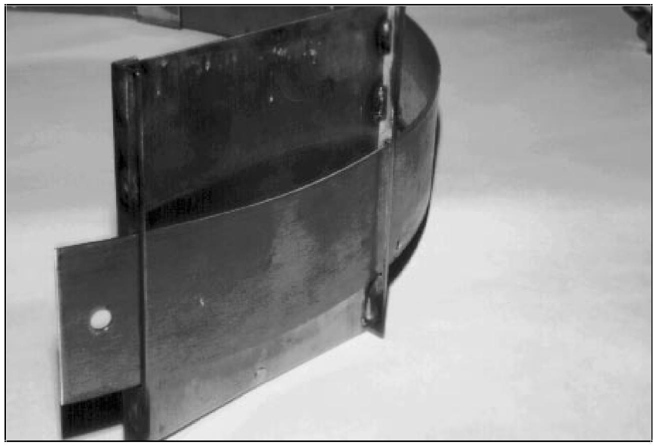
Sliding Ring Stabilizer onto Ring

3. Slide the ring stabilizer all the way around the ring until it is about 10 cm or 4 in. from the welded metal band at the other end of the ring.



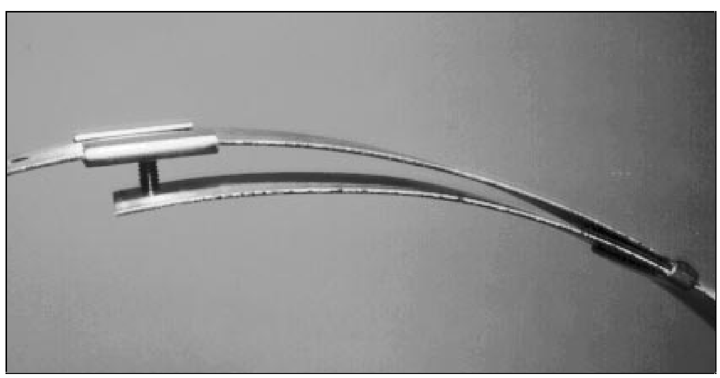
Moving the Ring Stabilizer into Position

4. Position the ring so that the holes along the edge of the ring (the downstream side) are facing you.
5. With the back of the ultrasonic mount facing you (the end with the small metal peg pushed through the main plate), slide the mount onto the end of the ring's right side (the end without the welded metal band).



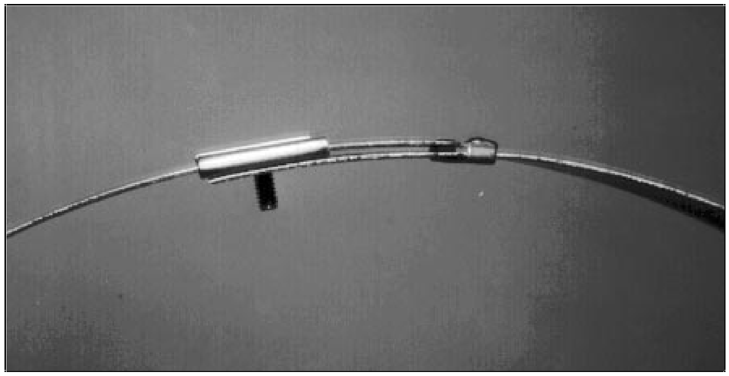
Adding the Sliding Ultrasonic Sensor Mount

6. Move the ultrasonic sensor mount to the left side of the ring.
7. Slide the end of the right side of the ring through the opening in the welded band (on the left end of the ring) until there is about 10 cm or 4 in. of overlap.
8. Spread the overlapping sections of the ring until you are able to slide the ring stabilizer and spreader mechanism screw into the gap, as shown in the following illustration.



Ring Stabilizer Moved into Position

9. Insert the spreader mechanism screw through the hole at the end of the right side so that the end of the right side of the ring fits snugly against the ring stabilizer.



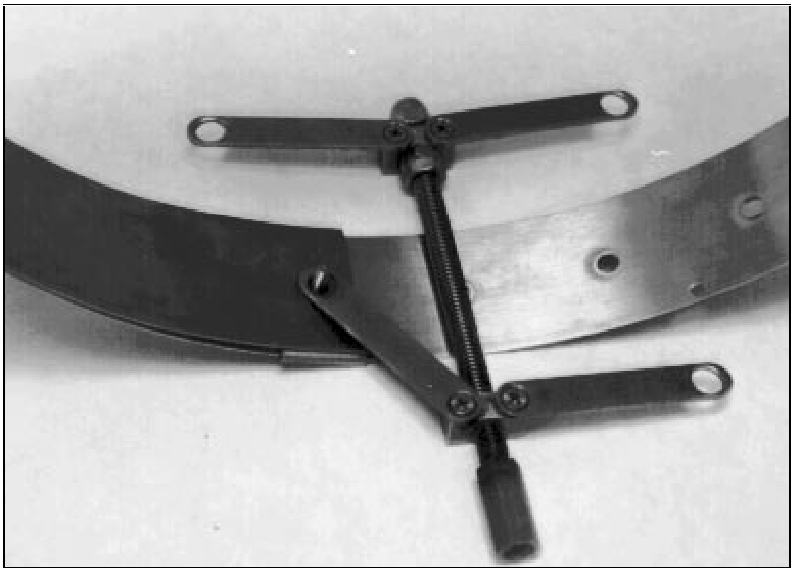
Ring Stabilizer Fully Connected (Side View)

Connecting the Spreader Mechanism

Once the ring has been assembled, the spreader mechanism must be attached. The spreader mechanism is delivered assembled and only needs to be attached to the ring. Follow these steps in order to attach the spreader mechanism to the ring.

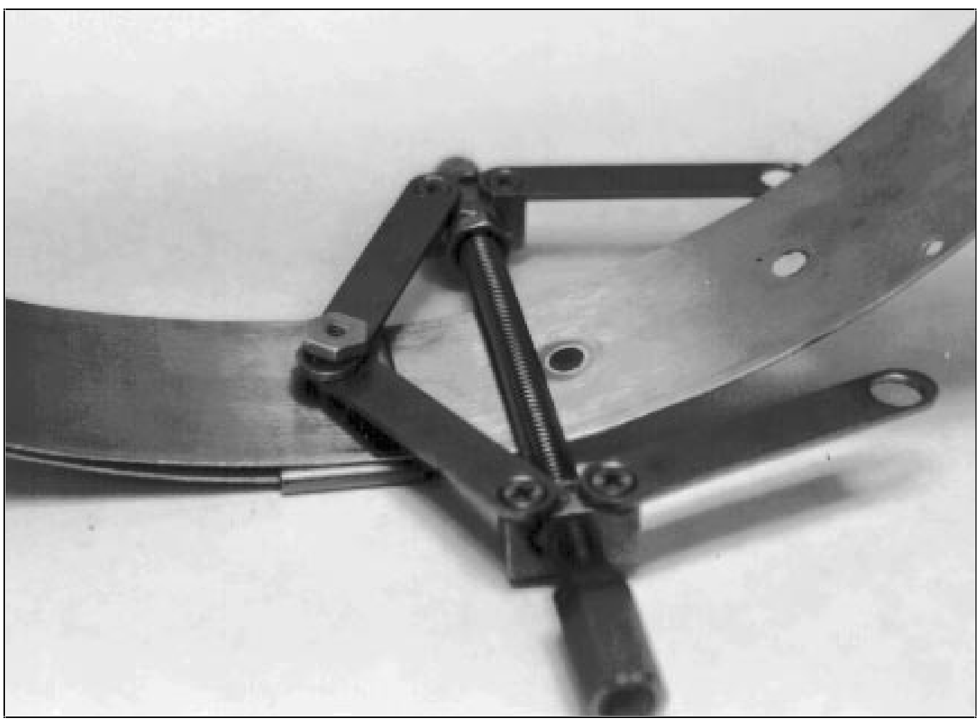
1. Place the ring on a flat surface with the spreader mechanism screw facing up.
2. Orient the ring so that the holes along the edge (downstream side) are facing you.
3. Orient the spreader mechanism on the inside of the ring so that the downstream end of the mechanism (the end with a large welded nut) is facing you, the four spreader bars are facing towards the inside of the ring, and the shoulder bolts are pointed towards the outside of the ring.

4. Place a washer then the downstream, left side spreader bar onto the spreader mechanism screw on the left side of the ring by passing the screw through the hole (as illustrated in the following figure).



Orienting and Attaching the Spreader Mechanism

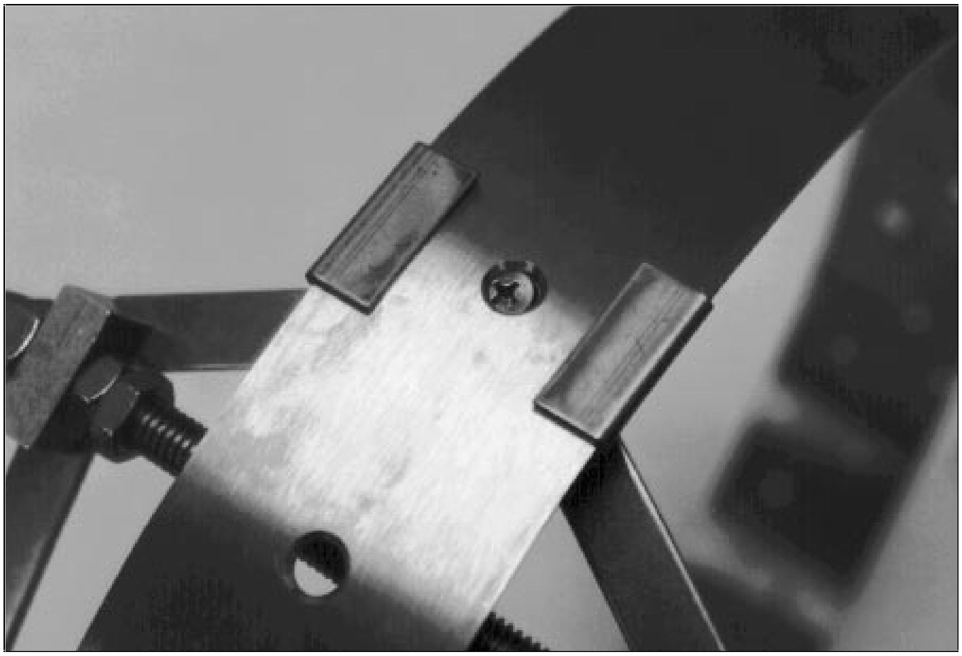
5. Place the upstream, left side spreader bar onto the same screw.
6. Lightly turn the hex nut onto the screw, ensuring that it passes through the holes in the end of the spreader bar.



Attaching the Spreader Bars

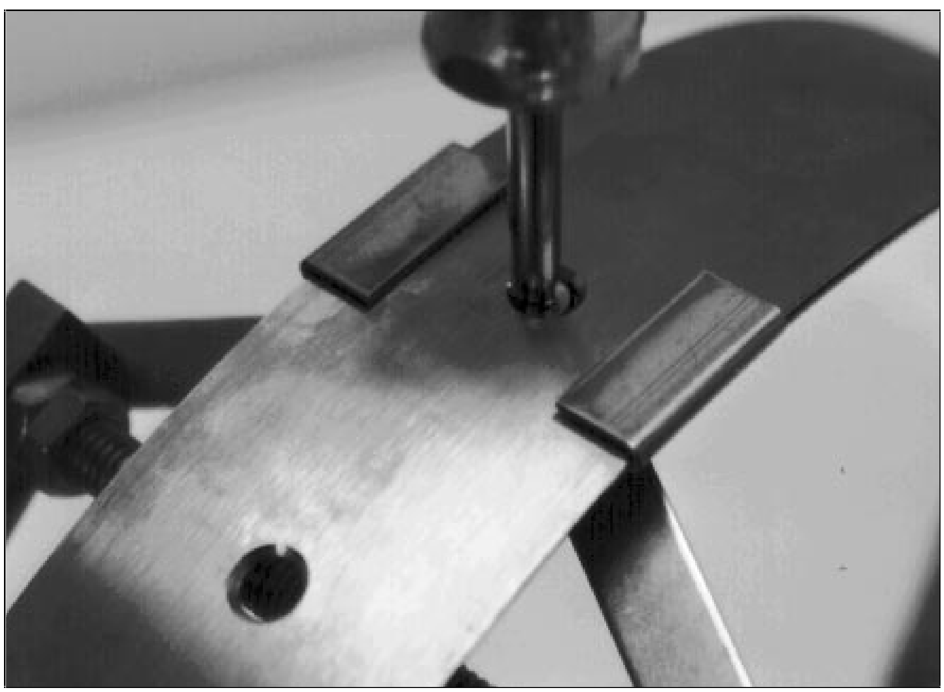
7. Turn the ring until the spreader mechanism is in a 12:00 position.

8. Align the spreader mechanism screw so that the head is visible through one of the ring size adjustment holes.



Aligning Screw Head and Adjustment Hole

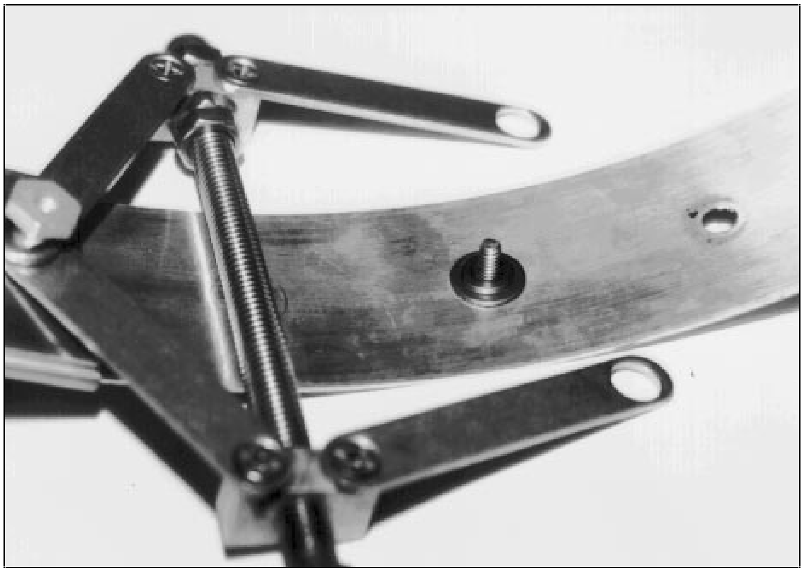
9. Insert a Phillips head screw driver through the hole into the screw head while holding the hex nut with the 1/2 in. (*13 mm*) nut driver to tighten the screw.



Tightening the Spreader Mechanism Screw and Hex Nut

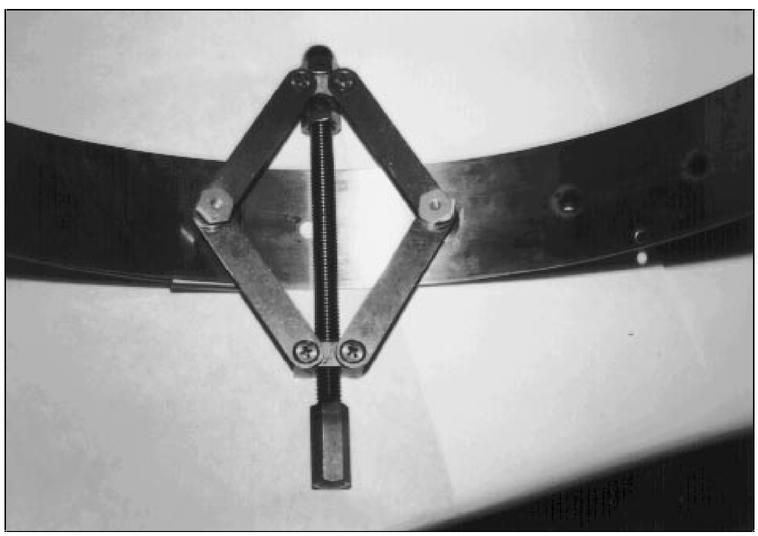
10. Return the spreader mechanism back to the 6:00 position by turning the ring.

11. Insert the second spreader mechanism screw through the desired ring size adjustment hole.
12. Slip the large washer onto the screw.



Inserting Washers onto the Spreader Mechanism Screw

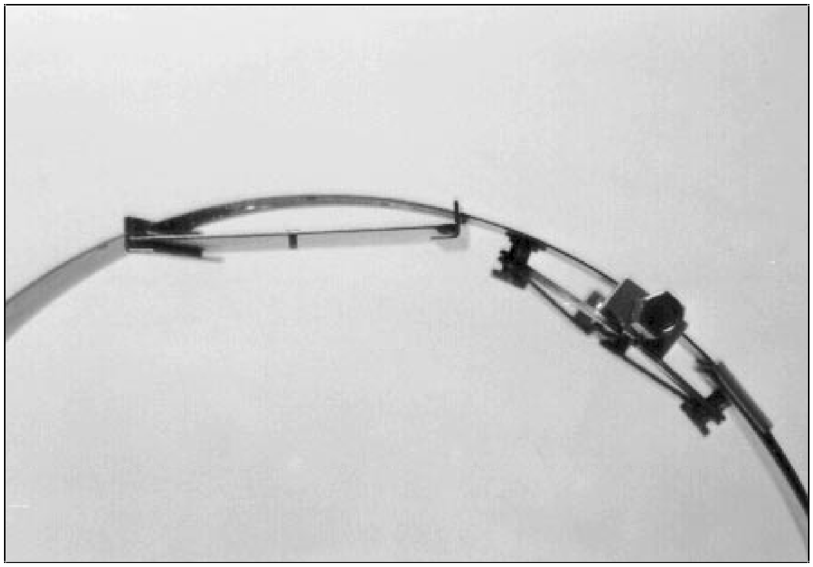
13. Through the holes in the end of the spreader bars, turn and tighten the second hex nut on the screw.



Complete and Attach Spreader Mechanism (Inside Ring View)

Quality Control

There are two checks you can make to ensure the quality of the ring assembly.



Properly Installed Spreader Mechanism

- The spreader mechanism will be loose on the hex nuts, but will tighten when the ring is tightened inside a pipe.
- Look at the previous figure. Notice that the spreader mechanism fits snugly against the inside of the ring. This is what the ring should look like when it's properly assembled.

Note: When assembling the ring, check on the site report to see if silt is present. If silt is present, this will affect the sensor placement on the ring. Refer to 4-18 for more information on silt deposits.

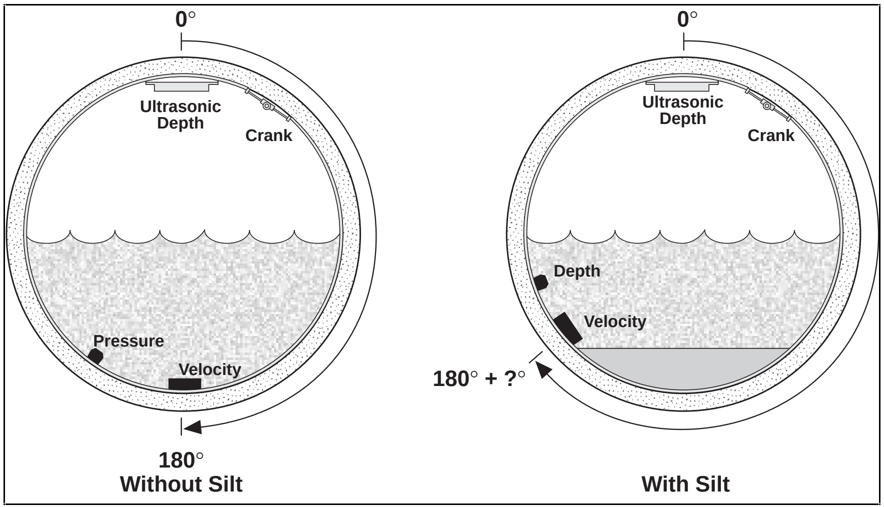
Non-Overlapping Rings

Notice that the 8, 10, and 12 in. *(20, 25, and 30 cm)* rings do not have an overlapping section. Therefore, the assembly of these rings is simpler than the overlapping types. Perform the following steps as previously outlined in this section:

- Steps 4, 5, and 6 under "Ring Assembly" and
- Steps 1 through 6, and 11 through 13 of "Connecting the Spreader Mechanism."

Mounting the Sensors

The following topics guide you through the steps necessary to mount the ultrasonic, velocity, and pressure sensors. The following figure illustrates their positions on the ring.



Sensor Positions

> **Note:** When mounting the sensors, check on the site report to see if silt is present. If silt is present, this will affect the sensor placement on the ring. Refer to 4-18 for more information on silt deposits.

Mounting an Ultrasonic Sensor

Mount the ultrasonic sensor to the inside of the ring.

- Slide the base of the sensor into the sensor mount (located at the top of the ring). The top of the sensor (with the four disk-shaped transducers) should face downwards towards the surface of the water.
- Verify that the ultrasonic sensor is mounted on the ring at the pipe's crown (soffit). Later, when installing the ring and sensor into the pipe, you will have to verify that the ultrasonic sensor is both horizontally and vertically level with the surface of the flow.

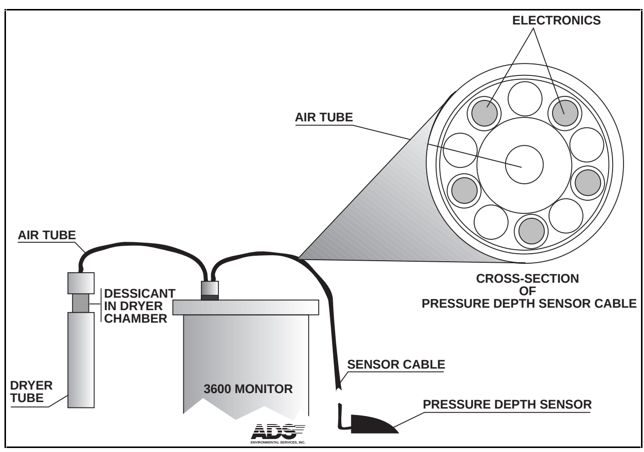
Mounting a Doppler Velocity Sensor

- Mount the velocity sensor to the inside of the ring with two M-3 × 10 mm stainless steel screws. This sensor should be placed below and perpendicular to the ultrasonic sensor. Do not substitute any other screws.

- Position the spreader assembly handle facing you. On the right-hand side of the ring, begin to secure the velocity cable along the trailing edge of the ring in a clockwise direction. Attach the sensor cables to the ring with cable ties that are 4 in. (*10 cm*) long and 0.08 in.*(2 mm)* wide. Pull the ties until they are taut. Continue this process until you reach the ultrasonic sensor. Cut off the excess portion of the cable ties.
- Be careful to secure the velocity cable to the outside trailing edge of the ring to prevent debris from accumulating around the cable.

Mounting a Pressure Depth Sensor

- Orient the ring so that the ultrasonic sensor is directly on top. If an ultrasonic sensor is not being used, orient the ring so that the spreader assembly is directly on top.
- Place the pressure depth sensor on the bottom of the ring with the front of the sensor (the pointed end) facing upstream and away from the spreader mechanism handle (downstream). If a velocity sensor is present, the pressure sensor should be about 5 cm (2 in.) to the left or right of the velocity sensor.
- Point the dryer tube downward when installing (see the following figure). Place the pressure depth sensor on the inside of the ring. The pressure sensor is secured to the ring in the same manner as the velocity sensor.

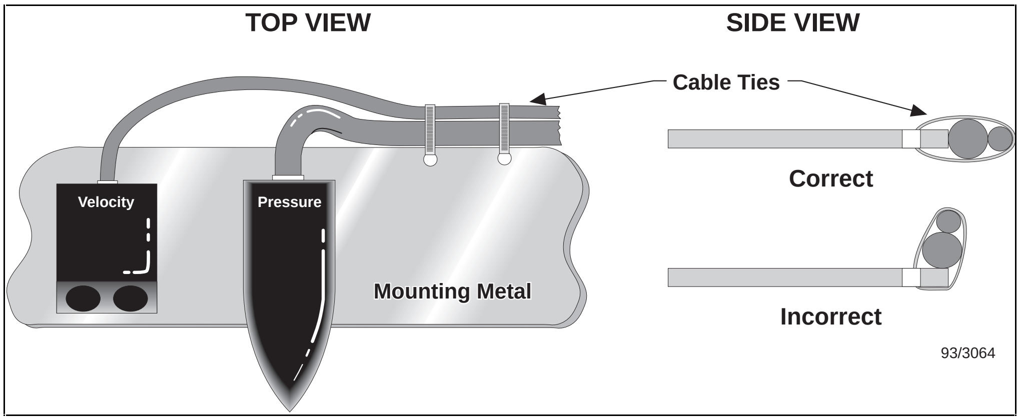


Dryer Tube and Air Tube as Incorporated into the Pressure Depth Sensor Cable

- Secure the pressure depth cable to the outside of the ring to prevent debris from accumulating around the cable. The pressure depth cable sheathes two components: the electrical cables required to operate the sensor and an air tube that ventilates the sensor. If you tighten the cable ties too much, you will pinch the air tube and cause incorrect pressure depth readings.
- Because of the air tube in the sensor's cable, be sure that the connector-end of the sensor is not kinked, contains no moisture, and has a pressure dryer that is attached and filled with active blue desiccant.

- Position the spreader assembly handle facing you. On the right-hand side of the ring, begin to secure the velocity and pressure cables along the trailing edge of the ring in a clockwise direction. Attach the cable to the ring with cable ties that are 4 in. (*10 cm*) long and 0.08 in. (*2 mm*) wide. Pull the ties until they are taut. Continue this process until you reach the ultrasonic sensor. Cut off the excess portion of the cable ties.

Note: When mounting a pressure and a velocity sensor cable to the ring, place the velocity cable on top of the pressure cable and secure both together. See the following figure for more information about cabling.



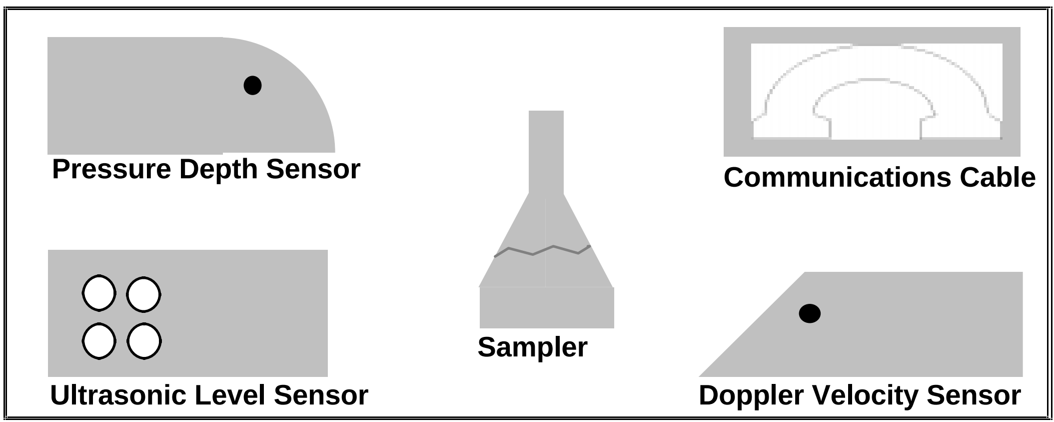
Sensor Cabling

Connecting Inputs and Outputs

After the ring is prepared and the sensors have been attached, connect the cables to the appropriate ports on the monitor lid. Ports on the lid are marked with symbols to identify which sensor cables should be connected to which ports. Each sensor is unique and will not fit into another sensor's port.

The procedure for connecting cable connections to the lid ports follows.

- Place the monitor in an upright position with the connectors facing upward.
- Visually inspect each sensor connector and monitor port for damaged or broken pins. If defective connectors are found in the lid port, replace the entire monitor.
- Visually inspect each sensor connector and monitor port for debris and moisture. Clean off any debris and dry surface moisture.
- Connect each sensor cable to the appropriate port. Tighten each connector in a clockwise direction until it clicks and verify that it is seated correctly.



Icons on the Monitor Lid Indicate Proper Cable Connections for Each Port

- Seal any unused connectors with a cap.
- Use waterproof splicing tape to seal around the sensor connectors and lid ports. Apply Scotchkote® to seal.

Installing the Ring

> **Caution:** Ring installation requires entering a dangerous environment. Be extremely careful and follow all government and ADS safety procedures.

- Designate one person to enter the manhole and install the ring. First, have the installer enter the manhole and position himself or herself to receive the ring. The installer should examine the sewer pipe to ensure that nothing is obstructing the flow or will inhibit installation.
- Using the prepared mounting assembly ring, with its pre-mounted sensors, uncoil the cables and prepare to lower the ring into the manhole.
- Lower equipment in a bucket into the manhole. The bucket should contain
  - ❑ small, medium, and large cable ties,
  - ❑ a nut driver (7/16 in. or *11 mm*),
  - ❑ 10 1/4 in. stainless steel anchor bolts or 10 plastic cable anchors,
  - ❑ a carpenter's level,
  - ❑ a hammer,
  - ❑ pliers,
  - ❑ a depth of flow (DOF) stick (folding carpenter's rule),
  - ❑ diagonal cutters, and
  - ❑ a cranking handle.
- Lower the sensor mounting assembly ring into the manhole. Be careful not to bump the assembly against the walls of the manhole. If possible, the installer in the manhole should grasp the ring to stabilize it while it is being lowered.
- Adjust the ring size to slightly less than the actual pipe diameter.
- Orient the ring so that the pressure sensor and velocity sensor both face upstream so that all sensor cables run downstream and away from the ring. Also, orient the ring so that the ultrasonic depth sensor is on the top and the velocity sensor and pressure sensor are on the bottom.
  - ❑ If silt exists in the monitored line, measure its depth before it is disturbed.
  - ❑ If silt exists in the pipe, clear enough silt to allow installation of the sensor mounting assembly. Place the silt upstream of the sensor installation position in the incoming line, either in the invert, or on the apron. You will need this silt later in the installation process to fill the hole left around the mounting assembly.

- Place the ring assembly into the upstream pipe as far as necessary to ensure a good environment for flow measurement. The exact position of the ring varies from site to site, depending on pipe size and hydraulic conditions.
  - ❑ The ring should not be near the pipe mouth draw-down.
  - ❑ Install the ring flat (flush) against the inside wall of the pipe; otherwise it will obstruct flow and catch debris. Feel around the front and back edges of the ring with your fingers, pushing and pulling on the edges of the ring until you are sure that the ring is flat against the side of the pipe. This may take several attempts as you tighten and loosen the spreader mechanism crank before you are finished.
- Position the sensors in the pipe.
  - ❑ Place the ultrasonic range sensor at the highest point in the pipe.
  - ❑ Allow for some ring rotation because the ring will move slightly when the spreader mechanism is used to fit the ring into the pipe. The ultrasonic range sensor must be on the crown of the pipe.
  - ❑ If a velocity sensor is used, place it directly below the ultrasonic sensor, often at the bottom center of the pipe unless silt is present. If silt is present, the sensor must be rotated to the left or right of the center until the sensor is above the silt level.
  - ❑ If a pressure depth sensor is used, place it in the flow and oriented to the left or right of the velocity sensor, usually about 5 cm (2 in.). Verify that its nose touches the bottom of the pipe to prevent debris from collecting on the sensor and blocking its port. If silt is present, the sensor must be rotated again to the left or right of the velocity sensor
- Use a carpenter's level on the face of the ultrasonic range sensor, and verify that the sensor's face is both horizontally and vertically level to the flow. Once leveled, tighten the ring by turning the crank on the spreader mechanism in a counter-clockwise direction until the ring is snug. Be careful not to tighten the crank too much to prevent the crank assembly from bending. Once the ring is snug, push and pull on the top of the ring to make sure the ring doesn't move.
- Verify that the ultrasonic range sensor is level. Also, verify that the sensors are in their proper positions. If the ring is not placed properly, turn the crank in a clockwise direction to free the ring and install it again.
- If silt was present, replace the silt to its natural level where the ring was installed. Be aware of the location of the sensors.
- Remove all slack in the sensor cables and secure them with large cable ties. To perform this task, attach the 8 mm (3/8 in.) plastic cable ties, with a molded anchor bolt bracket, to the sensor cable. Be careful not to overtighten at this point. Slide the semi-tight cable ties in position with the 6 mm (1/4 in.) stainless steel anchor bolts. Attach and pull snug. Anchor bolts should be

spaced every 46 to 61 cm (18 to 24 in.) from the bottom of the manhole to the top.

Final Sensor Cable Preparation

- Neatly bind together all sensor cables leading away from the ring. Use cable ties that are 20 cm (8 in.) long and 0.4 mm (0.14 in.) wide. Space the cable ties 20 to 30 cm (8 to 12 in.) apart along sensor cables located within 1.5 m (5 ft) of the ring. The remaining length of cables should be secured at any interval deemed appropriate by the field crew. Again, do not tighten the ties too much and be sure to cut off all excess portions.
- Verify that the dryer tube on the pressure depth sensor's air hose points downward. Secure it to the monitor.
- Ensure that the desiccant within the dryer tube is blue.
- Verify that the sensor cables are neatly coiled and installed in an orderly manner. If not, disconnect the sensor cables from the monitor, repeat the previous steps, then reconnect the sensor cables (page 4-15).

Note: Never coil the sensor cables with any other cabling. This could compromise the IS of the installation.

Special Installations

This topic deals with installing equipment in non-standard environments. For example, pipes which are not round and pipes greater than 48 in. (a standard stainless steel ring cannot be used) require a special installation.

If the site requires a special installation, usually the requirements are site-specific. Regardless, a special installation will require two independent installations; one for the ultrasonic sensor and one for the velocity sensor.

There are three special installation methods for the ultrasonic sensor:

- the standard ultrasonic mount (page 4-21),
- the adjustable ultrasonic mount (page 4-27), and
- the surcharge mount (page 4-30).

There are two special installation methods for the velocity and pressure sensor:

- 3/4 band velocity mount installation (page 4-34) and
- 1/2 band velocity mount installation (page 4-38).

The installation methods for installing the pressure sensor are similar to the velocity sensor. Refer to 4-36 for more information on pressure sensor installation.

Note: In all special installations, spreader mechanisms are not used. All mounts are installed directly to the pipe surface with the anchor bolts.

Required Supplies

Obtain the following supplies before conducting a special installation. You may not need all of the materials each time you need to do a special installation, but the materials should be available to prevent any costly delays. Supplies can be ordered from the ADS corporate office in Huntsville, Alabama. When ordering, specify QS3600 flow monitor special installation hardware.

Quantity	Unit	Description	ADS Part Number
1	each	QS3600 flow monitor	QS3600
15	each	11 in. cable tie *(28 cm)*	I05-0003
25	each	4 in. cable tie *(10 cm)*	I05-0001
15	each	8 in. cable tie *(20 cm)*	I05-0002
10	each	anchor cable ties	I05-0004
as required	can	Scotchkote® (electrical coating)	I20-0002
as required	roll	splicing or stretch tape (130C)	I45-0001
15	each	1/4 × 2 1/4 in. anchor bolts (with 7/16 in. nuts)	I01-0002
3	each	3/8—3/16 in. × 1 in. nut	I15-0002
6	each	3/8—3/16 in. washer	I55-0001
3	each	3/8—3/16 in. × 1 in. bolt	I01-0001
1	each	3/8 × 2 in. *(8 × 50 mm)* stud	I01-0009
2	each	4-40 × 5/16 in. screw	I35-0001
8	each	6-32 washer	I55-0002
4	each	6-32 × 1 in. *(25 mm)* machine screw	I35-0004
4	each	6-32 × 5/16 in. *(8 mm)* nut	I15-0003
1	each	quick release bracket	I40-0009
1	each	ultrasonic mounting plate	I40-0008
as required	each	surcharge mounting bracket	I40-0002
1	each	1/4 in. (6.5 mm) masonry drill bit	F35-0018
1	each	special predrilled flange (8 ft strip) *(2.5 m)*	I40-0007

Note: Values and units that appear in *italics* are direct conversions only; these mechanical sizes may not actually exist. These values and units were converted only to enhance readability.

Standard Ultrasonic Mount

The standard ultrasonic mount is the original sensor mounting method, and it is still the most popular mounting method in use.

You will need the following parts when assembling one standard ultrasonic mount:

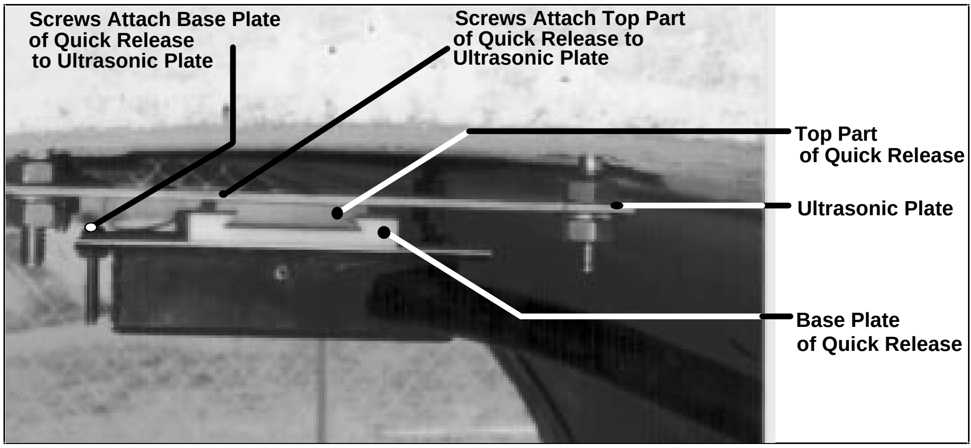
- one metal ultrasonic plate,
- one quick release bracket (machine screws included),
- four 6-32 × 1 in. *(25 mm)* round head machine screws,
- eight 6-32 washers, and
- four 6-32 × 5/16 in. *(8 mm)* nuts.

You will need the following tools when assembling one standard ultrasonic mount:

- a small slotted screwdriver,
- a small Phillips-head screwdriver, and
- a 5/16 in. *(8 mm)* nut driver.

Pre-Installation Assembly

- Locate the four countersunk holes in the middle of the ultrasonic plate.
- Slide the *top* portion of the quick release mechanism off the base and locate the four countersunk holes.
- Align the holes and secure with the 4-40 × 5/16 in. (*3 mm*) machine screws.
- Orient the *base* of the quick release mechanism with the top of the ultrasonic sensor until the pre-drilled holes line up.
- Insert a 6-32 × 1 in. (*25 mm*) machine bolt with a 6-32 washer through the base and the ultrasonic sensor holes. Secure with a 6-32 washer and 5/16 in. (*8 mm*) nut.
- Secure the three remaining locations as described in the previous step.



01-12.pcx

Ultrasonic Plate

Installation

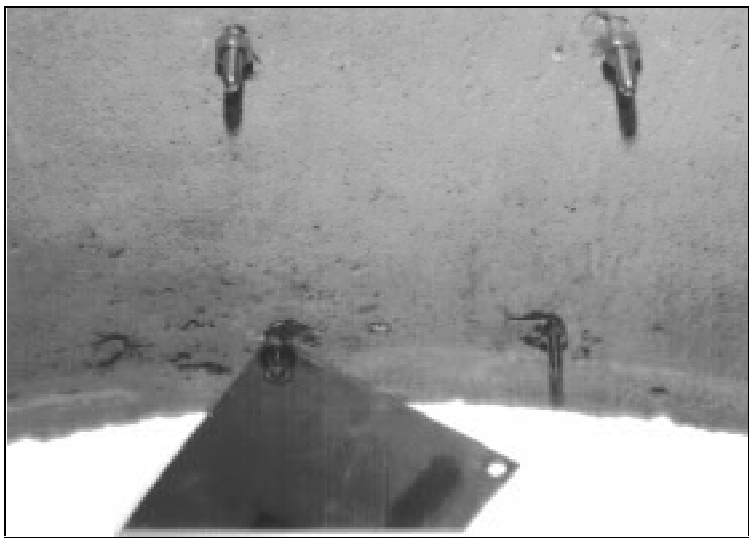
- Determine location where the ultrasonic sensor is to be installed. (Refer to location report.)
- Locate the apex of the pipe.
- Position and firmly hold the ultrasonic plate at the center apex of pipe and spot drill (mark) one of the four anchor holes.

01-14.pcx

Spot Drilling the Ultrasonic Depth Sensor Plate

- Remove the plate and drill the anchor bolt hole to a depth of 1.25 in. (*30 mm*).

- Mount the anchor bolt.
- Place a 7/16 in. (*11 mm*) nut on the bolt and twist until it stops (hand tight only). This nut is referred to as the *adjustment nut*.
- Replace the plate over the anchor bolt and install a washer and a second 7/16 in. (*11 mm*) *securing nut* just enough to hold the plate on the stud.
- Orient the attached ultrasonic plate in the desired position and press against the crown (soffit) of pipe.
- Spot drill (mark) the remaining three holes for the ultrasonic sensor mounting plate.
- Swivel the plate 180°.



01-05.pcx

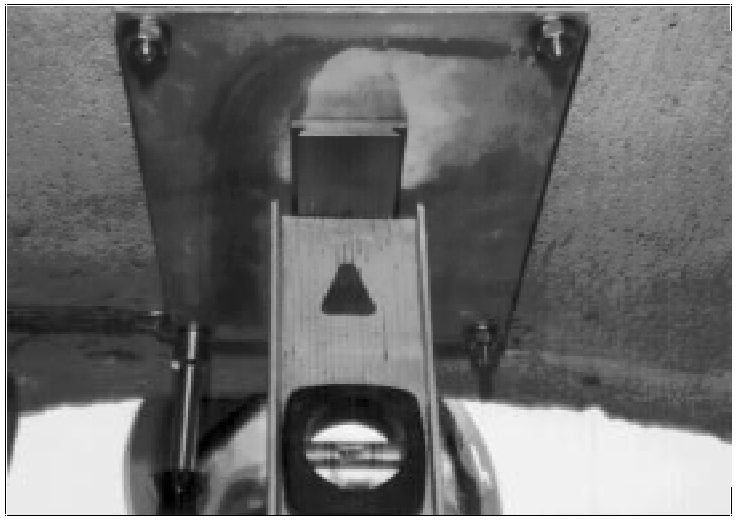
Plate Rotation

- Mount the three anchor bolts as described earlier.
- Swivel the plate back to correct the position and align the holes.
- Firmly push the plate up to the adjustment nuts and secure the plate with 7/16 in. (*11 mm*) securing nuts until they're tight.

Note: In some instances the anchor bolt may be slightly offset from the plate holes. Re-alignment can be done by simply loosening the 7/16 in. (*11 mm*) adjustment nut at the end of the anchor bolt and gently tapping with a hammer until the correct alignment is attained. Tapping the nut eliminates any thread damage to the anchor bolt.

- Level the plate with a carpenter's (torpedo or line) level. A fine-tune adjustment is done using the adjustment nuts on the back side or upper surface of the ultrasonic plate.

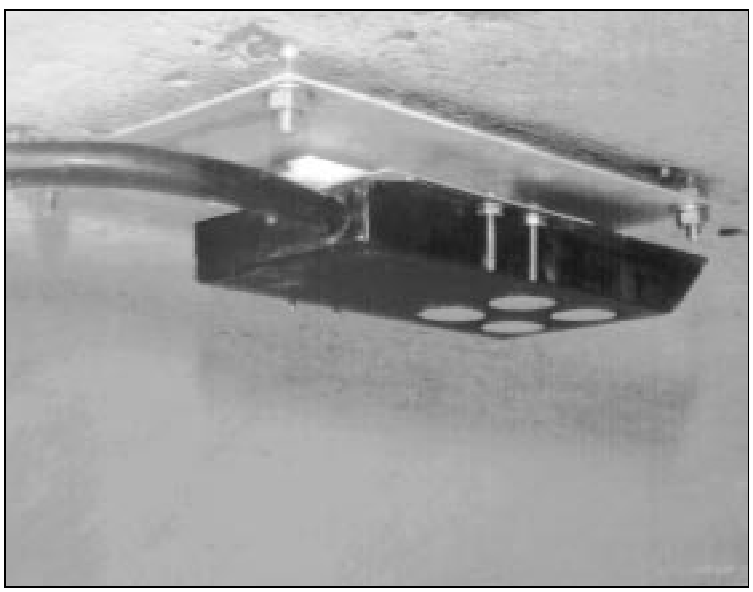
Note: In some instances, the plate may bind and can be lowered with the aid of a flat head screw driver.



01-17.pcx

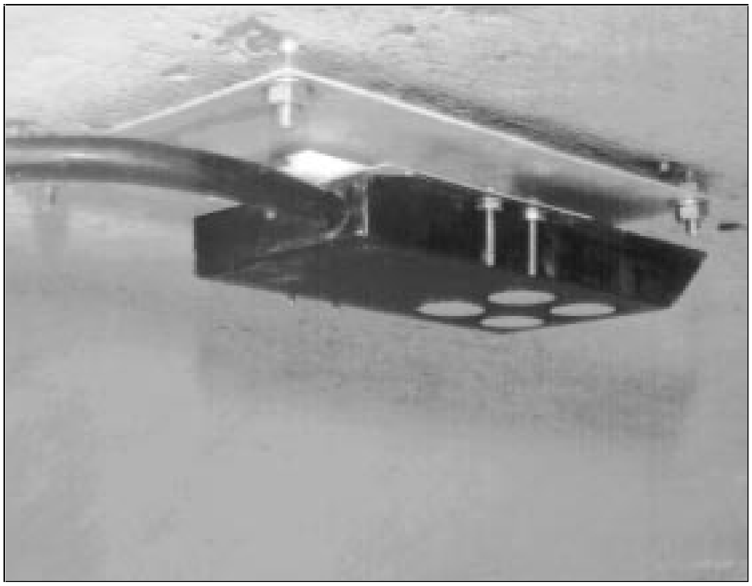
Leveling the Plate

- To ensure that the plate remains level, hold the adjustment nuts firmly in place with the aid of a 7/16 in. (*11 mm*) wrench. Firmly tighten the 7/16 in. (*11 mm*) securing nuts against the bottom side of the plate.
- Attach the ultrasonic sensor to the installed ultrasonic plate via the quick disconnect mount. Verify the installed ultrasonic sensor is level.



01-02.pcx

Installing the Sensor on the Plate:
Engage the Slide Mount on the Upstream Side and Slide the Ultrasonic Sensor Back until It Hits the Stop.



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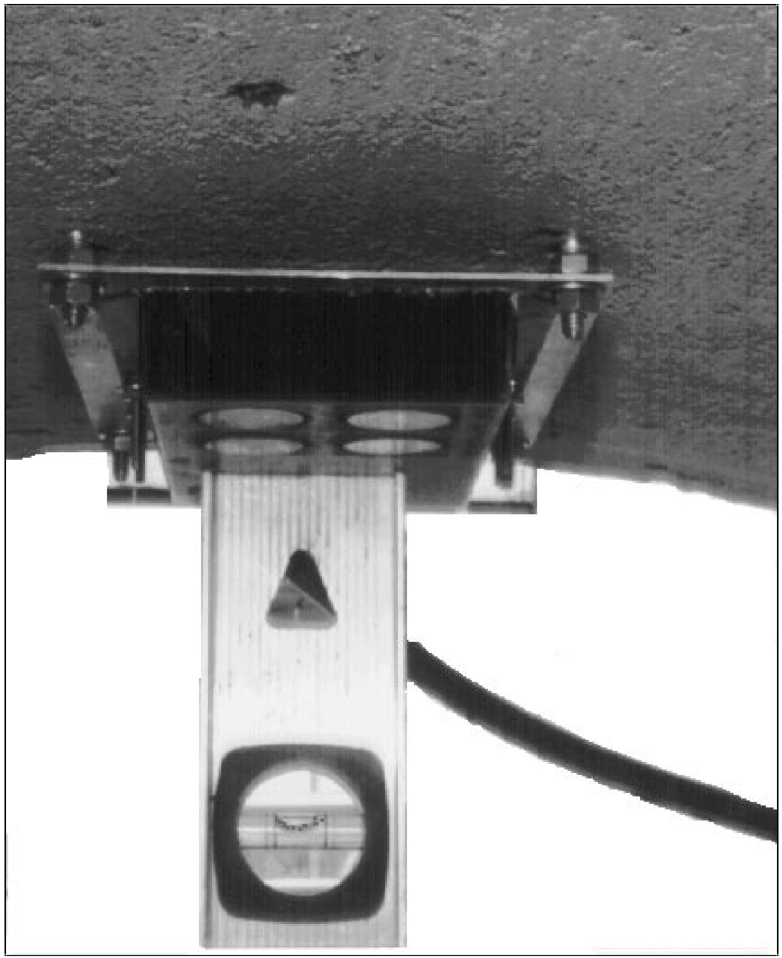
The Finished Installation of the Plate and Sensor

Verify that the Ultrasonic Sensor is Level.



01-07.pcx

End View Showing the Sensor and the Mounting Plate Halves of the Quick Release Mount

Adjustable Ultrasonic Mount

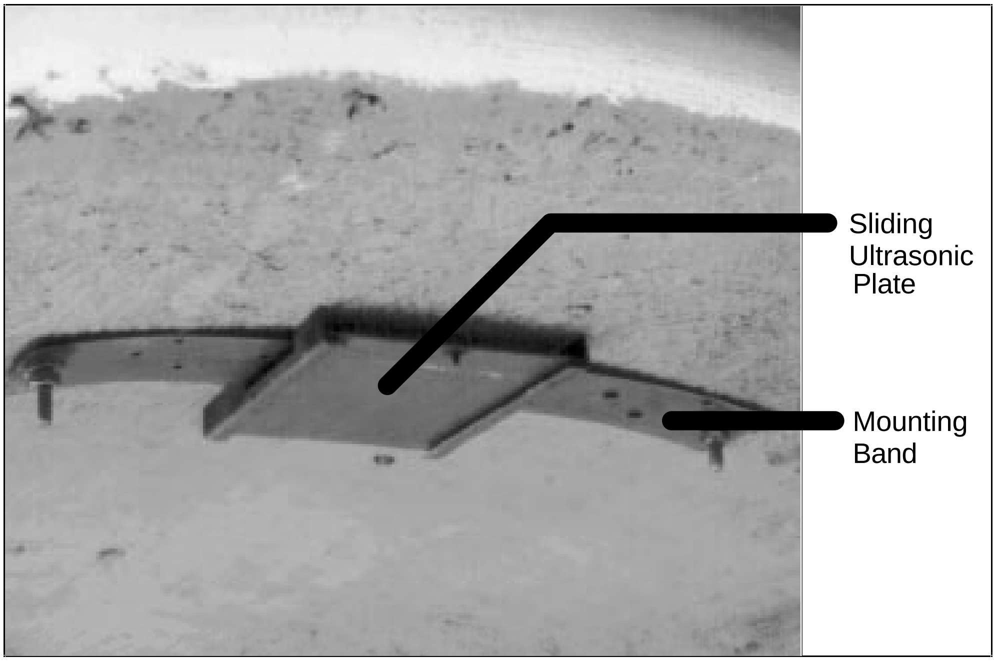
The adjustable ultrasonic mount was derived from the adjustable ring concept–a piece of stainless steel with a sliding ultrasonic plate. It is a new design and will improve the time efficiency of the ultrasonic installation.

You will need the following parts when assembling one standard ultrasonic mount:

- one 30 cm (12 in.) stainless steel mounting band and
- one sliding ultrasonic plate.

Pre-Installation Assembly

Due to the simplicity of its design, no assembly takes place until installation.



01-01.pcx

Ultrasonic Plate and Mounting Band

Installation

01-01.pcx

The Adjustable Ultrasonic Depth Sensor Mount

- Locate the apex of the pipe.
- Position and hold the sliding ultrasonic plate in center apex of the pipe and scribe a mark on both sides where the ultrasonic plate is to be located.

- Center the 30 cm (12 in.) band, allowing about 100 mm (4 in.) of overhang on each side from scribed location.
- Press one end of the curved band until it conforms with the pipe configuration and spot drill to mark the bolt location.
- Remove the curved band and drill the anchor bolt hole.
- Mount the anchor bolt.
- Locate the pre-drilled hole on the curved band and attach the band to the anchor bolt with a washer and a 7/16 in. (*11 mm*) nut and hand tighten.
- Slide the adjustable ultrasonic plate on the band with the backstop pin pointed toward the invert and the two band slots facing up.
- Align the sliding ultrasonic plate with the scribe marks (done earlier) and conform the other end of the curved band with the pipe and spot drill to mark.
- Mount the anchor bolt to the pipe.
- Attach the band through pre-drilled holes and secure with a washer and a 7/16 in. (*11 mm*) nut and hand tighten.

Note: If the adjustable ultrasonic plate has too much play in it, attach another anchor bolt approximately 25 mm (1 in.) from the plate.

- Slide adjustable ultrasonic mount along the metal band until level. Tighten the anchor bolt nuts securely with the nut driver.

01-04.pcx

Tapping the Adjustable Ultrasonic Depth Mount to Make It Level

- Slide the ultrasonic sensor into position on the adjustable ultrasonic plate until the back of the sensor comes in contact with the backstop pin.

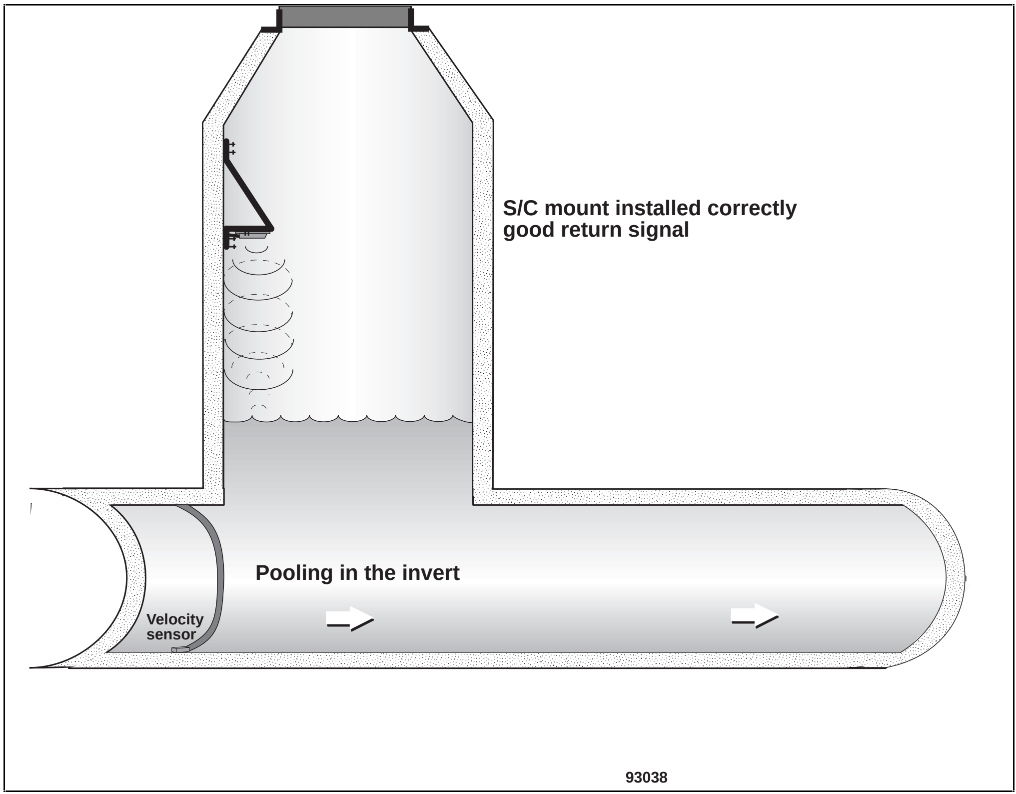
01-02.pcx

Sliding the Ultrasonic Sensor in Place

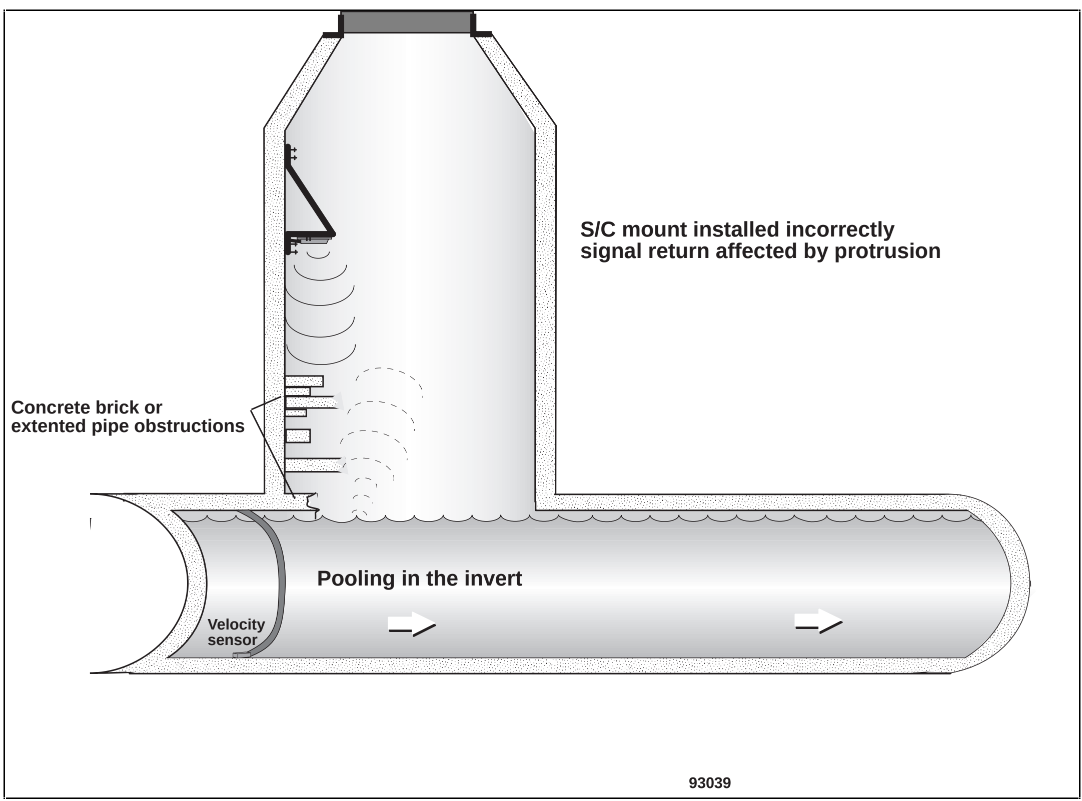
- Double check the ultrasonic sensor to confirm that it is still level.

Surcharge Mount

The surcharge mount is a V-shaped bracket with an ultrasonic plate attachment. Its use is limited to installations on manhole walls and not in the sewer pipe itself. Surcharge mounts are used very infrequently but will be necessary when the flow level is continually in the dead zone of the pipe-mounted ultrasonic sensor or when a pressure sensor has not been installed in a site that surcharges frequently.



Because the Bracket Mounts onto the Manhole Wall, Be Aware that Rungs and Brick Outcroppings May Affect the Ultrasonic Sensor Readings.



In Some Instances, the **Pulse Command** and **Spare 2** Must Be Adjusted to Record the Correct Depth Readings.

You will need the following parts when assembling a surcharge mount:

- an aluminum surcharge mount,
- four 6-32 × 1 in. (*25 mm*) round-head machine screws,
- eight 6-32 washers, and
- four 6-32 × 5/16 in. (*8 mm*) nuts.

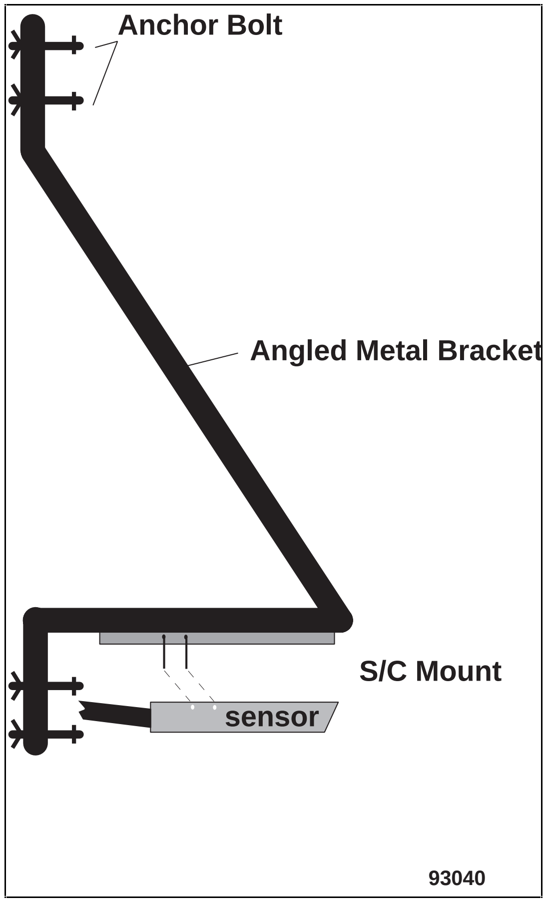
You will need the following tools when assembling a surcharge mount:

- a medium slotted screw driver and
- a 5/16 in. (*8 mm*) nut driver.

Pre-Installation Assembly

- Position the top of ultrasonic sensor to the base of the surcharge plate.
- Align the holes of the ultrasonic plate with the ultrasonic sensor.
- Insert a 6-32 × 1 in. (*25 mm*) round-head machine screw with a 6-32 washer through the ultrasonic plate and sensor.
- Secure with a 6-32 washer and 5/16 in. (*8 mm*) nut.
- Secure the three remaining locations as described in the previous step.

Note: A quick release mechanism can be interfaced between the surcharge bracket and ultrasonic sensor.



Surcharge Mount

Installation

- Locate the height at which the ultrasonic portion of the bracket needs to be installed (determined by location report).
- Press the bracket firmly against the manhole wall.
- Locate the three pre-drilled holes at the top of the bracket.
- Spot mark the middle hole with a drill.
- Remove the bracket.
- Drill and mount the anchor bolt.
- Secure the top bracket to the manhole wall with a washer and 7/16 in. (*11 mm*) nut.
- Push up on the bottom portion of the bracket until the ultrasonic portion of the bracket is level.
- Hold the bracket firmly in place against the manhole wall.
- Locate the three pre-drilled holes on the bottom of bracket.

- Spot mark with a drill in the middle hole.
- Rotate the bracket 90°.
- Drill and mount the anchor bolt.
- Secure the bottom of the bracket with a washer and 7/16 in. (*11 mm*) anchor bolt.
- Verify that the ultrasonic portion of the bracket is level. If it is slightly unleveled, horizontal adjustments can be made on the bottom of the bracket by moving the bottom portion of the bracket to the left or right (bottom mounting holes are oval, thus allowing for minor horizontal adjustments).
- Drill and mount the anchor bolt in one of the pre-drilled holes located at the top portion of the bracket for extra security.
- Confirm that the ultrasonic sensor is level.

3/4 Band Velocity Mount

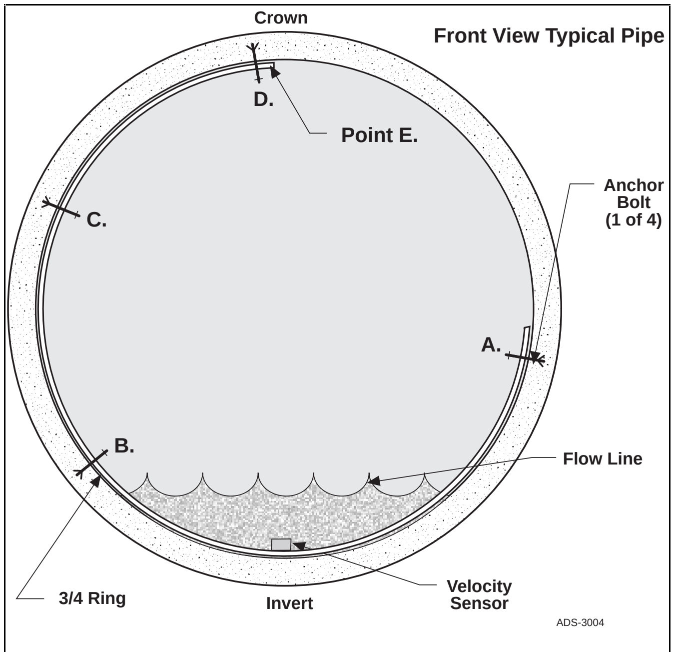
The 3/4 band velocity mount and the 1/2 band velocity mount require almost identical methods of construction. Only one difference exists between the designs. Because both sides of the 3/4 band are secured to the pipe wall, the construction of the 3/4 band velocity mount usually allows for the velocity/pressure sensor to be mounted in the center of the flow. This is not possible with the 1/2 band velocity mount.

You will need the following parts when assembling one velocity band:

- two 3 mm × 8 mm flat-head machine screws, and
- a segment of stainless steel or aluminum special flange of site-specific length. The special flanges come in standard 2.5 m (8 ft) lengths. If one special flange will not reach around the pipe, attach two bands together. (If the installation is in a square-shaped pipe, use a 2.5 m (8 ft) straight aluminum strip).

You will need the following tools when assembling one velocity band:

- a small slotted screw driver,
- diagonal cutters,
- a rotary drill,
- a 3 mm (7/32 in.) drill bit (ADS part number F35-0025), and
- a 10 mm (3/8 in.) drill bit (ADS part number F35-0023).



Pre-Installation Assembly

- Position the metal band so that the small holes drilled along the edge of the ring are facing towards you. This is the downstream side of the band.
- Check the site report to determine if the cable route and entry will be from the left, middle, or right of the designated installation position. This determines which side of the band will be the short end of the velocity band. The short end of the band is the side opposite of the pipe where entry occurs. If one enters in the middle of the pipe, it will not make a difference.
- Once the short end has been designated, locate the second pre-drilled hole down from the short end of the band.
- Check the site report for silt measurement and DOF at investigation.
- If silt is present at the site, the velocity sensor mounting point must be relocated up the side of the band so that it will be clear of any silt when installed.

  — OR —

  If silt is not present, you must determine the location in which the velocity sensor is attached on the band.
- If holes do not already exist at or near the mark, drill holes in the band for the velocity sensor using a 3 mm (7/32 in.) drill bit (*near* depends on the amount of flow in the line). In large pipes, flow levels are usually high enough that one can be off several inches. The critical concern is to make sure the sensor is covered with flow at its lowest level.

- Place the velocity sensor on the band surface that will face inside (or towards the flow). The velocity cable should exit toward the edge of the band where the small pre-drilled holes (which run the length of the band) are located.
- Line up the holes in the band with the screw holes on the bottom of the velocity sensor.
- Attach the velocity sensor to the ring using the two 3 mm × 8 mm countersink screws. Tighten until the sensor is securely attached to the band.

Note: The following steps are for attaching the pressure sensor to the band. Perform these steps as needed; not all sites require a pressure sensor.

The pressure sensor is mounted on the band in the same fashion as the velocity sensor.

- Mark a position two inches to the left of the velocity sensor. Be sure that the marked position will place the sensor underneath the flow after installation.
- Secure the pressure sensor to the band using two 3 mm × 8 mm countersink screws. Tighten until the sensor is securely attached.
- If your pressure sensor does not have screw inserts, use two medium -size cable ties to secure the pressure sensor to the ring. Crisscross the cable ties across the top of the sensor and underneath the band.

Use the following steps to attach the sensor cables to the band.

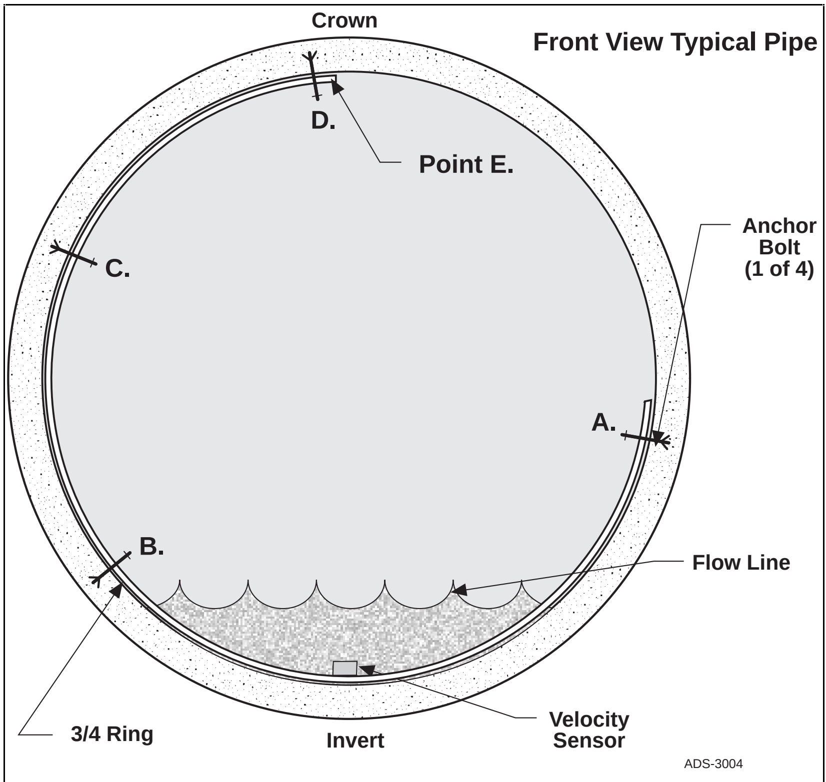
- Run the cable from the pressure sensor up the backside of the band (the side with pre-drilled holes along the edge) in the direction you intend to run the cables.
- Repeat the above step for the velocity sensor cable, but run it on the *outside* of the pressure cable.
- Attach the sensor cables to the ring by inserting a 100 mm (4 in.) cable tie into the holes drilled through the backside of the band. Secure the cables with the cable ties at *every hole* until the top of the band is reached. Leave enough slack in the cable ties to allow the sensor cables to lie flat behind the band. Remove all excess cable tie material.

Note: If there are no 10 mm (3/8 in.) holes present for anchoring the band to the pipe wall, drill the holes every 30 cm (12 in.) along the length of the metal band.

Installation

The 3/4-mount installation is the preferred method of velocity band installation. This procedure involves securing the band on *both* sides of the pipe with anchor bolts. This design keeps the ring flush and tight against the bottom of the pipe. It will not be damaged or ripped from the wall as the depth of flow increases. The limiting factor of this kind of installation is flow depth and silt.

- **Flow Depth** If the pipe is large and flow levels deep during minimum flows the velocity band may not reach the other side of the pipe. (Securing two bands together may give the necessary length, but the installation will become more difficult.)
- **Silt** If there is excessive silt present in a large pipe, it will hamper the installation of the band. Removing massive silt amounts in a large deep line is usually impractical.



"C" or 3/4 Ring Velocity Special

- Position the velocity band so the sensors are in the flow below minimum flow depth. (This ensures the sensors will not come out of the flow at night.)
- Position the band so that two of the pre-drilled holes are visible on the *opposite* side of the pipe. Maneuver the band until the lowest hole is almost at water level and spot mark with a drill.
- Drill and mount the anchor bolt onto the pipe wall with a pneumatic drill.
- Attach the band to the anchor bolt and secure it with a washer and 7/16 in. (*11 mm*) nut.
- Apply a downward pressure to the long end of the band and hold the band in place with foot pressure.
- Verify that the band and sensors are flush with the pipe surface.

- Continue to apply pressure to the band and locate the pre-drilled hole closest to the water surface on the long end of the band.
- Drill and mount the anchor bolt to the pipe surface.
- Maneuver band in position; it should be a very tight fit, and you may have a problem lining up the pre-drilled hole with the anchor bolt.
- Secure the band to the anchor bolt with the 7/16 in. (*11 mm*) washer nut combination.
- Check to make sure the band and sensors have remained flush with no gaps present. (In old pipes with brick construction there may be periodic gaps, but this is unavoidable; if larger gaps are present they can be filled with plumbers putty.) If the installation is not correct, start over. This will prevent problems in the long run.
- Go to the first anchor location and push the top of the band firmly to the pipe surface, and drill and secure the end of the band with the anchor bolt and corresponding washer and a 7/16 in. (*11 mm*) nut.
- Determine how many anchor points are required to secure the long end of the velocity band to the apex of the pipe. An anchor bolt every 60 cm (24 in.) is usually sufficient.
- Push the long end of the band in a downward motion, conform the band to the pipe surface, and secure with anchor bolts.

Note: Make sure that the sensor cables are not positioned between the metal band and the pipe as cable damage could result.

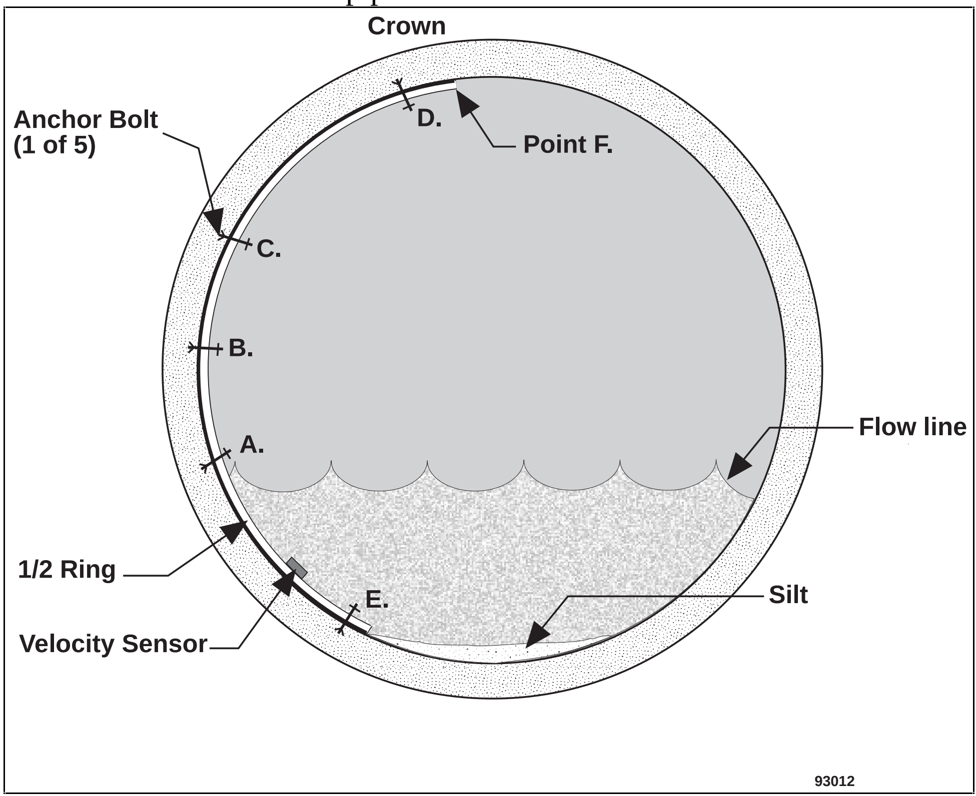
- Cable tie the ultrasonic and velocity cable together and secure with an anchor bolt at the crown (soffit) of the pipe.
- Secure the cables with anchor bolts every 60 cm (24 in.) along the crown (soffit) of the pipe until the invert is reached.
- Cut excess cable tie material.

1/2 Band Velocity Mount

The procedures for assembling a 1/2 band velocity mount are similar to the procedures for the 3/4 band velocity mount. The differences between the two methods follow.

- The sensors are installed at or near the end of the sensor band.
- Silt is *not* a primary concern during the construction of the band because it can be easily positioned in the correct location. The band is anchored on only one side of the pipe.

- This mounting method uses a special flat strip of rigid aluminum instead of the standard band. It is stronger and is less likely to become damaged during high flow conditions.
- It is imperative that the ring (below the water's surface) be secured with an anchor bolt and placed within 25 to 75 mm (1 to 3 in.) of the velocity sensor. This will prevent the velocity sensor from becoming clogged should debris accumulate between the pipe and the metal band.



1/2-Band Velocity Mount (Special Mount)

Installation

- Position the sensor portion of the band in the flow, below minimum flow levels and out of silt.
- Orient the band in a fashion that allows one of the pre-drilled holes to be right at the water surface.
- Spot mark with a drill.
- Drill and mount the anchor bolt to the pipe wall.
- Attach the band to the anchor bolt with a washer and a 7/16 in. (*11 mm*) nut.
- Position the submerged portion of the band until it is flush with the bottom of the pipe. A slight downward bend of the band right below the water surface may aid in ensuring that the band and sensors are flush.

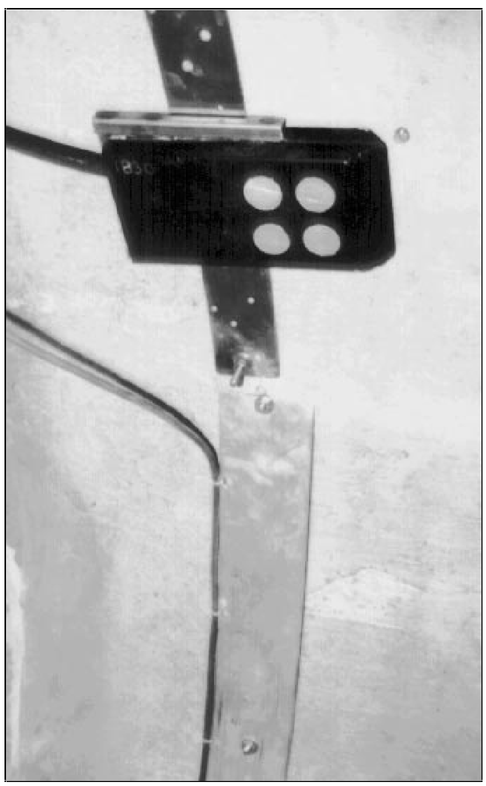
- Step on the band to determine if any play is present.

Note: If the band is not completely flush, locate the pre-drilled hole closest to the sensor. This is rather difficult as you will have to use the touch and feel method. Once located, use a compressor drill or a 60 cm (24 in.) extended bit and drill another anchor bolt hole under the flow surface. Secure the anchor bolt to the pipe and attach the band with a 7/16 in. (*11 mm*) nut and corresponding washer.

- Mold the long end of the band up the pipe wall.
- Secure the band with anchor bolts up the pipe wall every 60 cm (24 in.) until the end of the band is reached.

Note: Ensure the sensor cable is not between the band and pipe during the installation, or cable damage could result.

- Cable tie the velocity sensor to the ultrasonic cable and secure with the anchor bolt at the crown (soffit) of the pipe.



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Completed 1/2-Mount Velocity Band Installation (Looking Towards the Top of the Pipe)

- Anchor the bolt and secure the sensor cables every 60 cm (24 in.) along the pipe crown (soffit) until the invert has been reached.
- Cut the excess portion of the cable tie.

Note: If the pipe is large and the velocity sensor cable is not run to the apex of the pipe, then attach the velocity cable to 13 mm (1/2 in.) PVC tubing that has been anchored (bolted) to the wall. This will help to prevent sensor damage during flow increases.

CHAPTER 5

Monitor Installation and Activation

Once the adjustable ring and the sensors have been installed into the sewer pipe, you must install and activate the monitor. If you are not installing a monitor with an IS modem, you must also install the external modem unit (EMU). As with the ring and sensors, installing the monitor requires training and should not be attempted by inexperienced personnel. Because of the hazardous conditions that can exist in sewers and other places where the monitor is installed, a team of two or more people should be involved in the installation operation. Specific safety procedures are beyond the scope of this manual, but you should follow all company and governmental safety policies.

To learn about: ***See page:***

Installing the EMU

The following information serves as a guideline for installing an EMU. Carefully follow these guidelines so that the installation conforms to all NEC (national electrical code) guidelines for installations into Class 1, Division 1, Groups C and D hazardous areas.

Observe all local regulations and requirements for installing a pavement box, such as planning permits required for a pavement box, local regulations regarding buried cables, and local regulations regarding inspection of installations.

- Select a location for the EMU.
- The preferred location is within a customer supplied above ground housing.
- An alternative location, which is inside a flush-mounted pavement box, requires that you select a location with telephone access. Locate the manhole and the phone source. Determine if cabling must be in the conduit or if it can be buried directly. Measure the length of communication cable needed. For detailed information about communication cable installation, see page 5-8.
- Locate all underground services and lines. Have service locators mark any underground pipes, wiring, etc. For detailed information about underground services and lines, see page 5-3.
- Dig a trench from the manhole and from the phone source to the pavement box location (ADS recommends using a subcontractor for this task). Lay the cables in place. For detailed information about using pavement boxes and trenching for cables, see page 5-4.
- Install the pavement box by first digging a hole, then setting the box in place with the cables running from the bottom of the box up through the gravel bedding. For detailed information about installing a pavement box, see page 5-5.
- Install the EMU by placing bricks or cinder blocks inside the pavement box to hold the EMU off the bottom of the box. For detailed information about installing the EMU, see page 5-8.
- Install the communication cable in the manhole. For detailed information about installing the communication cable, see page 5-8.
- Wire the communication cable and telephone cable into the EMU. For detailed information about wiring the cables, see page 5-12. See page 5-15 for information about “Direct Connection Communication (SCADA System).”
- Contact an ADS certified technician to set the monitor to the correct baud rate. For detailed information about setting the options switch, see page 5-15. In addition, have the ADS certified technician set the multiplexor switch correctly. For detailed information about the multiplexor switch, see page 5-20.

Pavement Box Location

Locate the pavement box in a well-drained, level, grassy area which is slightly higher than the surrounding area. The box should not be subjected to standing water during and after rain events.

Although the cover will withstand most loads, the boxes are not designed for constant abuse by traffic. The pavement box should only be installed in a road after all other options are exhausted. If there is no other location for the pavement box, then select a stronger pavement box and/or pour a concrete footing to spread out the load and to increase the stability.

Orient the pavement box so that one end faces the phone source and the other end faces the manhole as much as possible. This will avoid cable confusion in the manhole and will meet the IS requirements for cable separation.

When the location is finally determined, obtain the required length of communication cable, but allow for extra footage. The maximum cable length connecting the EMU to the QS3600 flow monitor is 90 m (300 ft). Install the pavement box between the QS3600 flow monitor and the phone source. Keep the cable lengths to a minimum. If a long cable is required, locate the pavement box as near as possible to the monitor and run the telephone cable the longest distance.

Underground Services and Lines Location

Search for any underground services that may be buried in the area where the box and cable trenching is planned.

- Use the proper authorities to conduct this search. Normally, each utility company provides a location service that visits the site to mark the location and depth of the underground services to be avoided.
- Be onsite when the underground service locators are conducting their search.
- If the service is of a vital or hazardous nature, request that a member of the locating service be present during digging. Make this request in writing and give the date and time when the digging will begin. Services of a vital or hazardous nature include
  - ❑ gas lines,
  - ❑ steam lines,
  - ❑ fiber optic mass-use phone ducts, and
  - ❑ high voltage power lines.
- The service owners have the right to ask that the trenches be hand dug. Hand digging avoids the potential damage that a backhoe or other powerful

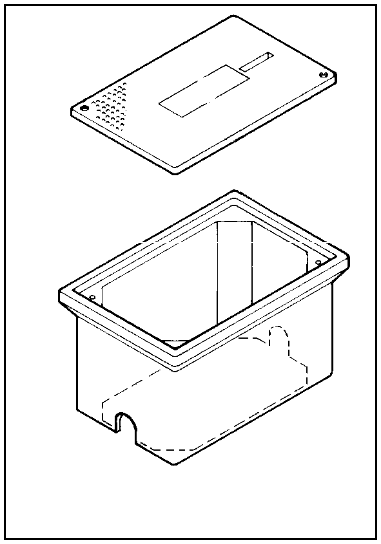
equipment can cause. This is a very reasonable request and should never be ignored.

- Verify the minimum depth of the trenches as required by local codes. Local authorities will verify the local code requirements for trenching depths. The authorities will need to know that our trenches are being dug for cabling that carries maximum voltages of
  - ❑ 9 Vdc for a communication cable and
  - ❑ normal phone voltages for telephone service.

Pavement Box and Cable Trenching

Whenever possible, hire a subcontractor to dig the trenches and to install the pavement box.

- When requesting estimates from subcontractors, give them the following information:
  - ❑ the pavement box location,
  - ❑ a confirmation that all underground services have been located and marked,
  - ❑ the name of their contact with your group,
  - ❑ the location of the telephone service source,
  - ❑ the location of the manhole,
  - ❑ the burial depth of the cables/conduits,
  - ❑ the sizes of the conduits (if required),
  - ❑ the overall site plan, and
  - ❑ the drawings of the site plan.
- Because the trench for the cables will be permanently covered with concrete or asphalt when the subcontractor's job is completed, always install conduit so cables can be replaced if defects occur.
- Some of the work installing the conduit will be inside the manhole. Inform the subcontractor that they will not be expected or permitted to enter this area. ADS or the system owner will provide the safety-approved labor for any confined space tasks.
- Obtain the subcontractor's insurance information. Explain that all permits for road openings, traffic control, site reinstatement, etc., are the subcontractor’s responsibility.



Pavement Box

Pavement Box Installation

Prior to installation, obtain 25 kg (50 lb.) of pea gravel and one brick for each corner of the box. The bricks provide direct ground support for the EMU to prevent it from sinking into the gravel.

- Dig the trench approximately 20 cm (8 in.) deeper than the depth of the box.
- Add 15 to 20 cm (6 to 8 in.) of pea gravel or crushed rock to the bottom of the trench. The gravel provides drainage for the EMU.
- Place the pavement box in the trench with the top surface at grade level.
- Fill the trench and compact the soil until it is level with the cover on the pavement box.
- If the grade level is raised later (through landscaping, etc.), a straight-sided box can be pulled up and bricked at the bottom on one or four sides to conform to the landscape.

You will need the following tools in order to install the pavement box:

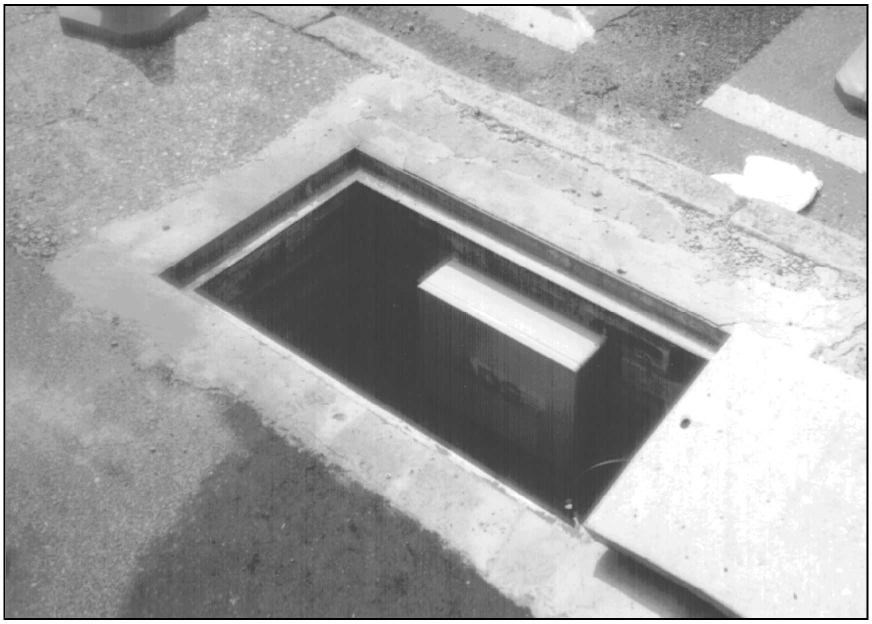
- a heavy duty hammer drill,
- a 1 in. × 2 ft (*25 mm × 0.5 m*) carbide bit to fit the heavy duty hammer drill,
- a small pan to mix the cement,
- a 1 in. (*25 mm*) masonry trowel,
- an Allen wrench to fit the seal-off fitting close-up plug,
- rubber gloves to wear while using cement and seal-off compound,
- a narrow sharpshooter shovel for trenching,

- a pick-ax for stubborn digging,
- a regular digging shovel,
- a level for leveling the top of the pavement box,
- a chalk line to layout trenches,
- a hacksaw to cut the conduit,
- a socket set for the monitor and top of the pavement box,
- a 50 ft (*15 m*) of 1/8 in. (*3 mm*) fish tape to pull the cables through the conduit,
- an ac power supply for the hammer drill to install the communication cable,
- wire strippers,
- channel lock pliers,
- a pipe wrench, and
- paper towels.

The following supplies are required for installing the pavement box.

Quantity	Unit	Description
1	Each	Quazite PG1730BB12 Box with Mouseholes
1	Each	Quazite PG1730CA00 Non-Locking Cover
1	Each	Quazite UH0357AA Long Cover Hook (for cover removal)
1	Each	13 mm (0.5 in.) Rigid Galvanized Conduit Nipple--a minimum of 15 cm (6 in.) longer than the manhole wall thickness
1	Each	Type EY-1, 13 mm (0.5 in.) Sealing Fitting--Killark (brand) or equivalent
1	Each	Noalox Conduit Joint Compound--Ideal (brand) or equivalent
2	Kg (5 lb)	Hydraulic cement--Thompsons (brand) or equivalent
2	Each	13 mm (0.5 in.) Plastic Bushings
1	Each	13 mm (0.5 in.) diameter by 25 mm (1 in.) long Nipples
1	Each	Roll of PVC Electrical Tape
25	Kg (50 lb)	Pea Gravel
20	L (5 gal)	Clean Water for Cement and Tool Clean-up
If installing the conduit from the manhole to the pavement box, you will also need the following parts and supplies.		
1	Each	Female 13 mm (0.5 in.) PVC Adapter
as needed	m or ft	13 mm (0.5 in.) PVC conduit (must be long enough to extend from the manhole to the pavement box)
7	Each	Smooth 90° 13 mm (0.5 in.) PVC Elbows
1	Each	Can of PVC Primer (follow all of the safety instructions on the label)
1	Each	Can of PVC Glue (follow all of the safety instructions on the label)

External Modem Unit (EMU) Installation



Installed Pavement Box and EMU

Use the following procedure when installing the EMU.

- Place one brick or cinder block below each corner of the EMU to keep it off the bottom of the pavement box. Raise the EMU as high as possible, but verify that it does not prevent closing the lid on the pavement box.
- Ensure that the phone cable and the communication cable enter the EMU from opposite ends (this is necessary to remain in compliance with the IS requirements).

Note: To comply with IS rules, verify that the telephone cable and the communication cable enter the EMU from opposite ends. Do not allow the cables to cross each other. Never coil the communication line and the telephone line together.

Communication Cable Installation

Cable entry into the manhole must conform with the electrical code for service entry into hazardous areas. Use standard electrical fittings that are available from most professional electrical supply business. ADS installs the communication cables into the manholes using a method called *sealing off*. The fittings used for this job are typically called *XP* (explosion proof).

The method for installing the communication cable between the monitor and communication device depends on the hardware. When installing the cable running between an *EMU* and *the QS3600 monitor,* ADS recommends running the cable through conduit since it is not direct burial cable. To install this cable, refer to *Installing the Communication Cable Using Conduit* on page 5-10.

However, when installing the communication cable between the *DAA* and the *QS3601 monitor*, ADS does not require running the cable through conduit because the cable used in this application is direct burial cable. To install this cable directly in the ground, refer to *Installing the Communication Cable Directly in the Ground* on page 5-11.

Use the following procedure to install the communication cable in the manhole.

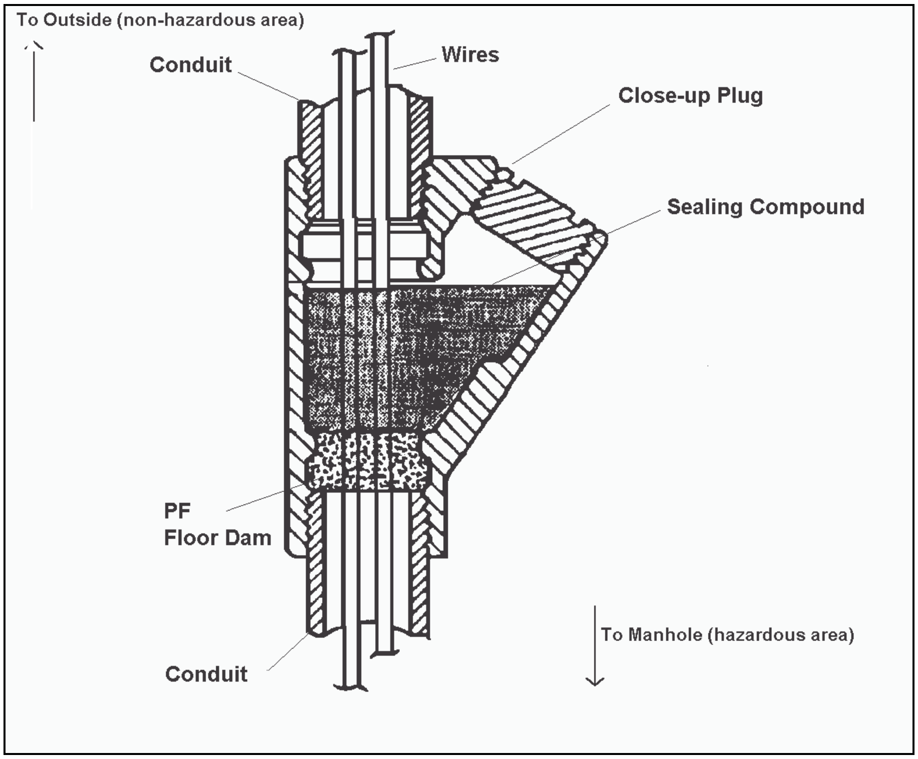
- Dig the trench to the manhole and widen the trench enough to accommodate the drill. If conduit is used for the communication cable, place it so that it drains toward the pavement box.
- Drill the hole from outside the manhole straight into the manhole, at the very bottom of the trench.
  - ❑ Drill the hole so that the conduit exiting the manhole wall lies on the very bottom of the trench. This position decreases the chance that damage will occur at the junction of the conduit and cable while back-filling and tamping the trench.

> **Note:** When using PVC primer and PVC glue, carefully follow the safety instructions on the labels to avoid injury.

- Prepare the conduit and fittings.
  - ❑ Apply Noalox® compound to all threaded conduit junctions.
  - ❑ Attach the 13 mm (0.5 in.) capped elbow to the nipple that will pass through the manhole wall.
  - ❑ Tighten firmly. Over-tightening will crack the elbow casing.
  - ❑ Attach a 13 mm × 25 mm (0.5 in. × 1 in.) nipple to the elbow, then attach the seal-off fitting (XP fitting).
  - ❑ Orient the close-up plug to so that it faces away from the nipple that will go through the manhole wall.
  - ❑ Attach another 13 mm × 25 mm (0.5 in. × 1 in.) nipple to the bottom of the seal-off fitting. Then, screw on a 13 mm (0.5 in.) plastic bushing.
- Apply regular electrician's tape to the threaded portion of the nipple. Pass the nipple through the hole in the manhole wall. The elbow should be flush with the inside manhole wall and pointing straight down. Use wedges to hold the assembly in position.
- Using gasoline or alcohol, remove all grease and Noalox from the conduit near the manhole walls.
- Moisten the concrete blocks or bricks around the conduit.

- ❑ Following the directions on the hydraulic cement can, mix enough of the cement to apply around the conduit–both from inside and outside the manhole.
- ❑ Wearing rubber gloves and using a trowel, force the cement into the hole surrounding the conduit, then trowel a bead around the conduit. The cement should harden in about one hour.

Note: Wire the communication cable to the communication device before mating the communication cable connector to the flow monitor.



Killark Series EY Sealing Fittings: Relationship between the Conduit, the Communication Cable, the Sealing Compound, and the Close Up Plug

Installing the Communication Cable Using Conduit

Install the communication cable using conduit in the following way:

- Find the free end of the conduit extending out of the manhole wall into the trench. Remove the tape from this end and attach the 13 mm (0.5 in.) female PVC adapter to this end of the conduit.
- Lay the remaining conduit from the manhole to the pavement box. Insert the fish tape into the conduit closest to the pavement box. Push the tape through the conduit until it appears at the capped elbow in the manhole.
- Find the trailing end of the communication cable (the end opposite of the connector). Push this end up through the seal-off fitting and out the capped elbow in the manhole. Attach this end of the cable to the fish tape using liberal

amounts of tape (do not use cable ties). Pull the cable through the conduit to the pavement box.

- Allow extra length on the communication cable so that the monitor can be removed easily from the manhole for service.

Installing the Communication Cable Directly in the Ground

Install the direct burial communication cable in the following way:

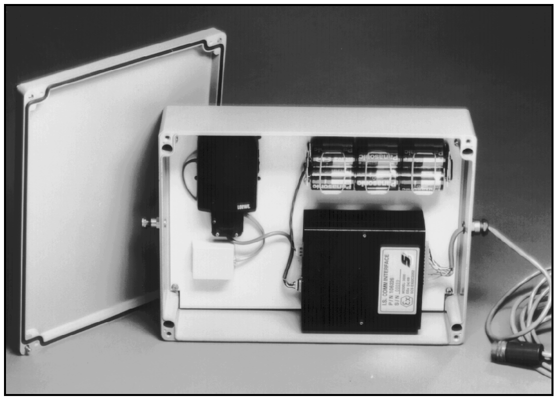
- After the cement hardens, remove the protective tape and screw a plastic bushing onto the rigid conduit.

Warning: Wire the communication cable to the DAA before mating the communication cable connector to the QS3601 flow monitor.

- Find the trailing end of the communication cable (the end opposite the connector). Push this end through the seal-off fitting, through the capped elbow, and through the manhole wall.

Note: The instructions on the seal-off data sheet (included with the seal-off fitting) must be followed exactly to maintain a Class I, Division 1, Groups C and D rating for installation.

- Lay the cable in the trench between the manhole and the DAA. Back-fill the trench carefully using clean fill dirt. Do not use rocks or any fill dirt that could damage the cable during back-filling and tamping.
- To test the communication cable, attach the appropriate cable end to the QS3601 flow monitor and to the DAA. If the cable has been installed properly, you should be able to communicate with the monitor.
- Remove the close-up plug on the seal-off fitting. Follow the directions on the seal-off data sheet included with the seal-off fitting. When completed, be sure to replace the close-up plug on the seal-off fitting and to replace the cap on the elbow.
- Alternatively, you can seal the conduit using expandable foam sealant (such as Secofoam® made by Expandite) that can be purchased from building suppliers.



Inside View of the EMU

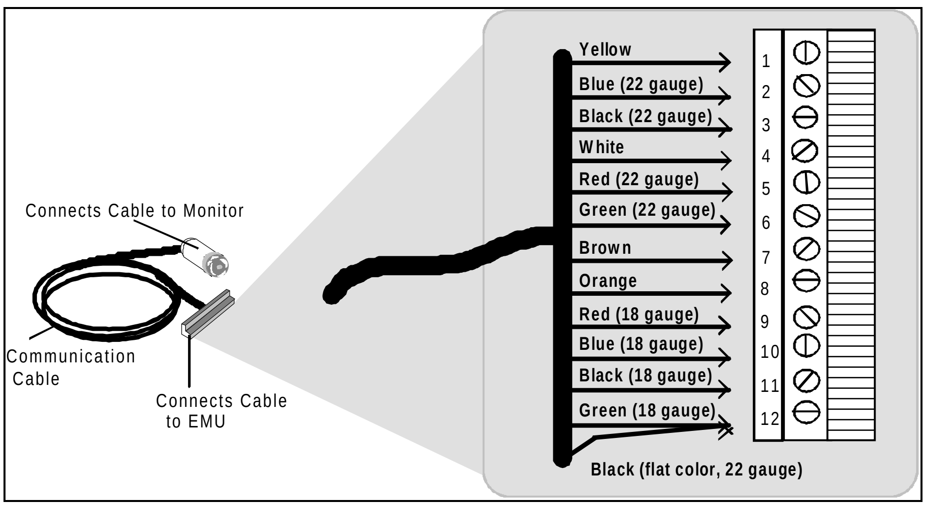
Communication and Telephone Cable Wiring

A communication cable must join the EMU and the monitor. First you must verify that the EMU cable connector is not connected to the monitor because cables easily short and blow a fuse in the monitor when they are pulled through conduit.

> **Note:** The instructions on the seal-off data sheet (included with the seal-off fitting) must be followed exactly to maintain a Class I, Division 1, Groups C and D rating for installation.

Next, connect the individually colored-coded wires on the communication cable to the hard-wired in-field connectors on the communications box inside the EMU (see the following figure). The color wires should be installed in the following order to match the marking strip alongside the hard-wired connectors. As you review the following table, please note that 18 gauge wire is thicker than 22 gauge wire.

Number	Description
1	Yellow
2	Blue (22 gauge wire)
3	Black (glossy color and 22 gauge wire)
4	White
5	Red (22 gauge wire)
6	Green (22 gauge wire)
7	Brown
8	Orange
9	Red (18 gauge wire)
10	Blue (18 gauge wire)
11	Black (glossy color and 18 gauge wire)
12	Green (18 gauge wire)
Drain	Black (flat color, heat-shrunk cover and 22 gauge wire)



Proper Communication Cable Wire Connections

A telephone cable must join the EMU to a telephone line.

- Verify that the telephone cable (phone jack cable) has four wires: yellow, blue, red, and green.

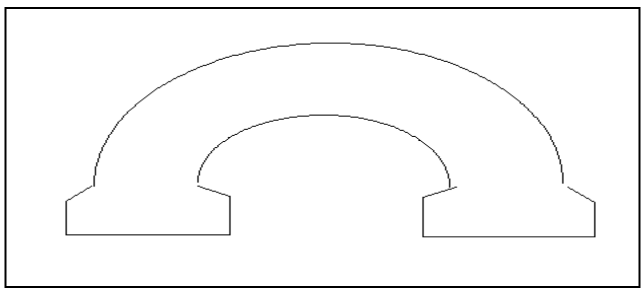
- Because EMU telephone cable connections vary from country to country, connect the phone cable to the connectors on the EMU communication box according to the following color scheme.

Country	Telephone Cable Wires
Germany	Connect the black and yellow cable wires.
Britain	Connect the red and green cable wires.
United States	Connect the red and green cable wires.
Australia	Connect the red and green cable wires.

The communication cable must join the monitor and the EMU.

- Connect the communication cable to the monitor by inserting the communication cable connector into the appropriate port on the monitor lid marked with a telephone icon.

Note: Wire the communication cable to the EMU *before* connecting the communication cable to the monitor.



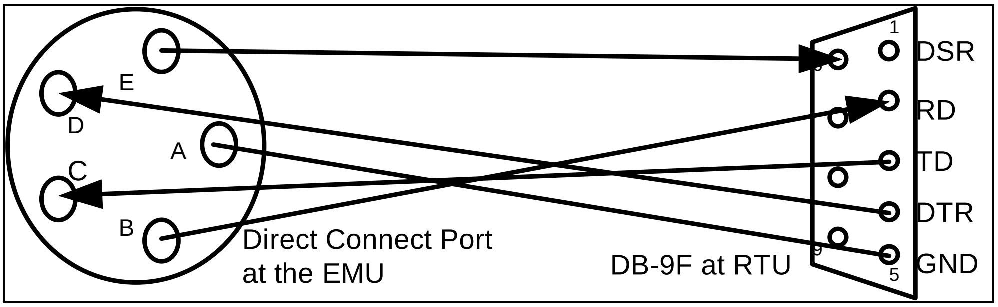
Icon on the Monitor Lid for the Communication Cable Port

Direct Connection Communication (SCADA System)

One type of EMU allows the QS3600 to communicate with a local RTU over a direct serial connection and with QuadraScan over a modem. This type of EMU communicates with the RTU over a direct serial RS-232 connection and via a cable that carries both serial communications and operating power. The EMU is configured with a serial multiplexor which splits the serial communications signal between the modem and a local connection to an RTU. However, not all EMUs have the external power and the serial multiplexor feature. Refer to the table on page 2-8 for SCADA EMUs available with both the serial multiplexor and the external power capability.

Communications Signals

The EMU direct connect serial interface implements the following RS-232 signals. Refer to the next figure which shows a typical wiring configuration.



Typical Wiring Configuration

Pins	Function
Pin A to Pin 5	Signal ground.
Pin B to Pin 2	RD - Receive Data is the signal by which serial data is transmitted from the 3600 flow monitor and received by the RTU.
Pin C to Pin 3	TD - Transmit Data is the signal by which serial data is transmitted from the RTU and received by the 3600 flow monitor.
Pin D to Pin 4	DTR - Data Terminal Ready is the signal asserted by the RTU to request that the serial multiplexor be switched to the RTU.
Pin E to Pin 6	DSR - Data Set Ready is a signal used to indicate whether the serial multiplexor is switched to the RTU channel or not and whether the monitor is prepared to communicate. An active signal indicates that the channel is switched to the RTU and that the RTU can communicate.

Direct Connection Communication (Portable Computer)

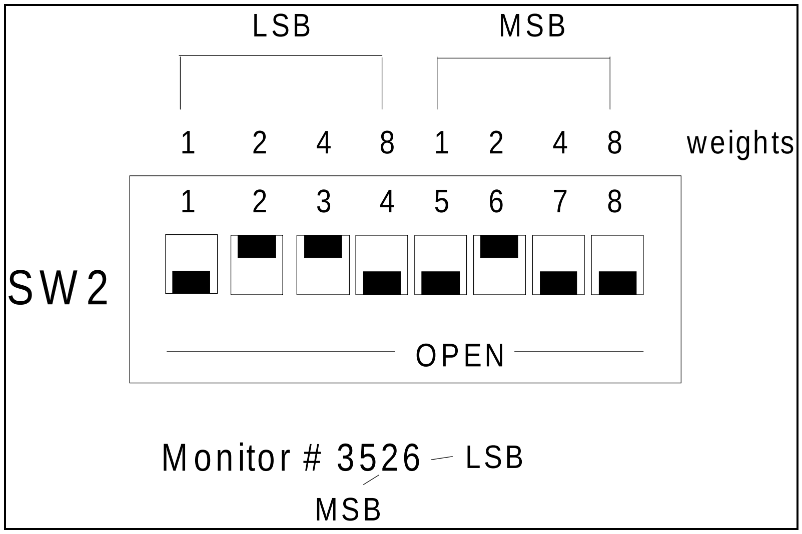
The EMU is provided with a direct connect extension cable (ADS part number 103203A). A portable computer can be connected to this extension cable using the standard 1502 temporary monitor direct connection cable (ADS part number 103191A).

Note: The portable computer must communicate at the baud rate that is currently in use by the modem. Typically, this rate is 2400.

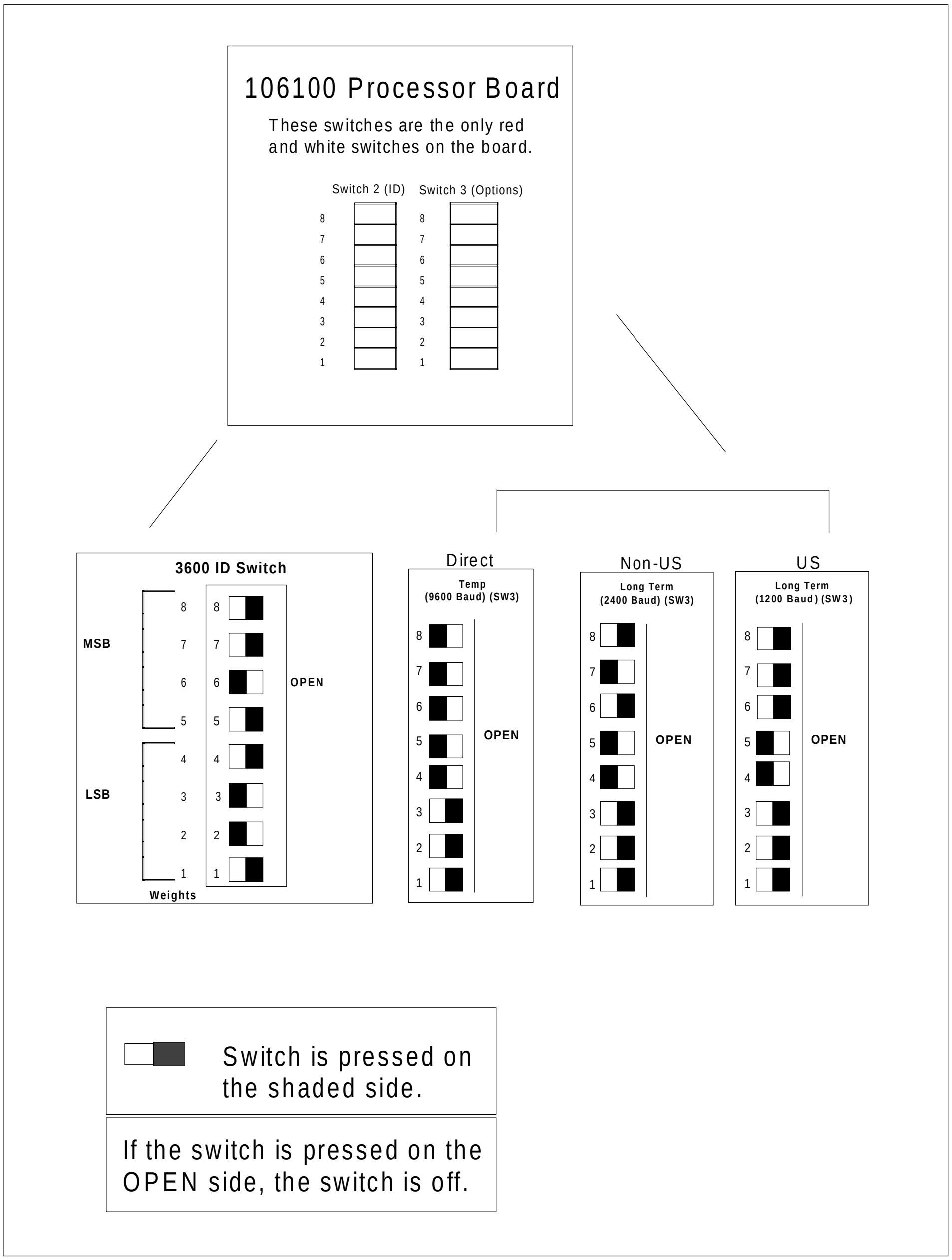
Baud Rate Setup

Most 3600 monitors are preset to a temporary 9600 baud rate. Before installing your monitor in the manhole, you must have an IS certified technician set the monitor to the correct baud rate if a change is required. Both the ID switch and the options switch must be set correctly. The ID switch (SW2) identifies the monitor serial number. The ID switch is normally set correctly by manufacturing; see the following figures for more information on the ID switch. The options switch (SW3) indicates the specific configuration of the monitor (modem/serial, baud rate, etc.). The options switch is normally set correctly by manufacturing; see the following figures and table for more information on the options switch.

Note: For both SW2 and SW3, closed means *on*, and open means *off*.



ID Switch



Options Switch Settings

- Determine the baud rate at which the monitor must be set.
- Have an IS-certified technician set the monitor to the correct baud rate.
  - ❑ Open the monitor and access the 106100 processor board.
  - ❑ Locate switches 2 and 3 (SW2 and SW3) on the processor board.
  - ❑ Verify that SW2 is set correctly (see the previous figures).
  - ❑ Change SW3 to the correct setting (see the following table).

1	2	3	4	5	6	7	8
Power	Time-out	Spare	106/103	Connection Type		Baud Rate	
Open	Monitor will go to sleep.						
Closed	Continuous power operation						
	Open	Time-out enabled (10 min)					
	Closed	Time-out disabled					
		Open	N/A				
		Closed	N/A				
			Open	103100 CPU			
			Closed	106100 CPU			
			Internal Auto Answer Modem	Open	Open		
			External Non-auto Answer Modem	Closed	Open		
			Direct	Closed	Closed	RS-232	
					1200	Open	Open
					2400	Closed	Open
					4800	Open	Closed
					9600	Closed	Closed

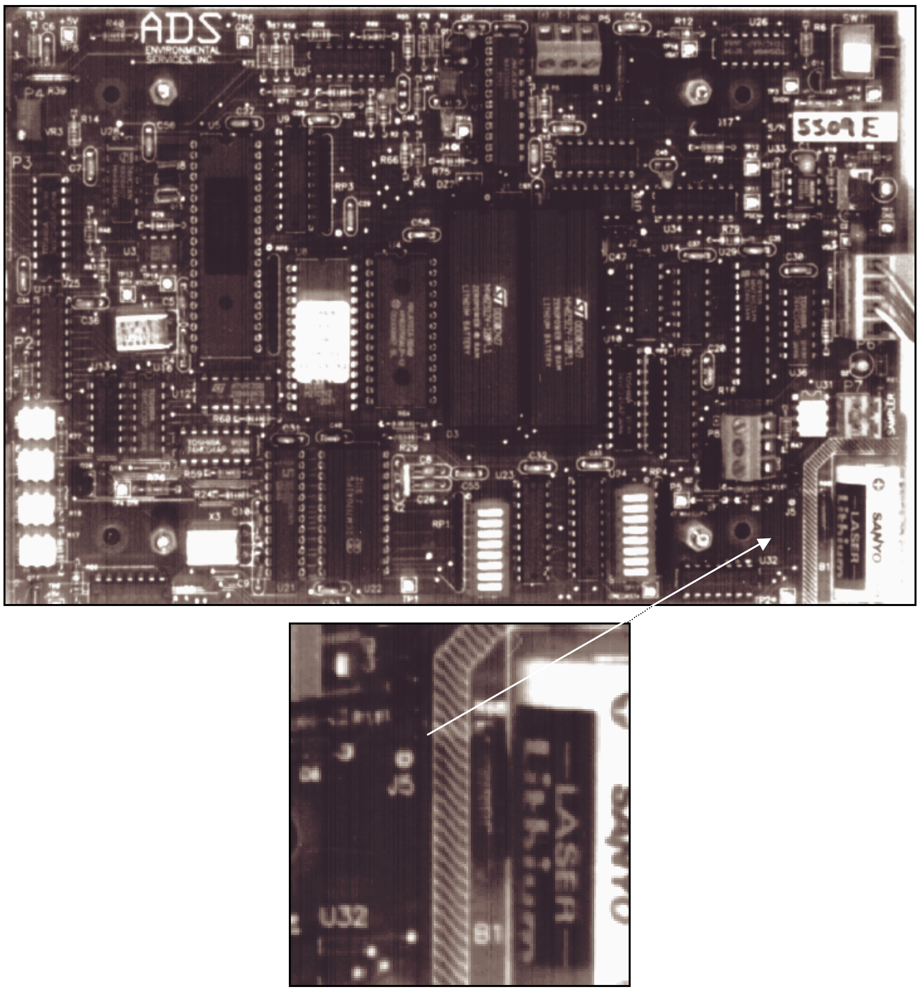
SW3—Options Switch (Standard switch settings are shown in shaded rows.)

Jumper Settings

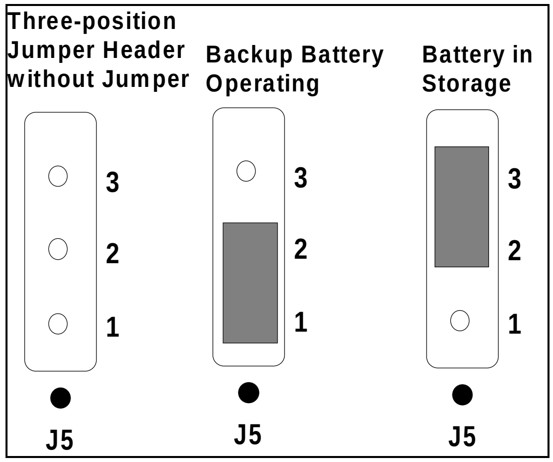
The following table shows the correct jumper settings for the 3600 flow monitor. However, the only configuration that you may need to change is the battery backup configuration. If you disable a board and place it in storage, the backup battery will need to be re-configured prior to use. Only an ADS certified technician can disable the board.

Configuration		Jumper	Position
Memory Configuration	1024K (512K×8 in U6 and U7)	J1 or J2	1-2 or 1-2
ADC Reference Configuration	MAX154 ADC (in U1)	J4	Not Installed
	AD7824 ADC (in U1)	J4	Installed
Battery Backup Configuration	Normal Operation	J5	1-2
	Storage	J5	2-3

When you store a monitor, you must disable the backup battery; use the above information to disable and enable a backup battery. The shaded cells are for general information only.



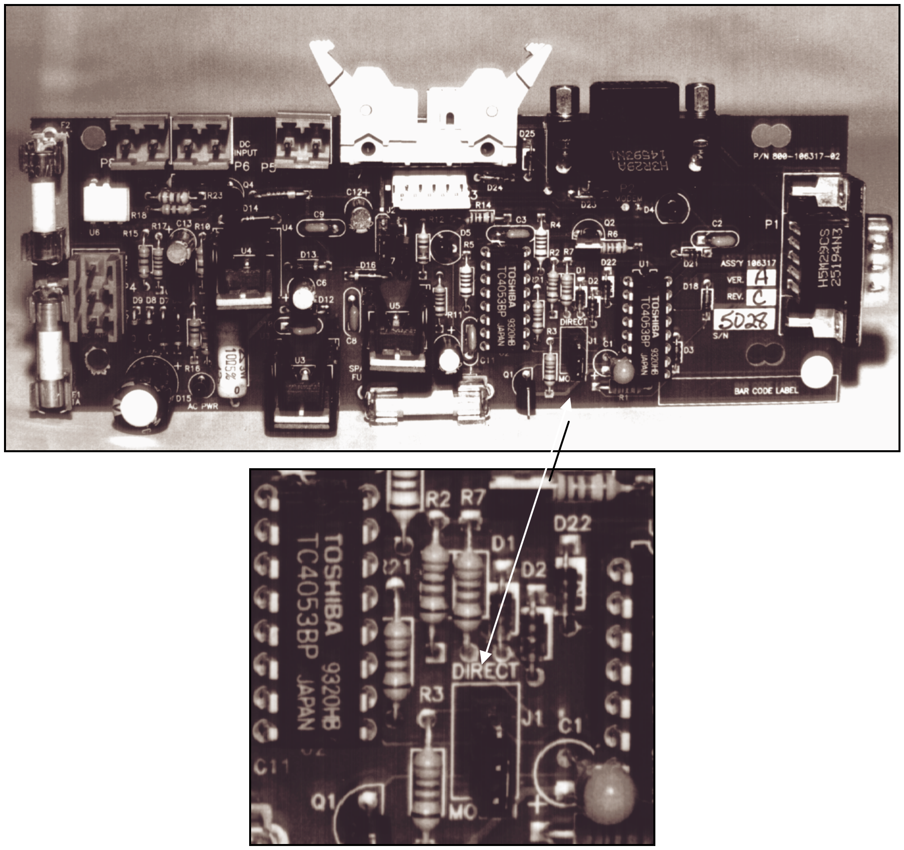
Location of Jumper 5



To disable the backup battery, locate Jumper 5 (a three position jumper header). Move the jumper to cover positions 2 and 3. The battery is now disabled. When the jumper is covering positions 1 and 2, the backup battery is operating.

Multiplexor Priority Setting

The serial multiplexor electronics are located inside the EMU. On the multiplexor power electronics printed circuit board (PCB) is a three-position jumper that can be used to specify which port will have priority, the direct connect port or the modem port. The 3600 monitor does not support the *direct connect* port. Therefore, always maintain the jumper in the *modem* position. This jumper is labeled “J1”.



106317A PCB—J1

In addition, most applications in a SCADA system require modem port priority. This allows the QuadraScan software to perform data collections and activations when necessary. Coordinating QuadraScan activities with SCADA system operation minimizes real-time data loss and ensures that these activities occur at a non-critical time.

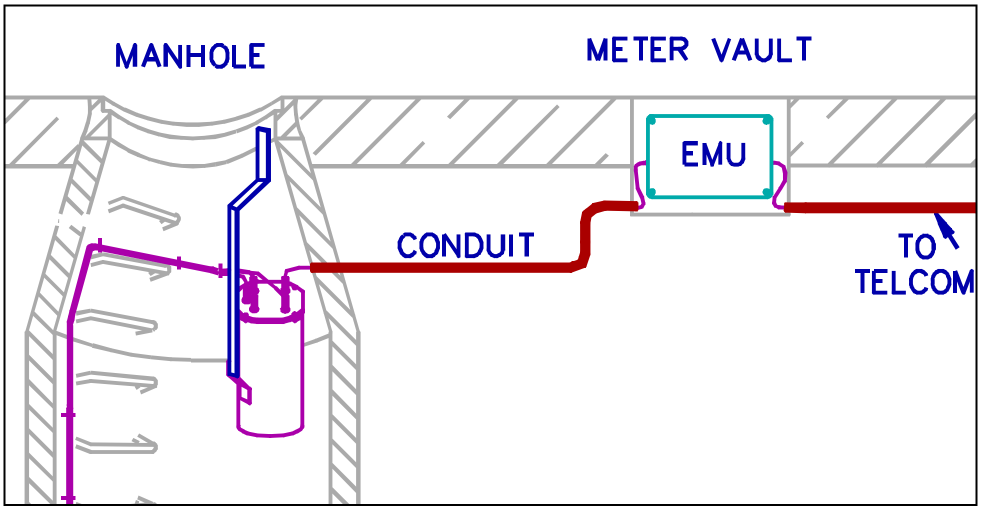
To ensure the modem port has priority, place the jumper on the two pins closest to the label “modem”. This will cause the modem to connect with the other modem and set the DCD when the modem detects a ring, switching the serial multiplexor to the modem port.

> **Note:** Refer to the figure on page 5-17 and the table on page 5-18 for options switch settings used during real time applications.

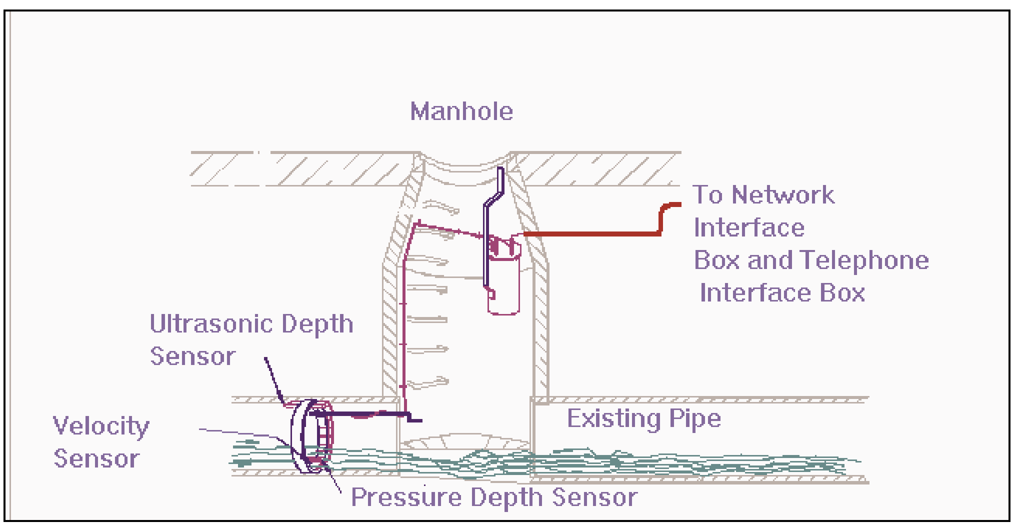
Monitor Installation

This section contains procedures which apply to most sites. However, because manholes differ, certain sites might require slight variations in these procedures.

Before installing the monitor at the site, verify that the monitor is configured correctly for the applications being supported. Verify that the monitor battery is operating correctly. (For more information on battery maintenance, see Chapter 6, "Monitor Maintenance.") Make any necessary changes to the configuration *before* mounting the unit.



Relationship Between Installed Monitor and EMU



Installed Monitor with an IS Modem

The monitor is mounted inside the manhole by means of an aluminum flange that is attached to the monitor and bolted to the manhole wall.

- Hold one end of the flange against the inside of the iron manhole rim where you wish to mount the monitor or plan to drill directly into the manhole wall.

Determine if one or two mounting holes can be drilled into the existing structure. Mark the location of the mounting hole(s).

- Drill the mounting hole(s) into the manhole rim 25 mm deep (1 in.) using an 8 mm (3/8 in.) bit.
- Place a tap in each hole with an 8 mm (3/8 in.) tap.
- Screw an 3/8 × 2 in. (*8 × 50 mm*) stud into the tapped hole.
- Mount the bottom of the flange onto the monitor with two 3/8 × 2 in. (*8 × 50 mm*) bolts and nuts. Drill holes as necessary.
- Attach a security line to the monitor to prevent accidental drops during installation. Pull the security line tight and avoid the sensor cables.
- Carefully lower the monitor into the manhole until the holes in the flange align with the stud.
- Secure and tighten the flange on the stud with an 8 mm (3/8 in.) nut and washer.
- Coil all slack in the sensor cables in a nice, neat fashion. Allow enough slack so that the monitor may be easily serviced. Cables will be secured to the anchor bolts in the manhole using large cable ties (35 mm or 14 in.).
- Visually inspect the manhole to ensure a neat and orderly monitoring site. Remove all debris from the area. Close the manhole lid and leave the site.

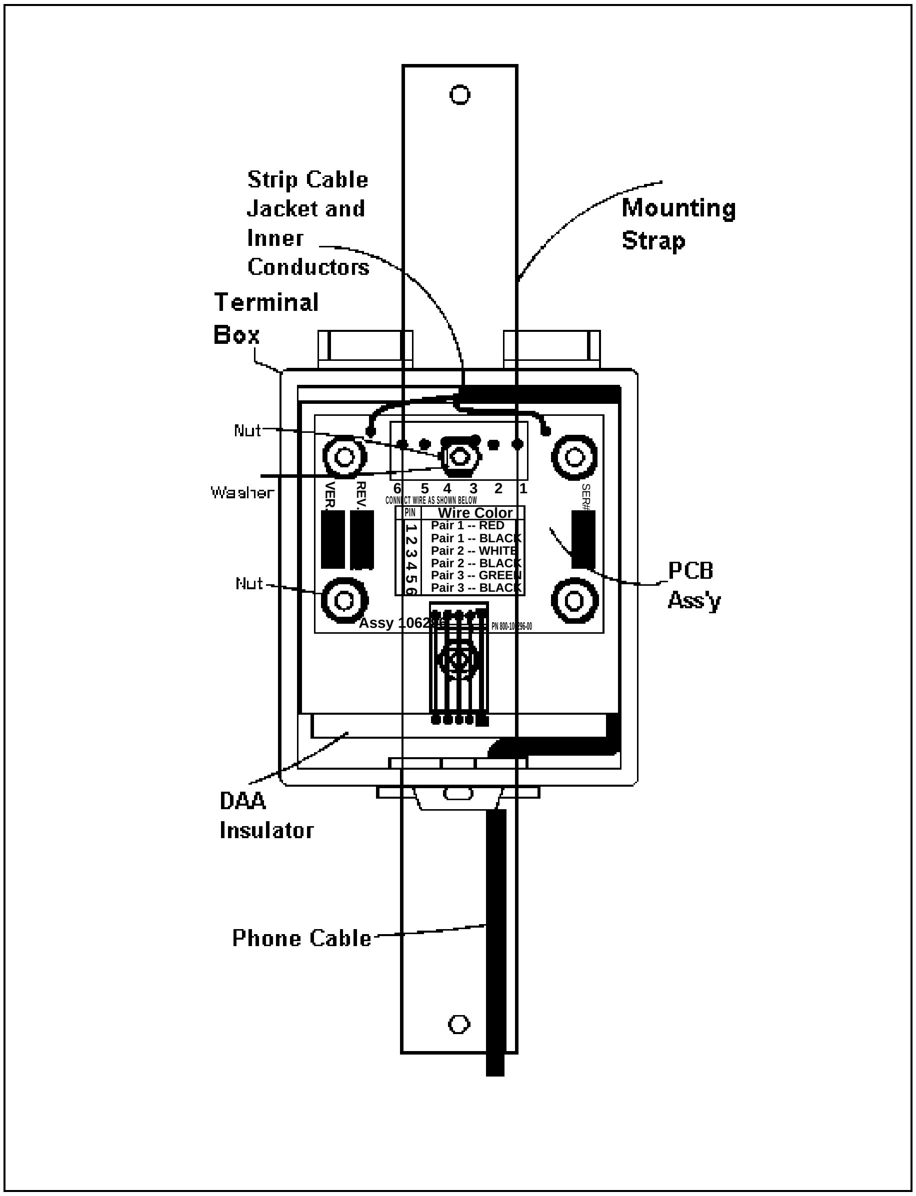
Telephone Interface Box Installation

The telephone interface box is a gray square box that is installed on a telephone pole or nearby pedestal. This box is connected with the IS modem within the monitor. Each box is shipped with self-tapping screws; use these screws to attach the box to the pedestal or telephone pole. Now, dig a trench between the box and the manhole; refer to "Underground Services and Lines Location" on page 5-3 in the manual and to local codes before digging. Using a special cable (ADS part number 902-09883-00), connect the interface box to the monitor. Open the telephone interface box. Facing you are two screw terminal connectors. Instructions appear on the interface box telling which color wires connect with which number on the terminal connector. Strip two inches into the outer jacket of the cable, and strip each individual cable 3/8 of an inch. Insert the each of the wires into the corresponding connectors. See the following table for specifics on the corresponding pins, wires, and wire colors. The other end of the cable is connected to the flow monitor with a Bendix connector on the top of the canister; this connector has been potted by manufacturing prior to shipping. Order the length required by the site. See the following diagram for more information.

> **Note:** When you order the cable, you must order the length required for that site. The maximum length is 300 ft.

Pin	Wire Color	
1	Pair 1	Red
2	Pair 1	Black
3	Pair 2	White
4	Pair 2	Black
5	Pair 3	Green
6	Pair 3	Black

Wire Colors in the Center of the Network Interface Box



Telephone Interface Box

Lightning Protection Module Installation

The lightning protection module is a gray rectangular box that is attached to a PVC pipe or to the telephone pole with 3/4 in. self-tapping screws. A cable connects the lightning protection module to the telephone company network interface box. A ground wire connects the module to the telephone company's ground rod or wiring.

> **Note:** This module is available as optional protection and is not included with the 3600 product.

The following procedures describe how to install the ADS lightning protection module. This procedure assumes the module will be mounted on an existing pole or post and that a ground rod is available.

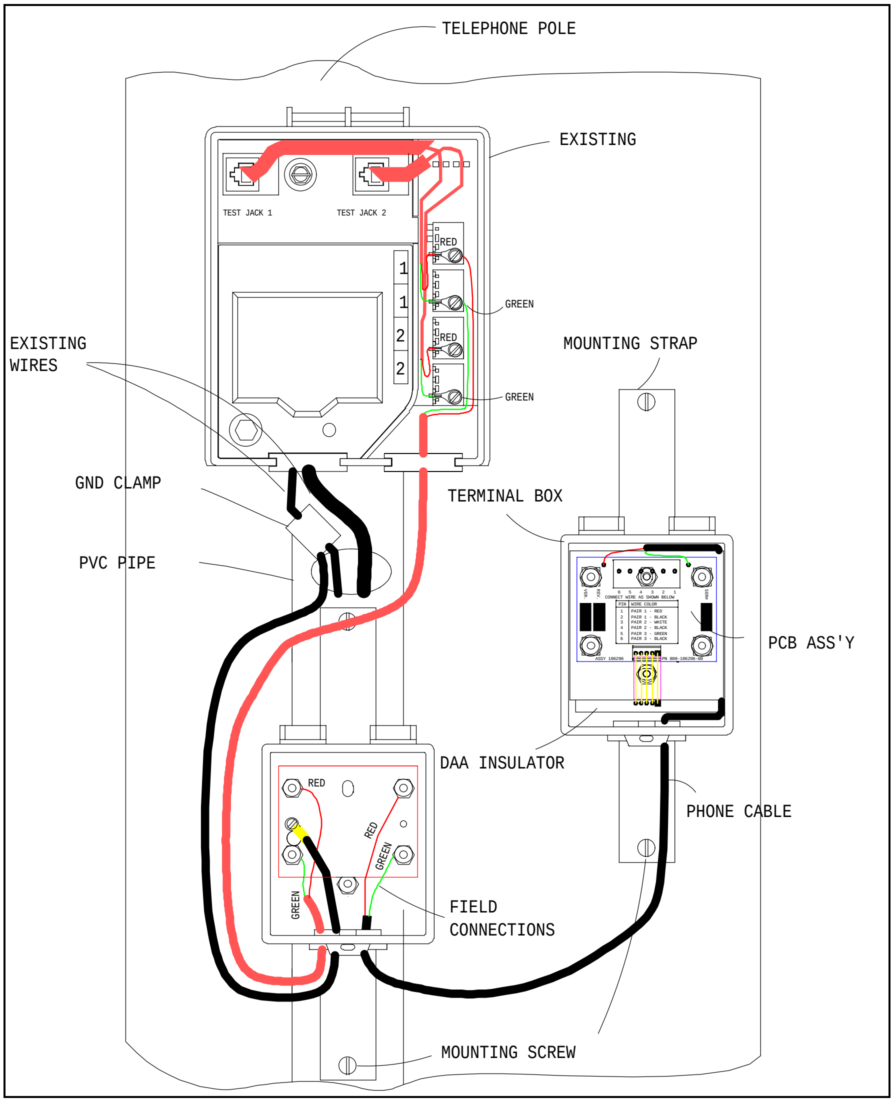
Before visiting the site, purchase the necessary ground clamps required for connection of the ground wiring. Always carry clamps sized for connection to the ground rod (approximately 5/8 in.) or the ground wire (10 to 14 gauge). One of these clamps will attach to the rod or wire and will have a connection point for the ground wire from the lightning module.

- Mount the module to the pole or post as close as possible to the ground rod or ground rod cable; it should be mounted at least 12 in. above ground level. Use $8 \times 3/4$ in. slot pan screws (ADS part number 514-00750-00) to attach the module to the pole or post.
- Disconnect the *test* plug in the network interface box to isolate the wiring terminals. If the site is already wired to the monitor, disconnect the wires that run to the monitor.
- Cut and strip a length of telephone cable to run from the network interface box to the lightning protection module. Connect the cable to the color-coded and labeled terminals in the network interface box as well as in the lightning protection module.
- Attach the ground wire from the lightning protection module to the ground rod or ground rod wire, using the grounding clamp. (A grounding clamp is specially designed to be used with grounding systems.) Ensure that the connection area is clean and free of corrosion. Tighten the clamp and check that the wiring cannot be pulled from the connection.

> **Warning:** Do not connect the ground wire to any terminals or cables inside the network interface box.

- Cut and strip the wire coming from the manhole and connect it as shown in the following figure of the lightning protection module.
- Plug the *test* plug into the network interface box to restore service to the monitor. Call the site and test telemetry.

- Secure the outside cover of the lightning protection module by inserting a cable tie through the slot at the top of the box. Ensure that the network interface box is closed and tightened.
- If the lightning protection module cable needs to be buried, refer to "Underground Services and Lines Location" on page 5-3 and to "Pavement Box and Cable Trench" on page 5-4.



Network Interface Box, Telephone Interface Box, and Lightning Protection Module

Monitor Activation

After the monitor is installed, QuadraScan software must be installed on the central computer, and the monitor must be activated. Once activated, the monitor can begin collecting flow data.

Software Installation Before the QS3600 flow monitor can be activated, QuadraScan software must be installed on the central computer. More than one computer can act as the monitor's central computer at different times. The term *central computer* refers to any computer that is linked to the monitor in order to

- activate the monitor (i.e. download BASIC programs, configuration information, and parameters to the monitor),
- collect and store data from the monitor, and
- perform interactive diagnostics on the monitor.

The central computer will typically be an IBM or IBM-compatible personal computer located at the central office. However, the central computer can also be the portable PC used by a field crew to service or activate a monitor or to collect data.

QuadraScan version 5.01 or higher software should be installed on the central computer at any time prior to activating the monitor. Personnel at the central office can load the software while field personnel install the hardware at the manhole. Once the software is installed, the site configuration information and parameters must be entered. The *QuadraScan User's Guide* contains instructions for software installation and entering site information.

During monitor activation, the site configuration information and parameters are downloaded from the central computer to the monitor. This enables the central computer, QuadraScan software, and the QS3600 flow monitor to properly gather data and to compile meaningful site reports.

Activation The purpose of activating the monitor is to download the BASIC files and other information from the central computer to the monitor. The monitor needs these files and information before it can begin taking flow measurements. Activating the monitor also serves to test the link between the central computer and the monitor.

- To check telemetry to the central computer, do not call the central computer from the monitor. Rather, call the monitor from any telephone to verify that the monitor modem responds. Also, verify that the monitor telephone number is entered correctly in the central computer.
- Activate the QS3600 flow monitor by following the instructions in the *QuadraScan User's Guide*. For real time SCADA applications, refer to the *Using ADS Flow Monitors for Real Time Applications*, ADS document number 530006.

- After the software is downloaded and the configuration information is entered, test for proper monitor operation by following the confirmation procedures outlined in the next section, “Data Collection and Confirmation,” and in the *QuadraScan User's Guide*.

Data Collection and Confirmation

QuadraScan software retrieves data over telephone lines or onsite from a monitor and places it into a collection device. Data is confirmed by periodically verifying the data’s accuracy.

Use the following procedure to perform a confirmation.

- A field crew member enters the manhole and directly measures the depth of flow and velocity data. The field crew reports these independent measurements to the QuadraScan operator at the central computer.
- At the same time, the utility software retrieves the flow data collected by the monitor. The software can command the monitor to perform a data conversion.
- These values retrieved from the monitor are recorded along with the field crew's direct measurements. To test the monitor's data collection accuracy, an analyst reviews the difference between the manually-measured flow values and the monitor's measured flow values.

QuadraScan software contains step-by-step procedures for managing data collection and confirmation. These procedures are beyond the scope of this document; refer to the *QuadraScan User’s Guide* for more information.

CHAPTER 6

Monitor Maintenance

The QS3600 flow monitor and flow sensors should be routinely checked in order to maintain them in optimal working condition and to prevent problems that might cause the loss of data.

The procedures outlined in this chapter include:

- remote confidence checks that can be performed at the central office by the data analyst and
- local confidence checks that are made at the monitor site.

ADS recommends that you make a local confidence check when you first install the QS3600, during a monitor site visit, and on a regular basis (such as each quarter or during battery replacement).

> **Note:** Please note that in all applications, only ADS Service Technicians are authorized to perform component-level service on the QS3600.

To learn about: ***See page:***

Remote Confidence Checks

Review the QuadraScan hardware logs to verify the normal status of the monitor clock, local monitor communications, the monitor BASIC code, the battery status, and the monitor temperatures. Replace the battery when the battery status indicates low (an approved technician must replace the battery in QS3600 flow monitors).

> **Note:** Local confidence checks are made onsite during a visit to the monitor location. You can perform local confidence checks on the monitor and on the flow sensors.

Monitor

Inspect the monitor mounting bracket to verify that the bracket and bolts are free of heavy corrosion. Verify that the bolts are secure in their moorings. Provide other mounting brackets as necessary. Verify that the four bolts holding the monitor together are snug. Tighten the bolts if they are loose. Verify that the monitor is still securely attached inside the manhole.

Inspect the monitor for general integrity. Verify that nothing more than surface corrosion is present and that the monitor has no obvious mechanical defects. Replace the monitor if necessary.

Perform monitor confirmations following the instructions provided in Chapter 5 and in the *QuadraScan User's Guide*.

Review the QuadraScan hardware logs to verify the normal status of the monitor clock, local monitor communications, the monitor BASIC code, the battery status, and the monitor temperatures.

Communication with the IS modem or with the modem located in the EMU can be checked remotely by calling the monitor.

Maintaining the Battery Pack

Check the battery status in QuadraScan before installing the monitor and after collecting data. If a battery’s status is low, the battery should be replaced.

The *QuadraScan User's Guide* outlines the procedure for requesting the battery voltage and status. When you request the battery voltage using QuadraScan, the battery status reads OK until the battery pack voltage falls below a fixed threshold, at which time the battery status reads Low. If QuadraScan reports that the battery status is low, the battery should be replaced as soon as possible (within the week). If the battery is completely dead, the monitor will not be able to respond to the QuadraScan request for the battery status.

As discussed in Chapter 1, "Maintenance Restrictions," IS monitors must be maintained by an ADS IS certified technician. If an ADS IS certified technician is not available locally to replace the battery, the IS monitors must be sent to ADS for battery replacement. In order to preserve its IS certification, a 3600 housing cannot be opened by anyone other than an ADS Service Technician. Opening the monitor housing will immediately void its IS status.

If you have any questions regarding the level of service you are allowed to perform on a monitor, refer to Chapter 1 or contact your regional ADS office.

Lightning Protection Module

If a lightning protection module is installed at the phone pedestal, check it for lightning strikes. If the lightning protection module has burned out, replace it with a new one and send the old one to ADS Environmental Services, Inc., for repair.

Telephone Interface Box

If you have any problems with the telephone interface box, check the connectors to ensure that the cable entries are tight and waterproof. If this does not solve the problem, replace the telephone interface box with a new one and send the old one to ADS Environmental Services, Inc., where an ADS IS certified technician will repair it. If anyone other than an ADS IS certified technician repairs this box, IS certification will be lost.

EMU

The EMU may be internally or externally powered. Maintenance for each type of EMU varies.

Internally Powered

If the EMU uses internal batteries, check that the monitor is not reporting low modem batteries in the EMU. Also, check that any cable entries are tight and waterproof and ensure that the lid of the EMU is tight.

Externally Powered

If the EMU uses an external power source, ensure the earth ground is connected. Also, check that any cable entries are tight and waterproof and ensure that the lid of the EMU is tight.

> **Note:** If the EMU uses an external ac power source, power is continuously received, and the NiCad batteries are continuously recharging.

For real time applications, an externally powered EMU is used. The modem must be set up using the following parameters if you replace this modem with a non-ADS modem or if your ADS modem is not functioning correctly. These parameters force the modem to be an auto-answer modem.

- First, for an auto-answer application, set S0=1 > type ATS0=1 < cr >.
- Second, if the DCD follows the carrier, set &C1 > type AT&C1 < cr >.
- Third, save the parameter changes: type AT&W0&W1 < cr >.

Flow Sensors

Verify that the ring is secure and mounted properly. Clear any debris that may have accumulated around the ring and sensors.

If the face of the ultrasonic depth sensor has a buildup of grease or scum, clean it with a soft brush saturated with rubbing alcohol. Scrub gently to avoid damaging the acoustic foam. Then, wipe the ultrasonic depth sensor with a clean, moist cloth.

Use a carpenter's level to verify that the face of the ultrasonic depth sensor is horizontally level with the flow. If the ultrasonic depth sensor needs to be repositioned, follow the installation procedures in Chapter 4.

Clean the face of the velocity and pressure sensor if it has a buildup of grease or scum by scrubbing the sensor's face with a soft brush saturated with rubbing alcohol.

Because debris can pull a cable away from the ring, make sure that all sensor cables are neatly arranged and securely fastened so that they do not snag particles in the flow. Repair or replace the cables as required; all cables should be free of cuts and breaks that may affect their performance.

Check the pressure sensor desiccant (it should be blue). When the desiccant is pink, it will not absorb any more moisture. Unscrew the middle of the drier assembly, empty and save the used desiccant, and fill it with new desiccant.

Maintaining the EMU Batteries

If the monitor using internal batteries reports that the EMU batteries are low, you can replace them (any field crew member can perform this procedure).

- Purchase six alkaline D-cell batteries from a local store.
- At the monitoring site, open the pavement box, and remove the lid from the EMU.
- Replace the old batteries with the new ones following the polarity chart in the battery holder.
- Replace the lid on the EMU and close the pavement box.

Note: Because a pavement box can be located in or near traffic, use all necessary safety precautions when replacing EMU batteries.

If the monitor using an external power source reports that the EMU power is low, the external power source has failed. When this condition is detected, only a few hours of operation are available after power is lost depending on the site configuration.

CHAPTER 7

Troubleshooting

This chapter provides general guidelines for correcting monitor problems and contains hints that will help you troubleshoot problems with monitor parts and subsystems.

> **Warning:** As discussed in Chapter 1, "Maintenance Restrictions," monitors used in IS applications must be sent to ADS for maintenance that requires opening the monitor's housing. Only ADS Service Technicians may perform component-level maintenance on monitors.
>
> Refer to the *I/S Monitors: Performing and Documenting Repairs* manual, document number 603005, before repairing, swapping, or configuring hardware internal to the monitor housing. This document is controlled by and can be obtained from the ADS office in Huntsville, Alabama.
>
> If you have questions regarding the level of service you are allowed to perform on a monitor, refer to Chapter 1 or contact your regional ADS office.

To learn about: See page:

Guidelines

Remember that when a monitor has to be shut down, all flow measurement and optional functions are also shut down. It is important that you keep monitor downtime to a minimum. This section explains methods of handling monitor problems which will help you minimize downtime.

Because the QS3600 flow monitor contains different types of printed circuit boards and may support a number of different functions, a major troubleshooting step is identifying the source of the problem as soon as possible. This is called *fault isolation*. To isolate a problem, consider the following points.

- When data problems occur, identify the affected subsystem(s).
- A problem that affects only one of the input/output subsystems is usually caused by a problem on that subsystem alone: either on the board, on the sensor (or other input device), or on the cabling.
- A problem that affects more than one subsystem can usually be traced to a problem with the processor board, power source, or communication lines. Also, a problem with one subsystem can create problems with other subsystems when the power source or communication lines are faulty.
- Problems with communication lines, clock readings, time stamps, and data storage intervals are usually due to a faulty processor board or to incorrect information entered on the central computer.
- If a failure occurs anywhere outside a connector (i.e., between the connector and the field input or output devices), then the field units or their cabling is causing the problem. If the failure occurs on the *inside* (i.e., between a connector and the printed circuit boards), then the boards or their cabling is causing the problem.

Many of the troubleshooting hints suggested in this chapter may be caused by a minor error and do not require a site visit. For example, incorrect equipment identification numbers or other system parameters can be re-entered on the central computer.

Inform the data analyst any time a field crew is departed to a monitor site to troubleshoot problems so that the analyst can attempt to collect the data. If the problem is a faulty monitor and the analyst cannot remotely collect data, replace the monitor and have the analyst attempt to collect the data in the office. Then, send the monitor to ADS for repair.

Troubleshooting

The following tables contain troubleshooting hints for managing problems with specific components and subsystems of the QS3600 flow monitor.

General Monitor Problems

The following tables contain common troubleshooting techniques for the 3600 flow monitor.

Problem	The monitor does not answer a telephone call.
Possible Cause	The EMU modem or monitor battery is low. The modem switch settings are incorrect. The modem, communication board, or processor board is faulty. The telephone line is noisy or has been cut. The connectors are loose.
Solution	Verify that the voltage of the pair of phone cables, which travels across the phone wire and enters the EMU, is approximately 48 Vdc on hook. Verify that the connection is firm and that the wires are stripped correctly. Replace the EMU modem with a new modem to determine if it the modem is the problem. If modem is faulty, replace the modem and send the old one to ADS for repair. Collect the data via phone lines. Temporarily connect the new EMU modem to the monitor to determine if the existing EMU communication board is okay. If the communication board is faulty, replace the board and send the faulty one to ADS for repair. Collect the data via phone lines. Temporarily connect a new monitor to the EMU with a test communication cable to determine if the monitor is at fault. If the monitor is faulty, replace the monitor and send the old one to ADS for repair. An ADS technician will retrieve data from the monitor in the office.

Problem	You receive a busy signal when calling the monitor.
Possible Cause	There may be a shorted or cut telephone line; water at or in the telephone connector; a faulty modem; or a low modem/EMU battery.
Solution	Remove the test wire from the bell box and call the office. If the line works, the problem is with the monitor. Check the voltages for a shorted (approximately +5 Vdc) telephone line. Check the area for a cut telephone line. Check the telephone connector for moisture.

Problem	**Destination ID** error message is received when calling the monitor.
Possible Cause	An incorrect monitor ID may have been entered in the central computer. The modem may be faulty.
Solution	Verify the monitor ID at the central computer and correct it if necessary. If the error message remains, contact your regional ADS office and arrange for an ADS IS certified technician to verify the ID switch settings. If the monitor ID is entered correctly at the central computer and the problem is still not resolved, contact an ADS IS certified technician to replace the modem. If the error still remains, contact the regional ADS Environmental Services, Inc., office to arrange for technical support.

Problem	The monitor establishes a connection, but does not respond to any message.
Possible Cause	Incorrect identification information may have been entered at the central computer. There may be loose cabling or a faulty modem.
Solution	Verify the information at the central computer (monitor serial number, telephone number, etc.) and correct it if necessary. Listen for noise at the site using a field phone. If noise is present, inspect the wiring, and if the wiring is okay, call the telephone company. If none of these procedures corrects the problem, the modem may be faulty. Contact an ADS IS certified technician to collect the data from the monitor, using a direct connection cable (ADS part number 106228A) and QuadraScan software, and then to replace the modem. If the error still remains, contact the regional ADS Environmental Services, Inc., office to arrange for technical support.

Problem	The time stamp on the collected data is incorrect.
Possible Cause	There may be a faulty monitor clock or an incorrect time on the central computer clock.
Solution	Verify the time on the central computer clock and correct it if necessary. Reactivate the monitor to enable the clock. If the problem is not resolved, collect the data from the monitor with QuadraScan software, replace it with a new one, reactivate the monitor, and send the old one to ADS for service. For more information, contact the regional ADS Environmental Services, Inc., office.

Problem	The time on the monitor hardware clock is incorrect. It may be displayed as **Gross Time Error** in QuadraScan's collect log.
Possible Cause	There may be a faulty monitor clock or an incorrect time on the central computer clock.
Solution	Verify the time on the central computer clock and correct it if necessary. Reactivate the monitor to enable the clock. If the error remains, collect the data from the monitor with QuadraScan software, replace it with a new one, reactivate the monitor, and send the old one to ADS for service. For more information, contact the regional ADS Environmental Services, Inc., office.

Problem	Statements do not print on the event notification station printer when the event status changes.
Possible Cause	Power to the printer may be off. The printer may be off-line or out of paper. The messages may not be configured properly in BASIC code. The modem may not be functioning properly.
Solution	Turn the printer on, load the paper, and set it to *on-line*. Call the modem with a regular telephone to ensure that it answers and is ready to receive. Verify the message configurations in BASIC code. If the problem is not resolved, follow the procedures described earlier in this section regarding monitor and modem connection problems.

Problem	You receive a **Device Time Out** error in QuadraScan.
Possible Cause	The processor board, depth board, or velocity board may be faulty.
Solution	Attempt communication several times to determine if the problem continues. If the problem persists, contact the regional ADS Environmental Services, Inc., office to arrange for technical support.

Problem	When reviewing data, you notice a gap in collected data.
Possible Cause	The monitor's basic code or variable file has become corrupted.
Solution	Using QuadraScan, call the flow monitor in Diagnostics and run the monitor status to verify that it is a CRC or basic code problem. Collect data until the file is corrupted. Reactivate the monitor and schedule a time to re-collect data to ensure that the problem is corrected. If the problem persists, contact the regional ADS Environmental Services, Inc., office to arrange for technical support.

Problem	You receive a CRC message when communicating with the monitor, or you notice a gap in collected data.
Possible Cause	The monitor's basic code or variable file may have become corrupted.
Solution	Using QuadraScan, call the flow monitor in Diagnostics and run the monitor status. Attempt communication several times to determine if the problem continues. If the problem remains, contact the regional ADS Environmental Services, Inc., office to arrange for technical support.

Problem	You receive an I/O error message in QuadraScan when communicating with the monitor.
Possible Cause	The processor board, depth board, or velocity board may be faulty.
Solution	Attempt communication several times to determine if the problem continues. If the problem persists, contact the regional ADS Environmental Services, Inc., office to arrange for technical support.

Ultrasonic Depth Subsystem

Use the following tips to help resolve problems with the ultrasonic depth subsystem.

> **Warning:** Prior to replacing a sensor, contact an ADS trained technician for further diagnosis.

Problem	The range from the ultrasonic depth subsystem is close but not exact.
Possible Cause	The electronic or physical offset may be incorrect. The pipe diameter could be incorrect.
Solution	Verify the physical offset and change it if necessary. Verify the pipe diameter. If this does not correct the problem, change the electronic offset.

Problem	The range from the ultrasonic depth subsystem is much too long.
Possible Cause	The ultrasonic depth sensor is not receiving an echo because the pulse command parameter is too small, the sensor is not level, or foam or another substance is absorbing the pulse. The sensor may be faulty.
Solution	Verify that the pulse command parameter in the QuadraScan software package is reasonable. Verify that the sensor is mounted properly, that the sensor is in good condition, and that the hydraulic conditions are reasonable. Try firing the ultrasonic depth sensor at a shorter distance onto a hard surface to confirm its accuracy. If the problem is still unresolved, contact an ADS trained technician for further information about replacing the ultrasonic sensor.

Problem	The range from the ultrasonic depth subsystem is much too short, but not zero.
Possible Cause	The pulse parameters are not adjusted properly or the sensor is dirty.
Solution	Clean the sensor. If the problem is still unresolved, review and change the pulse parameters if necessary. If the problem is still unresolved, contact an ADS trained technician for further information about replacing the ultrasonic sensor. If the sensor replacement does not work, contact the regional ADS Environmental Services, Inc., office to arrange for technical support.

Problem	The raw depth of flow data has a value greater than the pipe diameter.
Possible Cause	The pipe is surcharged; the sensor is dirty; or the sensor is faulty.
Solution	Verify that the pipe diameter, physical offset, and electronic offset are correct in QuadraScan's location information file. Clean the ultrasonic depth sensor. If the problem is still unresolved, contact an ADS trained technician for further information about replacing the ultrasonic sensor. If the problem is still unresolved, replace the monitor and send the old one to ADS for service.

Problem	The data indicates a surcharged pipe, but the pipe is free flowing.
Possible Cause	The sensor is dirty or faulty, or the ultrasonic depth board is faulty.
Solution	First, clean the ultrasonic depth sensor. If the problem is still unresolved, contact an ADS trained technician for further information about replacing the ultrasonic sensor. If the problem is still unresolved, replace the monitor and send the old one to ADS for service.

Problem	Readings from the ultrasonic depth subsystem are erratic.
Possible Cause	There is noise in the sewer line; the sensor is dirty; the flow is choppy or foamy; the sensor is not level; or the pulse parameters are set too low for the pipe.
Solution	Clean the ultrasonic depth sensor. Remount the sensor properly. (See Chapter 4, "Ring, Sensor, and Special Installations," for installation guidelines.) Review and adjust the pulse and SP2 parameters.

Problem	When the ultrasonic sensor is fired, less than six good readings are obtained.
Possible Cause	The ultrasonic sensor may be dirty or faulty. The depth board may be faulty.
Solution	Clean the ultrasonic sensor. Repeat the firing to determine if the number of good sensor pair readings has improved. If you have less than four good sensor pairs, contact an ADS trained technician for further information about replacing the ultrasonic sensor. If the problem persists, replace the monitor and send the old one to ADS for repair.

Problem	The ultrasonic sensor reports two abnormal temperatures.
Possible Cause	Both temperature sensors are faulty. The ultrasonic sensor is faulty.
Solution	If both temperature readings are abnormal, replace the sensor with a new one and send the old one to ADS. If the problem persists, replace the monitor and send the old one to ADS for repair.

Doppler Velocity Subsystem

Use the following tips to help resolve problems with the Doppler velocity subsystem.

> **Warning:** Prior to replacing a sensor, contact an ADS trained technician for further diagnosis.

Problem	A data value of 0 is read often.
Possible Cause	The Doppler velocity sensor may be dirty, weakened, or broken. The cabling between the velocity board and the velocity sensor may be bad. The velocity board may be faulty.
Solution	Clean the velocity sensor. Check the velocity parameters in QuadraScan and adjust them if necessary. Verify that the cables to the velocity sensor are tight and that the connector is free from moisture. If the problem is still unresolved, contact an ADS trained technician for further information about replacing the velocity sensor. If the problem persists, replace the monitor and send the old one to ADS for service.

Problem	Velocity data is flat (the data is non-zero but does not fluctuate much).
Possible Cause	The velocity sensor may be dirty or weakened.
Solution	Clean the velocity sensor. Check the velocity sensor connections. Check the velocity parameters in QuadraScan and adjust them if necessary. If the problem is still unresolved, contact an ADS trained technician for further information about replacing the velocity sensor. If the problem is still unresolved, replace the monitor and send the old one to ADS for service.

Problem	The velocity data seems erratic.
Possible Cause	The velocity sensor may be dirty or faulty. The velocity board may be faulty.
Solution	Clean the velocity sensor. Check the sensor connections. Check the velocity parameters in QuadraScan and adjust them if necessary. If the problem is still unresolved, contact an ADS trained technician for further information about replacing the velocity sensor. If the problem is still unresolved, replace the monitor and send the old one to ADS for service.

Problem	The velocity data readings are abnormally high.
Possible Cause	Wires on the P2 connector may be loose. The velocity sensor may be covered with silt. The velocity sensor may be out of the flow. The flow may be reversed or slower than 0.15 m/s (0.5 ft/s).
Solution	Check the site conditions and relocate the velocity sensor if necessary. If the problem is still unresolved, replace the monitor and send the old one to ADS for service.

Pressure Depth Subsystem

Use the following tips to help resolve problems with the pressure depth subsystem.

> **Warning:** Prior to replacing a sensor, contact an ADS trained technician for further diagnosis.

Problem	The temperature reading from the pressure depth sensor shows a value of -273° C (-459° F).
Possible Cause	The cable connecting the pressure mouse to the monitor may be broken. The pressure sensor may be faulty. The pressure depth board is not responding or may be faulty.
Solution	Replace the pressure sensor with a known good sensor and send the faulty one to ADS for repair. If the problem is still unresolved, replace the monitor and send the old one to ADS for service.

Problem	The pressure depth subsystem data readings are consistently incorrect.
Possible Cause	The coefficients are incorrect.
Solution	Enter the correct coefficients and reactivate the monitor.

Problem	The pressure depth subsystem data readings are consistently off by up to 7.62 cm (3 in.), but temperature readings are accurate.
Possible Cause	The pressure sensor has an offset that drifts over time.
Solution	Check the condition of the pressure dryer tube. Adjust the depth data by applying a delta offset to the readings until they match the values obtained during confirmation.

Problem	The pressure sensor temperature readings are incorrect, but depth data is accurate.
Possible Cause	The temperature sensor may be faulty.
Solution	Contact an ADS trained technician for further information about replacing the pressure sensor. If the problem is still unresolved, replace the monitor and send the old one to ADS for service.

Problem	The pressure depth subsystem temperature and depth readings are erratic.
Possible Cause	The cabling to the pressure sensor or the pressure board may be faulty.
	The pressure sensor may be faulty.
Solution	Examine the pressure sensor and clean it if necessary.
	If the problem is still unresolved, contact an ADS trained technician for further information about replacing the pressure sensor.
	If the problem persists, replace the monitor and send the old one to ADS for service.

Recommended Spare Parts

For a typical flow monitoring application, the system uptime is critical. If possible, do not disable a monitor in order to resolve a problem. ADS recommends maintaining a spares stock of at least 10% of monitors and sensors.

APPENDIX A

Features and Specifications

This topic contains information on the features and specifications of the QS3600 flow monitor and associated hardware components. Information is included on data storage; the processor board; the ultrasonic depth, Doppler velocity, and pressure depth subsystems; and communications.

To learn about:	See page:

General Features and Specifications

The following table contains information about general features and specifications of the QS3600.

Functional Description	The microprocessor-based flow monitor works with the central computer and ADS software and provides flow rate measurement and reporting functions. Optional functions include reading a rain gauge and sending signals to the optional sampler.
Physical Description	The flow monitor is housed in a cylindrical water-proof aluminum enclosure. The dimensions are 62.2 cm (24 in.) long by 16.8 cm (6.6 in.) in diameter. The monitor weighs 19.5 kg (43 lb.). The monitor is pressurized to ensure proper enclosure sealing. The operating temperature ranges from 0° to 60° C.
Power Requirements and Specifications	The monitor requires a replaceable 9 V battery, which should last up to one year depending on the sampling interval and the number of sensors. The backup 3 V lithium battery maintains the monitor memory if the battery pack fails.
Computer Interface Requirements and Specifications	IBM or IBM-compatible personal computer ADS QuadraScan software
Telephone Requirements and Specifications	Normal, voice-grade telephone lines are required for each site. One line is also required for use by the central computer; one line is required by the monitor, and additional lines are required for each event notification station.
Special Features	The monitor's interface with QuadraScan software is user-friendly and menu and mouse-driven; this software allows maximum flexibility and integration with other ADS flow monitoring systems. Voice-grade telephone telemetry is used for monitor set-up, remote diagnostics, and data collection. The event notification option includes the set-up of remote event notification station(s) for printed and audible reports of selected events. The text of the printed reports can be defined. Lightning and surge protection is provided for the telephone line Low power CMOS (method for storing computer set-up information in non-volatile RAM) processors and logic reduce power consumption. The modular construction simplifies repair. The circuit boards are mounted with standoffs for quick removal and replacement by ADS IS certified technicians.

Methodology	**Depth and Velocity Flow Measurement** The monitor activates flow sensors to take readings to determine the depth and velocity of the flow The monitor scans and stores sensor readings at prescribed intervals (such as every 15 min). The monitor evaluates the ultrasonic sensor readings, discarding those which are clearly erroneous, and performs error checking and correction operations on the data The monitor records the distance between the ultrasonic sensor and the flow; this data is converted into flow depth and velocity measurements by QuadraScan. **Optional Functions** The sample output is an optically-isolated open collector output, normally used to control an external flow proportional sampler; the output is controlled by BASIC code. Event Notification

Inputs and Outputs	The monitor supports any or all of the following numbers and types of input and output devices: one ultrasonic depth sensor input, one Doppler velocity sensor input, one pressure depth sensor input, one sampler output, and one rain gauge input.

Standard Configurations and Configuration Part Numbering	Forty-eight standard software configurations are available to allow a monitor to fit a particular application. The configuration is specified by suffixes added to the part number, 3600-Lx-Vx-Px-yz: ● *3600* represents the model number; ● *Lx* represents the number of depth (ultrasonic and pressure) interface boards (0 or 1); ● *Vx* represents the number of Doppler velocity interface boards (0 or 1); ● *Px* represents the number of pressure sensors (0 or 1), and ● *yz* represents the use of the auxiliary input and output: ❑ *S* equals the programmable discrete output (sampler control); ❑ *R* equals the rain gauge/accumulator input; ❑ *SR* equals the programmable discrete output and rain gauge/accumulator input, and ❑ *No entry* means that neither the auxiliary is input nor the output is used.

Downloaded Software	The downloaded BASIC program enables the QS3600 flow monitor to scan input devices and store readings on the processor board. A BASIC program is maintained in the battery-backed RAM to protect against program loss in event of a battery failure. The onboard BASIC interpreter provides sophisticated mathematical functions. The central computer downloads the BASIC program to the monitor via a modem and telephone line. A BASIC program can be downloaded to the monitor to reconfigure monitor functions. Optional programming is now available to allow for specialized monitoring, storing, and alarming.

Computer and QuadraScan Software	The central computer and the installed software (IBM or IBM-compatible personal computer with ADS QuadraScan software installed) activate the monitor and provide data processing, reporting, and data storage functions.

Communication	The monitor has a logic-level serial bus for communications between the processor and input boards. A modem and modem interface allow communication and data transfer between the monitor and the central computer and between the monitor and the event notification station. The modem communicates at a 1200/2400 baud communications rate over standard voice-grade telephone lines. The standard interface allows a direct connection for servicing by an ADS IS certified technician. The YAPP Communication Protocol (ADS proprietary protocol) for communications ensures high data integrity by utilizing block message structure with appended CRC-16 check digits. Response is prohibited until a correct identification (ID) is transmitted. Re-transfer of messages is permitted when an error is detected. Acknowledgments of receipt are required for each transmission. A terminal mode for input/output (I/O) board remote diagnostics is provided. Lightning protection on the incoming telephone line protects against nominal lightning transients.

Internal Monitoring	The monitor records internal conditions that are reported in a hardware log, such as the 9 V battery pack regulated voltage, the EMU battery status (if applicable), the internal monitor temperature, the BASIC code status, pending event status changes, and latest data time.

Data Collection and Storage	The monitor scans data inputs at specified time intervals to obtain readings for flow rate measurement and other functions. The monitor periodically samples the ultrasonic depth, Doppler velocity, and pressure depth sensors/boards in standard intervals of 2.5, 5, 7.5, 10, or 15 min (Other intervals between 1 min and approximately 18 hr can be specified, depending on the application.) The monitor stores data readings in its own memory until the central computer collects the data. When monitor memory storage locations are full, the monitor writes new readings over the oldest data. The period of time during which data can be stored before being overwritten depends on how many inputs are read and how often readings are stored.

Data Storage

The following table illustrates the number of days that data can be stored in the QS3600 memory in different monitor configurations.

Memory Capacity	Reading Interval	Number of Data Storage Days Sensors Connected		
		Ultrasonic	Ultrasonic + Velocity	Ultrasonic + Velocity + Pressure
1024 K memory (standard)	every minute	24 days	20 days	17 days
	every 15 min	364 days	303 days	260 days

106100 Processor Board

The following table contains information about general features and specifications of the 106100 processor board.

Processor	80C31 CMOS Microprocessor
Memory	The EPROM has 64K bytes (program storage).
	The RAM has 1024K bytes of battery-backed data storage.
Programming Language	BASIC
Program Loading	The program is loaded via a modem over standard, voice-grade telephone lines or via a direct serial connection.
Communication	The processor board uses a logic-level serial bus for communication with sensor interface boards.
	The modem communicates with the central computer via a 1200/2400 baud rate, Bell 224, Bell 212A, V22, V22.bis compatible modem/modem interface over standard, voice-grade telephone lines.
	Direct communication is available using a portable computer and an IS cable (ADS part number 106228A).
Protocol	The proprietary YAPP query-response protocol with CRC-16 error detection is used for modem communications.
Discrete Input	The discrete input is a 16-bit counter for counting external contact closures.
Discrete Output	The discrete output is an optically-isolated, open collector programmable output.
Temperature Measurement	Analog inputs are read from on-board (standard) and off-board (optional) temperature sensors.
Memory Capacity	The board can hold 174752 readings (1024K memory).
Memory Backup Battery	The 3 V lithium battery protects against loss of monitor memory.
Clock	This crystal-controlled, hardware clock/calendar is lithium battery backed.
Switches	8-position identification switch
	An 8-position option switch allows selection of the operating parameters, e.g. mode of communications or baud rate.
LED	LED is ON when processor is engaged in external communications, such as modem communications.

Depth Subsystem

The depth subsystem includes the ultrasonic depth sensor and the pressure depth sensor. This subsystem also includes the depth board.

Ultrasonic Depth Sensor

The following table contains information and specifications for the ultrasonic depth sensor.

Measurement Technique	Ultrasonic pulse echo ranging measures the elapsed time between the transmission of the ultrasonic signal to the flow surface and echo reception. Each reading by a sensor includes up to 32 individual transmissions/receptions for each active ultrasonic transducer pair. All false or multiple echoes are discarded; remaining readings are averaged into an elapsed time. This time is then compensated for air temperature changes. Using the speed of sound, the range, i.e., the distance between the sensor and the flow surface, is calculated based on this compensated average elapsed time . The depth of flow equals the range minus the pipe diameter.
Accuracy	The depth sensor has an accuracy that is within 3 mm (0.125 in.) or 0.5% of reading, whichever is greater.
Frequency	40 kHz
Quadredundancy	Up to four ultrasonic depth transducers can be used to determine depth of flow, ensuring more reliable data. These four active transducer pairs are selected from twelve combinations. Individual transducers can be enabled or disabled remotely at the central computer in case of a malfunction.
Calibration	Long-term calibration of depth of flow can be verified by comparing readings from each ultrasonic depth transducer with each transducer's performance, other transducers' past performances, and with field calibrations.
Temperature Compensation	Two temperature sensors located within each sensor compensate for temperature variations and minimize any measurement distortions due to changes in the speed of sound in air.
Housing	The housing dimensions are 19.05 cm (7.5 in.) × 10.79 cm (4.25 in.) × 22 mm (0.875 in.). It is made of saltwater marine aluminum (6061T6) or stainless steel.
Effective Range	The sensor has a range up to 2.4 m (8 ft) and a dead zone of 13 mm (0.5 in.); greater ranges are available.
Installation	The sensor is mounted at the top of a sewer pipe on an expandable stainless steel ring, or it can be bolted directly to the crown (soffit) of the pipe.

Pressure Depth Sensor

The following table contains information and specifications for the pressure depth sensor.

Measurement Technique	The pressure sensor gauge references the difference in atmospheric and water pressures in the sewer pipe to determine the depth of flow in the pipe.
Effective Range	The sensor has a range up to 3.35 m (11 ft). Greater ranges are available through factory modifications.
Resolution	The resolution is within 1.0 mm (0.04 in.).
Calibration	The sensor is factory calibrated to compensate for temperature drifts and nonlinearity. The software operator can remotely adjust offset drifts via a telephone and modem.
Temperature Compensation	Readings from the temperature sensor, located inside the pressure depth sensor housing, are used to compensate for the temperature effects on the depth data. Compensation is made using pre-calculated look-up tables that are specific to each individual sensor and are based on factory-calculated calibration data.
Housing	The housing dimensions are 12.7 cm (5.0 in.) × 35 mm (1.36 in.) × 25 mm (1.0 in.), and the housing is a streamlined, molded epoxy shell.

Depth Board Digital Specifications

The following table contains digital specifications for the depth board.

Processor	The depth board uses an 80C32 CMOS microprocessor.
Memory	The EPROM has 64K bytes.
	The RAM has 32K bytes.
Communications	The depth board uses a UART to communicate over a logic-level bus with the processor board.
Functions	The depth board transmits the following data to the processor board: depth readings from selected transducer pairs, the quality of the readings, temperature readings from both temperature sensors, and the number of over-ranges (no echo).

Doppler Velocity Subsystem

The following topic contains information about the Doppler velocity subsystem, including the Doppler velocity sensor and digital specifications for the Doppler velocity board.

Doppler Velocity Sensor

The following table contains information and specifications for the Doppler velocity sensor.

Measurement Technique	The ultrasonic Doppler frequency shifts measure changes in the frequency that ultrasonic waves are transmitted upstream through the flow and received back after reflection from particle matter. The received signals are processed through a digital spectrum analyzer, and the resultant data is used to calculate average velocities. Calculation is based on the principle of the Doppler effect.
Effective Range	The effective range is -1.52 to +4.57 m/s(-5 to +15 ft/s).
Resolution	The resolution is 0.012 m/s (0.038 ft/s).
Accuracy	For readings of 0 to 1.5 m/s (0 to 5 ft/s), the accuracy equals 1.0% full scale (20 ft/s); 1.5 to 3.0 m/s (5 to 10 ft/s), the accuracy equals 1.5% full scale (20 ft/s); and 3.0 to 4.57 m/s (10 to 15 ft/s), the accuracy equals 3.5% full scale (20 ft/s).
Beam	The sensor transmits an omnidirectional beam.
Housing	The housing dimensions are 38 mm (1.5 in.) × 28.5 mm (1.125 in.) × 12.7 mm (0.5 in.) and made of molded PVC plastic.
Installation	The sensor is installed in a sewer pipe on an expandable stainless steel ring below the level of minimum flow and typically upstream of any hydraulic disturbances associated with the invert.

Doppler Velocity Board Digital Specifications

The following table contains digital specifications for the Doppler velocity board.

Processor	The Doppler velocity board uses an 80C31 CMOS microprocessor and a digital signal processor.
Memory	The EPROM has 64K bytes. The RAM has 32K bytes.
Communications	The Doppler velocity board uses a UART to communicate over a logic-level bus with the processor board.
Functions	The Doppler velocity board transmits velocity readings in feet per second to the processor board.

Communications

The following topic contains information about the EMU, SCADA EMU, and DAA.

EMU

The following table contains information and specifications for the EMU.

Functional Description	Provides communication link between telephone network interface and 3600 monitor; contains modem, battery, and intrinsic safety barrier; and provides modem power
Housing	Painted steel
Dimensions	15¾ inches (40 cm) high x 12¼ inches (31 cm) wide x 4 3/8 inches (11 cm) deep
Operating Temperature	0° to 60° C (32° to 140° F)
Power	Six 1.5-volt D-cell batteries
Inputs and Outputs	Input: Voice-grade telephone line Output: Communication cable to 3600 monitor
Communication	Voice-grade telemetry at 1200 bps (United States) or 2400 bps (International)

SCADA EMU

The following table contains information and specifications for the SCADA EMU.

Functional Description	Provides communication link between telephone network interface (or RS-232) and 3600 monitor; allows RS-232 interface between 3600 monitor and SCADA system RTU; contains modem, multiplexer board, power supply, backup battery, and intrinsic safety barrier; accepts external power
Housing	Painted steel
Dimensions	15¾ inches (40 cm) high x 12¼ inches (31 cm) wide x 4 3/8 inches (11 cm) deep
Operating Temperature	0° to 60° C (32° to 140° F)
Power	External AC power with NiCad battery for 6-8 hours operational power during power failure External DC power
Inputs and Outputs	Inputs: AC or DC power; voice-grade telephone line Outputs: Communication cable to 3600 monitor; RS-232 interface to SCADA system RTU
Communication	Direct: RS-232 serial communication Remote: 14.4 Kbps modem

DAA

The following table contains information and specifications for the SCADA EMU.

Functional Description	Provides communication link between telephone network interface and 3601 monitor; contains non-intrinsically safe portion of the modem communication
Housing	Gray PVC
Dimensions	4.13 inches (10.5 cm) high x 3.25 inches (8.3 cm) wide x 1.88 inches (4.8 cm) deep
Operating Temperature	0° to 60° C (32° to 140° F)
Inputs and Outputs	Input: Voice-grade telephone line Output: 3601 communication cable
Communication	Voice-grade telemetry at 2400 bps

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