4110 Flow Logger

Installation and Operation Guide

TELEDYNE ISCO
A Teledyne Technologies Company

Part #60-3243-141 of Assembly 60-3244-072

Revision J, April 17, 2006

Foreword

This instruction manual is designed to help you gain a thorough understanding of the operation of the equipment. Teledyne Isco recommends that you read this manual completely before placing the equipment in service.

Although Teledyne Isco designs reliability into all equipment, there is always the possibility of a malfunction. This manual may help in diagnosing and repairing the malfunction.

If the problem persists, call or e-mail the Teledyne Isco Technical Service Department for assistance. Simple difficulties can often be diagnosed over the phone.

If it is necessary to return the equipment to the factory for service, please follow the shipping instructions provided by the Customer Service Department, including the use of the **Return Authorization Number** specified. **Be sure to include a note describing the malfunction.** This will aid in the prompt repair and return of the equipment.

Teledyne Isco welcomes suggestions that would improve the information presented in this manual or enhance the operation of the equipment itself.

Teledyne Isco is continually improving its products and reserves the right to change product specifications, replacement parts, schematics, and instructions without notice.

Contact Information

Customer Service

Phone:	(800) 228-4373	(USA, Canada, Mexico)
	(402) 464-0231	(Outside North America)
Fax:	(402) 465-3022	
Email:	IscoCSR@teledyne.com	

Technical Service

Phone:	(800) 775-2965	(Analytical)
	(800) 228-4373	(Samplers and Flow Meters)
Email:	IscoService@teledyne.com	
Return equipment to:	4700 Superior Street, Lincoln, NE 68504-1398	

Other Correspondence

Mail to:	P.O. Box 82531, Lincoln, NE 68501-2531
Email:	IscoInfo@teledyne.com
Web site:	www.isco.com

Revised September 15, 2005

General Warnings

Before installing, operating, or maintaining this equipment, it is imperative that all hazards and preventive measures are fully understood. While specific hazards may vary according to location and application, take heed in the following general warnings:

⚠ WARNING

Avoid hazardous practices! If you use this instrument in any way not specified in this manual, the protection provided by the instrument may be impaired.

⚠ AVERTISSEMENT

Éviter les usages périlleux! Si vous utilisez cet instrument d'une manière autre que celles qui sont specifiées dans ce manuel, la protection fournie de l'instrument peut être affaiblie; cela augmentera votre risque de blessure.

Hazard Severity Levels

This manual applies *Hazard Severity Levels* to the safety alerts, These three levels are described in the sample alerts below.

⚠ CAUTION

Cautions identify a potential hazard, which if not avoided, may result in minor or moderate injury. This category can also warn you of unsafe practices, or conditions that may cause property damage.

⚠ WARNING

Warnings identify a potentially hazardous condition, which if not avoided, could result in death or serious injury.

⚠ DANGER

DANGER – limited to the most extreme situations to identify an imminent hazard, which if not avoided, will result in death or serious injury.

Hazard Symbols

The equipment and this manual use symbols used to warn of hazards. The symbols are explained below.

Hazard Symbols	
Warnings and Cautions	
	The exclamation point within the triangle is a warning sign alerting you of important instructions in the instrument's technical reference manual.
	The lightning flash and arrowhead within the triangle is a warning sign alerting you of "dangerous voltage" inside the product.
Symboles de sécurité	
	Ce symbole signale l'existence d'instructions importantes relatives au produit dans ce manuel.
	Ce symbole signale la présence d'un danger d'électocution.
Warnungen und Vorsichtshinweise	
	Das Ausrufezeichen in Dreieck ist ein Warnzeichen, das Sie darauf aufmerksam macht, daß wichtige Anleitungen zu diesem Handbuch gehören.
	Der gepfeilte Blitz im Dreieck ist ein Warnzeichen, das Sei vor "gefährlichen Spannungen" im Inneren des Produkts warnt.
Advertencias y Precauciones	
	Esta señal le advierte sobre la importancia de las instrucciones del manual que acompañan a este producto.
	Esta señal alerta sobre la presencia de alto voltaje en el interior del producto.

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Section 1 Introduction

The 4110 Flow Logger is a flow monitoring instrument that measures the level and flow rate of an open-channel flow stream. The 4110 consists of a portable case and a detachable Ultrasonic Level Sensor (USLS) (Figure 1-1). The 4110 detects level with the sensor suspended above open-channel primary devices or open pipes and channels with a known relationship between level and flow. Connectors on the side of the case accept cables from compatible equipment, such as Isco samplers, rain gauges, or IBM-compatible computers. A strap on the top of the case can suspend the 4110 from a manhole ladder or other support.

The 4110 depends on an IBM-compatible computer running Flowlink®, Teledyne Isco's flow data management software, for programming, calibration, and report generation. To program the 4110, connect it to a computer running Flowlink, and program the 4110 from the computer's keyboard. With Flowlink, you can enter settings for sampler controls, and set up the 4110's memory for data collection. Flowlink also retrieves stored data and converts level data to flow data with conversion formulas or tables.

1.1 Features

Variable Blanking – You can program the 4110 to ignore echoes reflected by objects within a variable distance. The 4110 uses variable blanking to tune out echoes reflected from obstructions between the sensor and the water surface, such as grates, structural supports, the top of a primary device, or the walls of pipes or channels.

Sampler Controls – The 4110 paces samplers for flow-paced or trigger-paced sampling. It has a number of sampler-enable controls that start and stop the sampler when the 4110 detects programmed level, flow rate, or rainfall measurements.

Internal Memory for Data Storage – The 4110 stores level, flow, rainfall, and sample event data in 230 kilobytes of nonvolatile, battery-backed RAM (Random Access Memory).

Variety of Power Sources – Power the 4110 with two 6-volt alkaline lantern batteries, and Isco 947 Lead-Acid Battery, and Isco 946 Lead-Acid Battery recharged with the Isco 954 solar panel, or with a powered Isco sampler.

Low Power Consumption – Two 6-volt alkaline batteries power a 4110 (programmed to take readings at 15-minute intervals) for approximately 3 months without recharging or replacement. The 947 Lead-Acid Battery has a capacity of about 45 days.

Battery Protection and Battery Life Monitoring – To protect the 947 Lead-Acid Battery and your data, the 4110 shuts down before the battery discharges completely. The 4110 monitors 947 Lead-Acid and alkaline batteries, reporting the remaining battery life to Flowlink.

Optional 4200T Modem – A factory-installed option, the 4200T Modem is a full duplex, auto-answer modem with dial-out capabilities and a speech synthesizer. It lets Flowlink exchange data with the logger over standard voice-grade telephone lines and program it to deliver voice messages to as many as five telephone numbers when it detects user-definable alarm conditions.

> ☑ ***Note***
>
> The modem is disabled when an interrogator cable is connected to the flow loggers interrogator port. It cannot receive incoming calls, and the alarm dialout will be rendered inoperative, while this cable is connected. **Disconnect the interrogator cable in order to use the 4200T modem.**

Flash Memory for Easy Software Upgrades – As Teledyne Isco adds software features to the 4110, upgrade your unit by connecting a computer and uploading the new software.

Figure 1-1 3012 Ultrasonic Level Sensor

1.2 Compatible Equipment

The following equipment is compatible with the 4110 Flow Logger:

- 3700 and 6700 Series Wastewater Samplers
- Isco 674 Rain Gauge

1.3 Repairing Your Flow Logger

The 4110 Flow Logger has no user-serviceable parts. If you feel your flow logger requires repair, contact Teledyne Isco's Customer Service department for information on returning it to the factory.

1.4 How to Get Help

If you need assistance or have questions, contact Teledyne Isco's Customer Service department.

Teledyne Isco, Inc.
P.O. Box 82531
Lincoln, NE 68501
Telephone Within U.S.A.
Toll free: (800) 228-4373
Outside U.S.A.:(402) 464-0231
Fax: (402) 465-3022
Technical Service: (800) 775-2965

IscoService@teledyne.com

1.5 Technical Specifications

The following tables cover the technical specifications of the 4110 Flow Logger and the Ultrasonic Level Sensor.

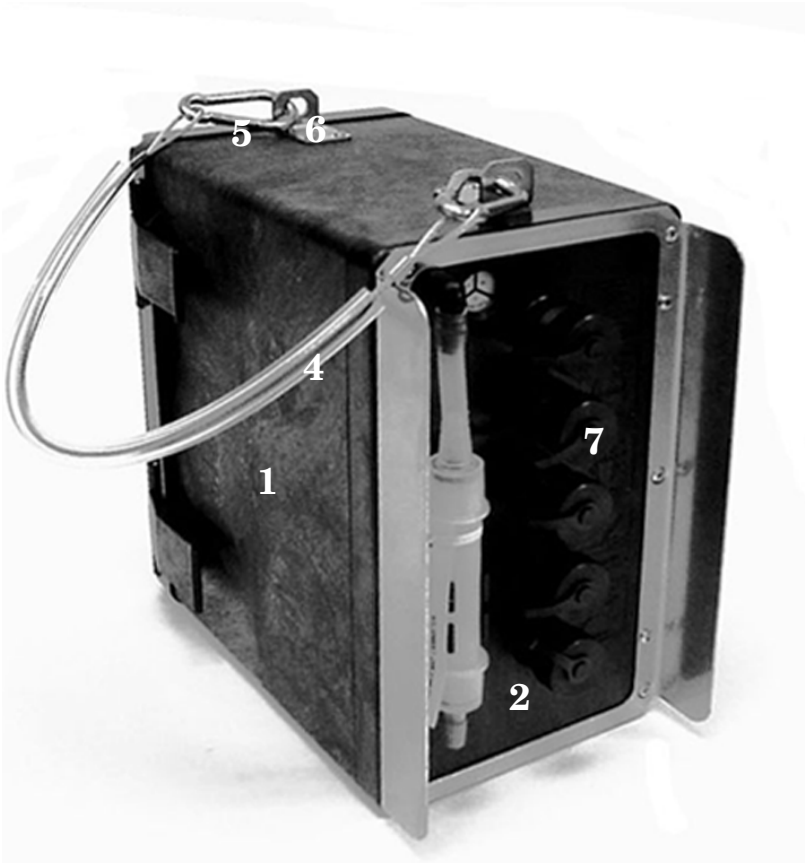


Figure 1-2 Materials Used in the 4110

Table 1-1 Materials Used in the 4110 (Figure 1-2)

1	Case and Battery Compartment Door	Polystyrene
2	Connector Panel	Noryl
3	Labels	Polyester (not shown)
4	Carrying Strap	Plastic
5	Handle Latches	Stainless Steel
6	Handle Latch Retainers	Stainless Steel
7	Connector Caps	Acetyl Plastic
8	Suspension Hook (not shown)	Stainless Steel

Table 1-2 Technical Specifications for the 4110 Flow Logger	
Dimensions	10.5 x 9.0 x 6.0 inches (26.7 x 22.9 x 15.2 cm)
Weight	8 lbs (3.6 kg), without batteries
Operating Temperature	0° to 140° F (-18° to 60° C)
Storage Temperature	-40° to 140° F (-40° to 60° C)
Enclosure	Self-certified NEMA 4X, 6
Power	Two 6-volt lantern batteries or one 12-volt Model 947 Flow Logger Lead-Acid Battery
Alkaline Battery Life	3 months with minimum reading intervals of 15 minutes

Table 1-3 Technical Specifications for the Ultrasonic Level Sensor	
Sensor Size	6.9 inches (17.5 centimeters)
Sensor Diameter	3.6 inches (9.1 centimeters)
Sensor Weight	2 pounds, 10 ounces (1.2 kilograms)
Range	Minimum distance from sensor face to liquid: 24 inches (0.6 meters) Maximum distance from sensor face to liquid: 12 feet (3.6 meters)
Span	0 to 10 feet (0 to 3 meters)
Level Measurement Accuracy	Head change of 0.0 to 1.0 foot (0.0 to 0.31 meter): ± 0.02 foot (± 0.006 meter) Head change of 1.0 to 10.0 feet (0.31 to 3.05 meter) ± 0.03 foot (± 0.009 meter) *(At 22° C, still air and 40 to 70 percent humidity)*
Compensated Temperature Range	-22° to 140° F (-30° to 60° C)
Temperature Error (over compensated temperature range)	± 0.000047 x D per degree Fahrenheit (± 0.000085 x D per degree centigrade), where D is the distance from the transducer to the liquid surface.
Operating Temperature Range	-22° to 140° F (-30° to 60° C)
Storage Temperature Range	-40° to 158° F (-40° to 70° C)

4110 Flow Logger

Section 2 Installation

2.1 Where Can You Install the 4110 Flow Logger?

You can install the 4110 Flow Logger in nearly any location. A removable strap at the top of the 4110 case can suspend the unit from a manhole ladder or other support.

You can install the Ultrasonic Level Sensor (USLS) where it can be suspended at least 2 feet above the highest anticipated level of the flow stream. The sensor works with any open-channel flow stream with a known level-to-flow relationship, including:

- Round pipes
- U-channel pipes
- Rectangular or trapezoidal pipes
- Open-channel primary devices

⚠ WARNING

The 4110 Flow Logger has not been approved for use in hazardous locations as defined by the National Electrical Code.
Before installing any device in a dangerous location, review safety precautions. (See General Safety Procedures Appendix C). Check applicable guidelines, codes, and regulations of federal, state, city, and county agencies.

2.2 About Power Sources

The 4110 Flow Logger requires a 12-volt DC power source. A number of power sources are available:

- Two 6-volt alkaline lantern batteries. Lantern batteries are available from Teledyne Isco or local hardware stores.

☑ *Note*

Use only alkaline lantern batteries; non-alkaline batteries cannot produce sufficient power under load.

☑ *Note*

When discarding disposable alkaline batteries, or any type of recyclable batteries, please dispose of them safely, observing all local environmental regulations.

- Isco 947 Lead-Acid Battery. This battery, built especially for the flow logger, is available only from Teledyne Isco.

- Isco 946 Lead-Acid Battery recharged on-site with an Isco 954 Solar Panel. The battery mounts on the solar panel; it does not fit in the 4110's battery compartment see Figure 2-1 and Figure 2-2).
- Power from an Isco sampler. The 4110 obtains power from the sampler through the cable connecting it to the sampler.
- A 12-volt DC marine battery can also be used as a power source for the 4110. These batteries require adaptor cables and must be mounted outside the 4110's case.

⚠ CAUTION

Do not use external power sources that produce more than 13 volts. Excessive voltage will blow the 4110's internal fuses, and may cause more serious damage.

A silicon band seals the battery compartment door when the door is securely latched. Seals around the battery connectors prevent moisture from entering the electronics compartment through the connectors. A desiccant cartridge keeps the battery connectors and contact plates dry when you latch the compartment door.

For information about charging Isco batteries, refer to the *Isco Power Products Guide*.

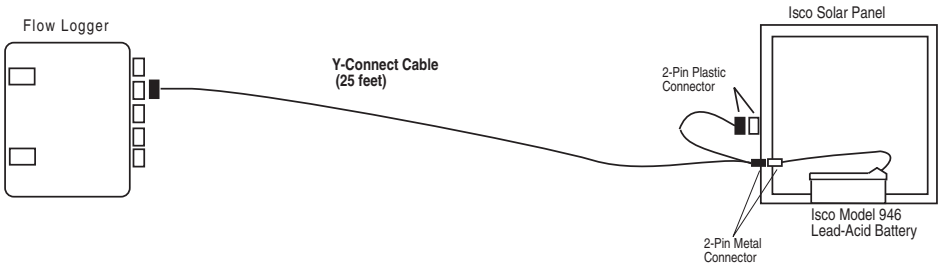


Figure 2-1 Connecting Solar Panels to the 4110

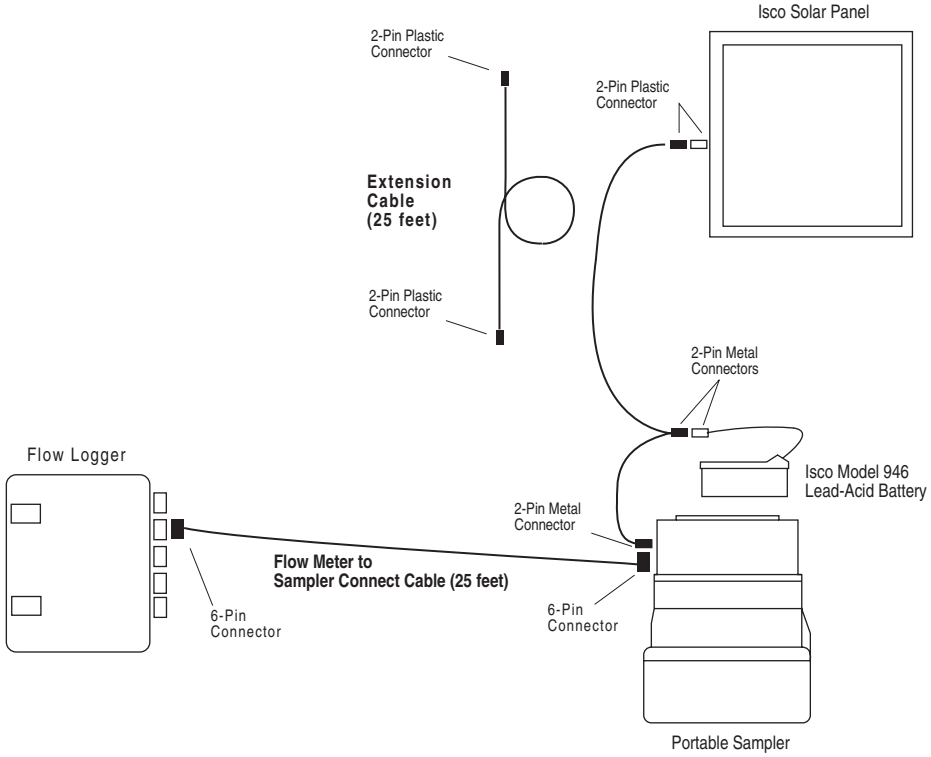


Figure 2-2 Connecting a Solar Panel and a Sampler to the 4110

2.2.1 Installing the 947 Lead-Acid Battery

The 4110's battery compartment has a 3-pin connector for the 947 battery. Install the battery as shown in Figure 2-3. The three brass contact plates on the back of the compartment fit the positive and negative contacts of alkaline batteries regardless of the batteries' orientation.

2.2.2 Installing Alkaline Batteries

Place an alkaline battery at each end of the battery compartment so that the springs contact the brass contact plates at the back of the compartment. (See Figure 2-4.) To complete the circuit, the plates extend from one end of the compartment to the other. A short section of nonconductive tape insulates the plates at the center of the compartment, preventing the batteries from touching the wrong contact plate and creating a short circuit.

If the insulating tape becomes damaged, have it replaced immediately. A short circuit in the compartment can severely damage the flow logger's case.

Figure 2-3 Installing the 947 Lead-Acid Battery

2.2.3 Battery Protection and Battery Life

Lead-acid batteries can be severely damaged or destroyed if completely discharged. The 4110 protects the battery (and itself) by monitoring the voltage level of the battery. It shuts down when the voltage declines to low levels. This protects not only the battery and the 4110, but, because readings can become unreliable at low voltages, it also preserves the integrity of your data. The 4110 monitors the battery capacity and reports the remaining battery life via Flowlink.

The 4110 will not lose any data if it shuts down. Readings stored in RAM are protected by a lithium battery that provides power to the RAM when the 4110 is unpowered; for example, when the 4110 shuts down or when you replace the battery. The lithium battery also maintains the 4110's clock so that you do not have to reset it after battery changes.

Figure 2-4 Installing Alkaline Batteries

2.2.4 Low Power Consumption

The 4110 Flow Logger consumes very little power. Although the actual power consumed by a flow logger depends on many variables, one is most significant: the frequency of readings.

To conserve power, the 4110 shuts down between readings. If you have programmed the flow logger to take frequent readings - at intervals of 5 minutes, for example - you can expect the flow logger to consume about six times more power than a flow logger programmed to take readings every 30 minutes.

Under most conditions, two fully charged, 6-volt alkaline batteries will power the 4110 for as long as 3 months without recharging or replacement when readings are taken at 15 minute intervals. The 947 Lead-Acid Battery has about one third that capacity. You can also power the 4110 for longer periods with a lead-acid battery that is recharged daily by a solar panel.

Even though you can expect a battery life of 3 months, you should check the remaining battery life regularly. The flow logger reports battery use when connected to a computer running Flowlink (Figure 2-5). You can use this information to prevent lost readings by scheduling a battery replacement before the current battery becomes completely drained.

Flowlink reports the type of battery, the current voltage, and the remaining battery capacity in the Power box. When the flow logger obtains power from an external power source, Flowlink reports the battery type as “external”.

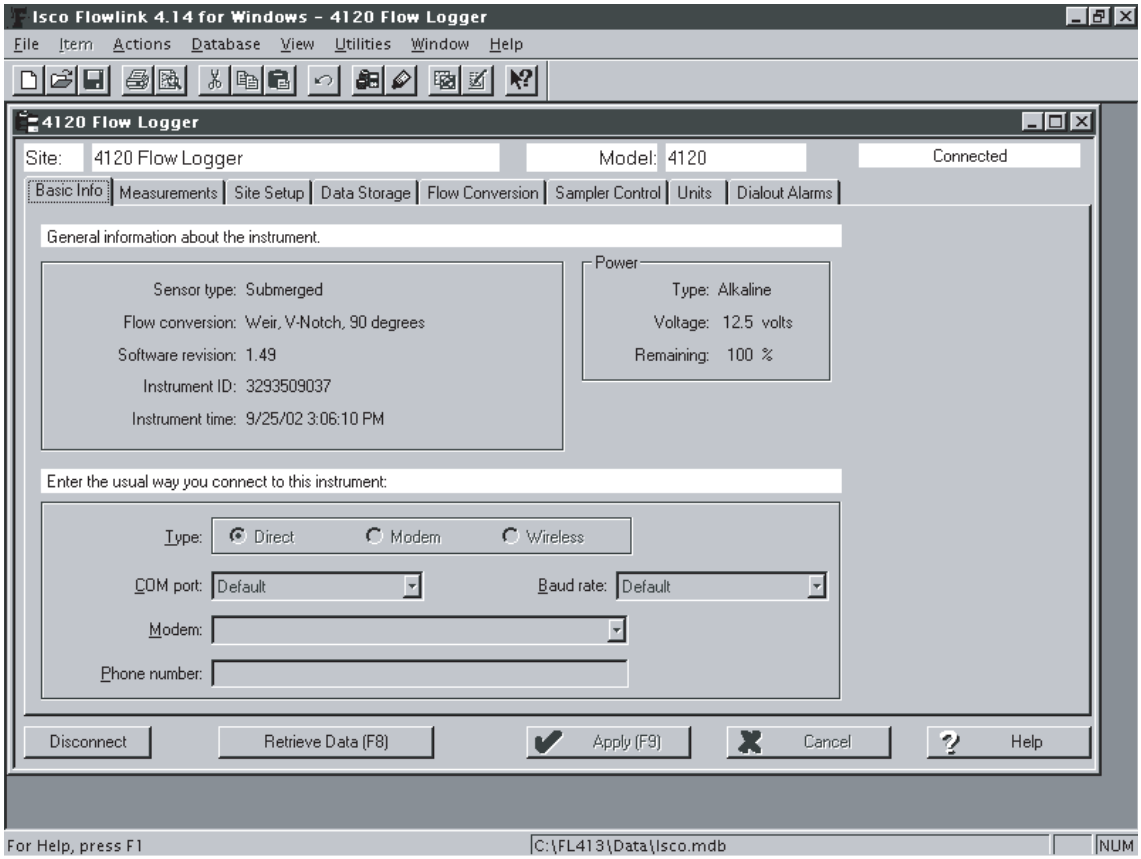


Figure 2-5 Remaining Battery Life Reported in Flowlink

2.2.5 How Does the Flow Logger Conserve Power?

The 4110 conserves power by providing power to the circuitry only under certain conditions. These conditions occur when the 4110 performs the following functions:

- **Respond to a signal from a tipping-bucket rain gauge.** The 4110 responds to a rain gauge signal only when programmed to store rainfall data or to monitor rainfall readings for sampler-enable controls.
- **Take a reading.** Using Flowlink, you determine the interval between readings (1, 2, 5, 10, 15, 30, 60, or 120 minutes) as part of the 4110’s program.

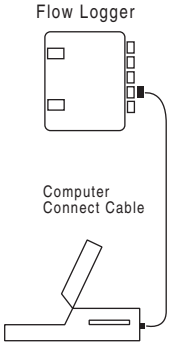
- **Send a pacing pulse (electronic signal) to a sampler.** When flow-pacing a sampler, a pulse represents a certain volume of water, i.e. 100 gallons; 5,000 cubing feet; or other volume setting entered with flowlink. When trigger-pacing a sampler, however, a pulse represents one of two possible time intervals.

  To conserve power, the 4110 must do as many tasks as possible when powered. So, it sends pulses while taking readings. If the 4110 has measured a large volume of water or if the trigger-pacing interval is shorter than the reading interval, it may send several flow pulses at once.

  For more information on flow-pacing and trigger-pacing, see Flowlink's Help guide.

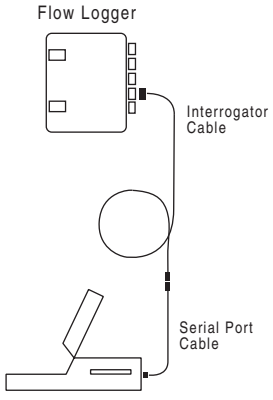
- **Respond to a computer.** The 4110 responds to a computer when it detects a completed circuit created by connecting an interrogator cable to the flow logger's interrogator connector. Leaving the cable connected to the flow logger drains power unnecessarily. **If your 4110 has a 4200T talking modem installed, disconnect the interrogator cable in order to use it.**

  Teledyne Isco supplies two cables, the Flow Meter Interrogator Cable and the Serial Port Cable, to interrogate flow meters. These cables are compatible with the flow logger. The computer-detecting circuit is in the 4-pin connectors that attach the cables to each other.



☑ *Note*

Leaving the Serial Port Cable and the Interrogator Cable attached to each other while the interrogator cable is attached to the flow logger will drain the battery.



- **Respond to a sample-event signal from a sampler.** A sample-event signal is an electronic signal called an event mark, sent by the sampler that indicates the sampler has completed a sample.
  The 4110 responds to a sample-event signal only when programmed to store sample-event data. When it receives an event signal, the 4110 records the time of the event mark and the bottle receiving the sample.

2.2.6 Adaptor Cables for Alternative Power Sources

Teledyne Isco provides three power-source adaptor cables (Figure 2-6). The first connects an Isco 947 Lead-Acid Battery to the Isco 965 Five Station Battery Charger. Because the charger connectors do not match those of 947 batteries (they were originally designed for Isco Nickel-Cadmium Batteries), an adaptor is required to connect the 947 to the charger.

The second cable connects the AC Power Pack to the 4110. It attaches to the flow logger's Sampler connector.

The last cable, the External 12-Volt DC Source Connect Cable, connects the 4110 to a 12-volt, deep-cycle marine battery. The cable has a connector at one end that attaches to the 4110's sampler connector. The opposite end of the cable has two battery clips. Attach the clip stamped with a "+" to the positive terminal of the battery.

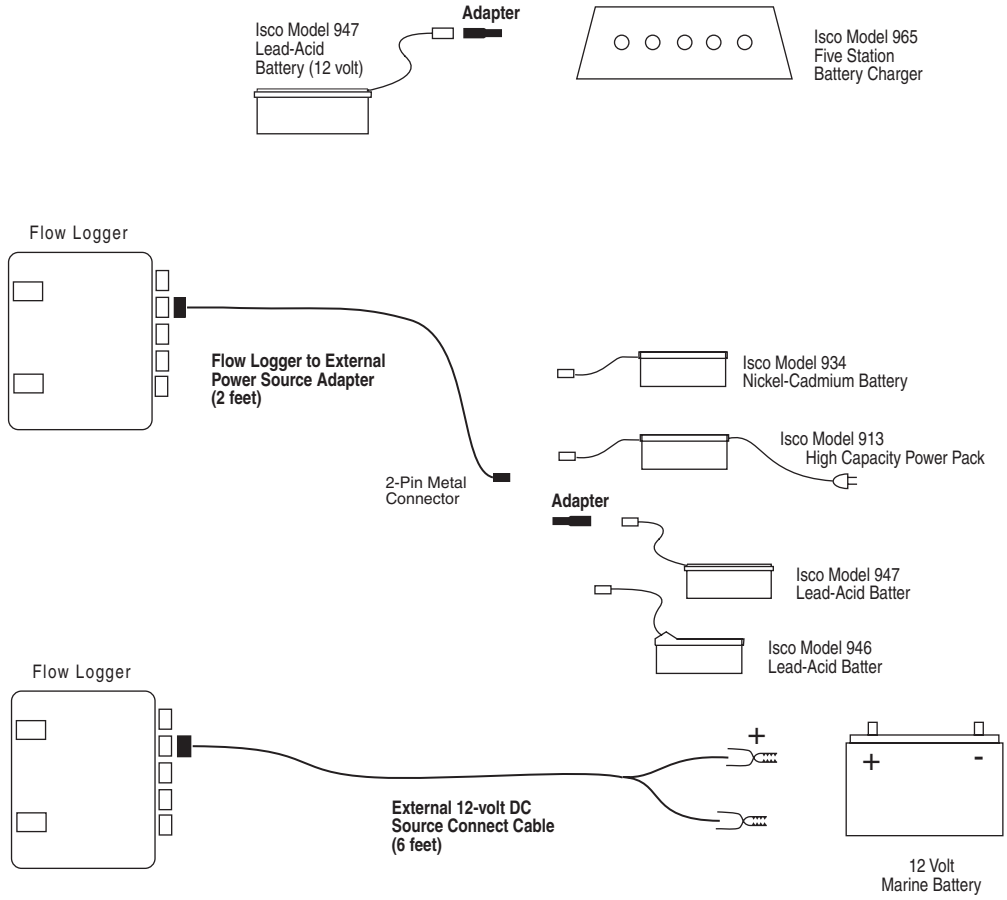


Figure 2-6 Adaptors for Alternative Power Sources

2.3 Programming and Calibration Requirements

- IBM PC or compatible computer - desktop or laptop model
- Isco 9-pin or 25-pin computer connect cable to connect the flow logger to the computer
- Flowlink software

2.4 Installation Checklist

1. Check the condition of the desiccant cartridge in the battery compartment. Replace or recharge the desiccant, if necessary. (Refer to Recharging and Replacing the Desiccant, Section 3.2 for more information.)
2. Install a fresh battery or connect to an Isco sampler.

⚠ CAUTION

Do not use external power sources that produce more than 13 volts. Excessive voltage will blow the 4110's internal fuses and may cause more serious damage.

3. Connect a computer to the 4110 and use Flowlink software to:

- Set up the 4110 memory
- Set up sampler-enable or pacing controls, if any
- Enter the flow conversion settings
- Check remaining battery life

At the installation site:

4. Install the level sensor by suspending it over the measuring point of a channel. You can suspend the sensor from its cable; the weighted cable stiffener forces the sensor to hang plumb.
5. Use the suspension strap and hook to hang the 4110 from the Isco Spreader Bar, a manhole ladder rung, or other support.
6. Connect the sensor's cable to the 4110. Conduit may be used, if needed.
7. Connect a rain gauge and sampler, if needed.
8. Connect a laptop computer to the 4110 and use Flowlink to calibrate the sensor.

2.5 Measuring Level with the Ultrasonic Level Sensor

The USLS consists of a 25-foot shielded cable and a sealed, cylindrical enclosure containing an ultrasonic transducer and its supporting electronics. The sensor, when suspended over the flow stream, determines the stream's level by emitting an ultrasonic pulse of about 49 kHz and measuring the time it takes for the echo to return from the stream's surface. The transducer acts as both transmitter and receiver. The elapsed time is proportional to the distance to the surface.

The speed of the sound pulse depends on the ambient air temperature; the speed changes about 1 percent for 10° F variation. The USLS has a temperature probe in the enclosure to measure ambient air temperature. It uses the temperature probe in conjunction with microprocessor-based compensation to adjust level readings for air temperature variations.

To operate effectively, the sensor must be able to detect a returning echo under a variety of conditions. Although the signal strength of the echo depends on several factors - the distance from the transducer to the liquid surface, the humidity of the ambient air, or the amount of wind encountered by the sensor - distance influences the signal most.

For every 2½-foot increase in the distance between the transducer and the stream's surface, the strength of the returned echo decreases by half. The sensor contains a ramp-gain amplifier that adjusts the gain of the return echo to compensate for distance. As the distance increases, the gain of the echo amplifier increases with time to compensate for the decreasing signal strength of the echo.

Because the speed of the pulse varies only slightly with humidity (maximum of 0.35 percent at 68°), the 4110 does not compensate for humidity. Humidity does have an effect on the echo's signal strength, however. Under conditions of extremely high or low humidity, the change in signal strength may be inconsistent with the characteristics of the ramp-gain amplifier and can cause a minor reading error.

2.6 Installing the Ultrasonic Level Sensor

Although variable-blanking settings determined through Flowlink minimize anomalous readings, proper installation assures you that readings are both reliable and accurate. Before installing the USLS, consider the following points:

- Abusive handling will damage the ultrasonic transducer inside the sensor. Although the USLS will survive normal handling and installation, treat the level sensor with reasonable care.
- When installing the sensor, place the sensor over the center of the flow stream. Use a circular bubble level to align the sensor vertically. Misalignment can cause the echo to bounce off the channel walls, causing erratic or erroneous level readings.
- When installing the level sensor in a primary device, locate the sensor at the head-measuring point of the device. The location of the USLS depends on the primary device because the head-measuring point is unique to each device. Refer to the table below for the typical measuring point for common devices. For more detailed information, refer to the *Isco Open Channel Flow Measurement Handbook* and to information provided by the device manufacturer.
  If flow is measured by some other means - the Manning Equation or by calibrating a section of the flow channel, the head-measuring location varies with the hydraulic

characteristics of the site and the method of level-to-flow conversion used. In open channel installation, where flow may exceed half of a full pipe, suspend the transducer at the midpoint between the pipe entrance and exit of the U-channel. This location normally produces the least turbulent flow.

Device	Head-Measuring Point
Weirs	Upstream from the weir plate by at least 3 times the maximum head.
Parshall Flumes	1/3 of the way into the converging section.
Palmer-Bowlus Flumes	Upstream from the flume entrance bay at least half the pipe diameter.

- Suspend the level sensor at least 2 feet above the maximum level anticipated for the channel, but no more than 12 feet - 12 feet is the sensor's maximum range - above the minimum level. The sensor has a 2-foot dead band directly below the transducer that prevents any measurement of level within the zone. To minimize the effect of distance on the accuracy of the level readings, mount the sensor as close as possible to a position 2 feet above the maximum expected level.

2.6.1 Minimizing Level Measurement Errors

In order to minimize measurement errors with the 4110, the following precautions should be observed in the installation of the ultrasonic level sensor. These are listed in the approximate order of their significance. Factors affecting accuracy of the ultrasonic technique were discussed in the beginning of this section.

Avoid Temperature Differences – Avoid installations where the ultrasonic level sensor will operate at a different temperature than the air between the level sensor and the flow stream through which the ultrasonic beam passes. The reason is that the temperature sensor mounted in the ultrasonic level sensor is intended to provide the flow meter with temperature readings taken from the surrounding air. If the ultrasonic level sensor operates at a different temperature than the surrounding air, the flow meter's temperature compensation will be based on the temperature of the level sensor rather than the surrounding air. This will lead to significant errors.

Use a Sunshade in Outdoor Applications – This situation is most likely to occur where the ultrasonic level sensor is installed outside and is directly exposed to the sun. In such installations, a sunshade should be provided to keep the sun from shining directly on the level sensor, as sunlight will raise the temperature of the level sensor's housing significantly higher than the surrounding air temperature.

Serious Errors Possible – Errors caused by the ultrasonic level sensor operating at a different temperature than the ambient can be quite serious. For example, with a distance of

only two feet and a temperature difference of 35° F, the level error is:

$$\text{LevelError} = 0.001 \times 35 \times 2 = 0.070\,\text{foot}$$

(about 1 inch)

Temperature differences between the ultrasonic level sensor and the flow stream surface will lead to velocity errors because the ultrasonic level sensor is at a different temperature than the air. Also, air layers of different temperatures between the level sensor and the flow stream surface will cause an abnormal reduction in the strength of the ultrasonic pulse. (The flow meter is designed to interpret the normal pulse correctly, not an abnormal one.) This may lead the flow meter to detect the wrong wave and introduce a wave detect error.

Avoid Prolonged Submersion – The sensor cannot work when submerged. The sensor is completely sealed, and temporary submersion in the flow stream will not damage it. However, prolonged submersion or submersion in dirty or greasy flow streams may coat the surface of the transducer with solid matter, causing the sensor to malfunction until cleaned.

Avoid High-Frequency Background Noise – Noise in the transducer's operating frequency range (about 49 kHz) can interfere with the flow logger's operation. The 4110 uses a tuned circuit to filter noise outside the operating frequency, but it cannot filter noise near the operating frequency without tuning out its own signal.

Avoid Wind Currents – As much as possible, the ultrasonic level sensor should be installed in a location protected from air currents. Wind reduces the strength of the ultrasonic pulse and echo. This causes the flow meter to have difficulty detecting the proper wave in the echo, resulting in a wave detect error. In severe cases, it is possible for the flow meter to lose the echo completely.

Avoid Excessive Distances – Although the ultrasonic level sensor cannot be mounted closer than two feet from the maximum level of the flow stream, it is recommended that the mounting be kept as close to the twelve foot limit as possible. The reason is that the error made by the flow meter in calculating the velocity of sound in the air is multiplied by the distance from the level sensor to the surface of the flow stream. Minimizing the distance will minimize the error.

Calibrate at Expected Temperature – The user should calibrate the level reading under temperature conditions as near as possible to those expected during operation. For small changes of level, the error due to temperature is determined by the product of the distance (from the transducer to the flow stream surface) and the temperature change. Calibrating the flow meter at the same temperature as the expected operating temperature will minimize this error.

Avoid Water Condensate – The ultrasonic level sensor will not operate properly if the bottom surface collects water droplets. This may occur if water condenses on the transducer surface as a result of high ambient humidity. Some users have found that mounting the ultrasonic level sensor horizontally and aiming it at a 45° angled reflector will keep water from collecting on the level sensor's radiating surface.

Avoid Foam, Oil, and Turbulence – If the flow stream surface is absorbent (such as with foam) or very irregular (such as highly turbulent water), the ultrasonic echo may not be correctly reflected back to the ultrasonic level sensor. This can result in a false measurement or no measurement at all. If the foam is reflective, the system will detect the top of the foam rather than the liquid surface. Also, if grease or oil is floating on the flow stream surface, it will be detected rather than the liquid surface. (See Figure 2-8.)

Small Pipes and Channels – Small circular pipes, narrow channels, and small flumes may also cause problems with ultrasonic distance measurement. Since the ultrasonic pulse expands outward at a beam angle of approximately 10° as it travels away from the ultrasonic level sensor, it may strike the sides of a channel or the sloping sides of a circular pipe with low flow. (See Figure 2-7). This can result in false echoes and incorrect level readings. The term “small channels” generally refers to “U” shaped channels and pipe inverts 10" in diameter and less. The term “small flumes” generally refers to 1" and 2" Parshall flumes. It should be noted that the level measuring point for many types of flumes (Palmer-Bowlus, Leopold-Lagco, etc.) is not in the flume, but upstream in the invert of the pipe; for these types of flumes the section of interest is in the pipe invert, not in the flume itself. Thus, care should be exercised in the use of 10" or smaller Palmer-Bowlus and Leopold-Lagco flumes.

Determining Suitability – The channel to be measured can be “pre-qualified” by a simple equation that will determine whether or not the channel is wide enough to allow correct positioning of the ultrasonic sensor. Since the beam angle is 12°, the equation is:

$$\text{MinimumWidth} = 0.21 \times \text{Distance}$$

...Where Distance is the distance from the bottom of the ultrasonic level sensor to the minimum expected level.

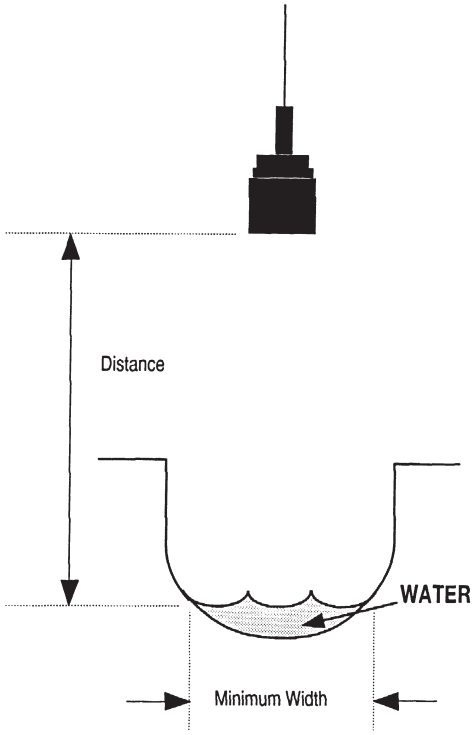


Figure 2-7 Small Pipes and Narrow Channels'

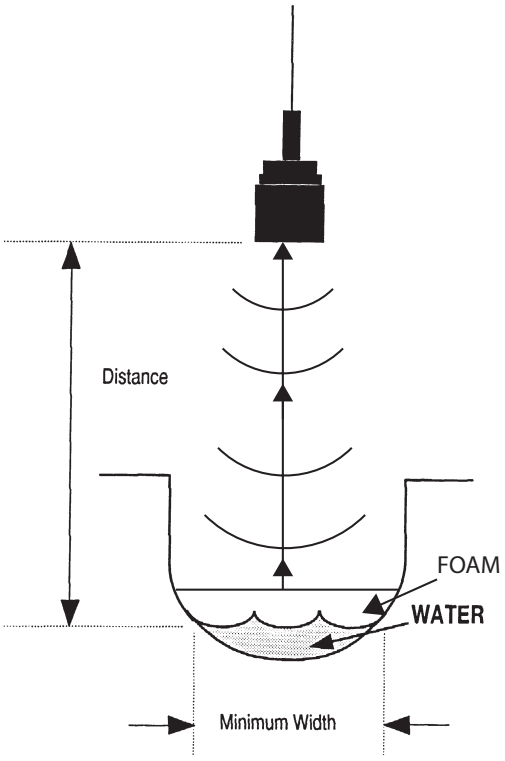


Figure 2-8 Foam and Oil on the Surface of the Stream

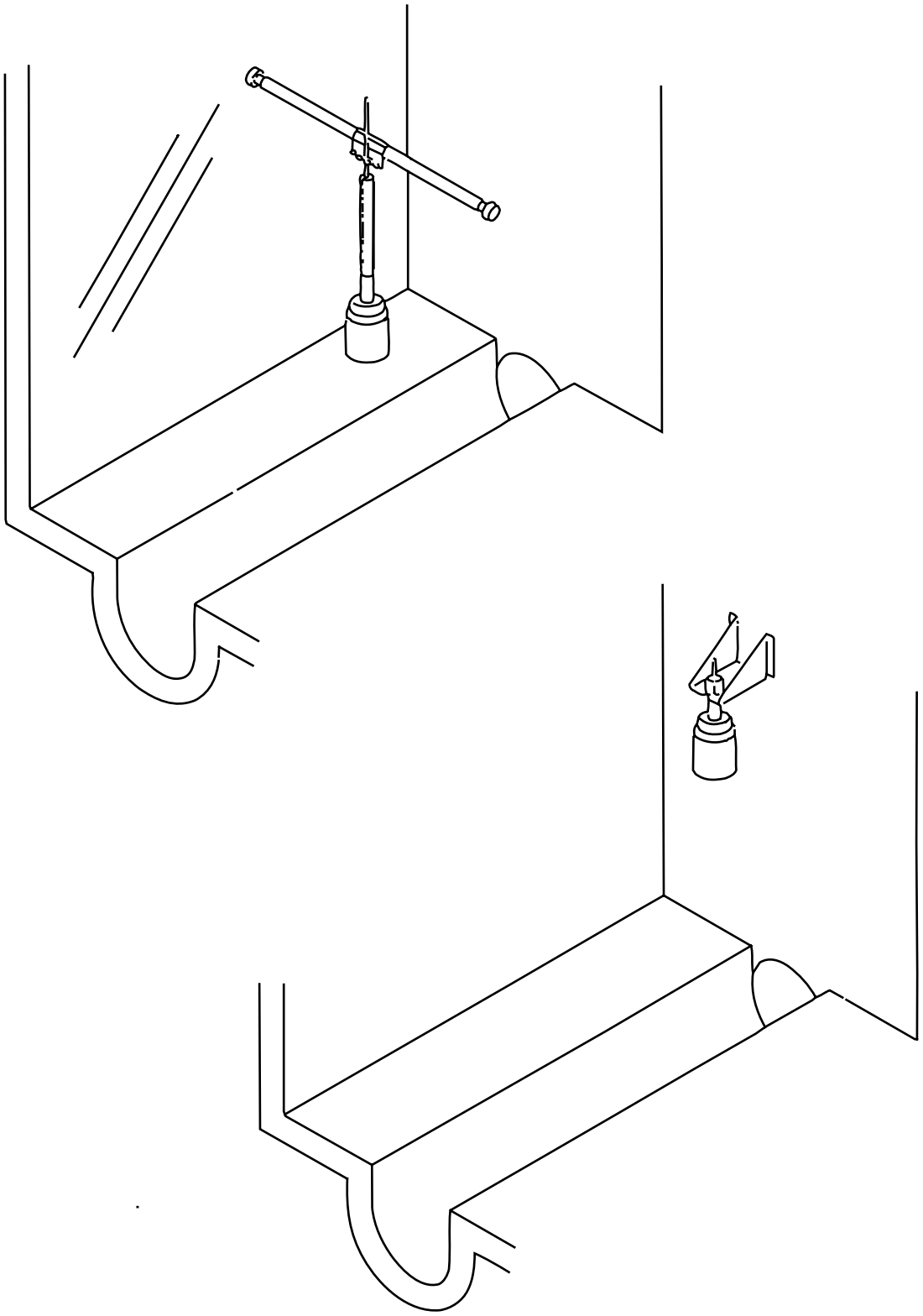


Figure 2-9 Mounting the Level Sensor

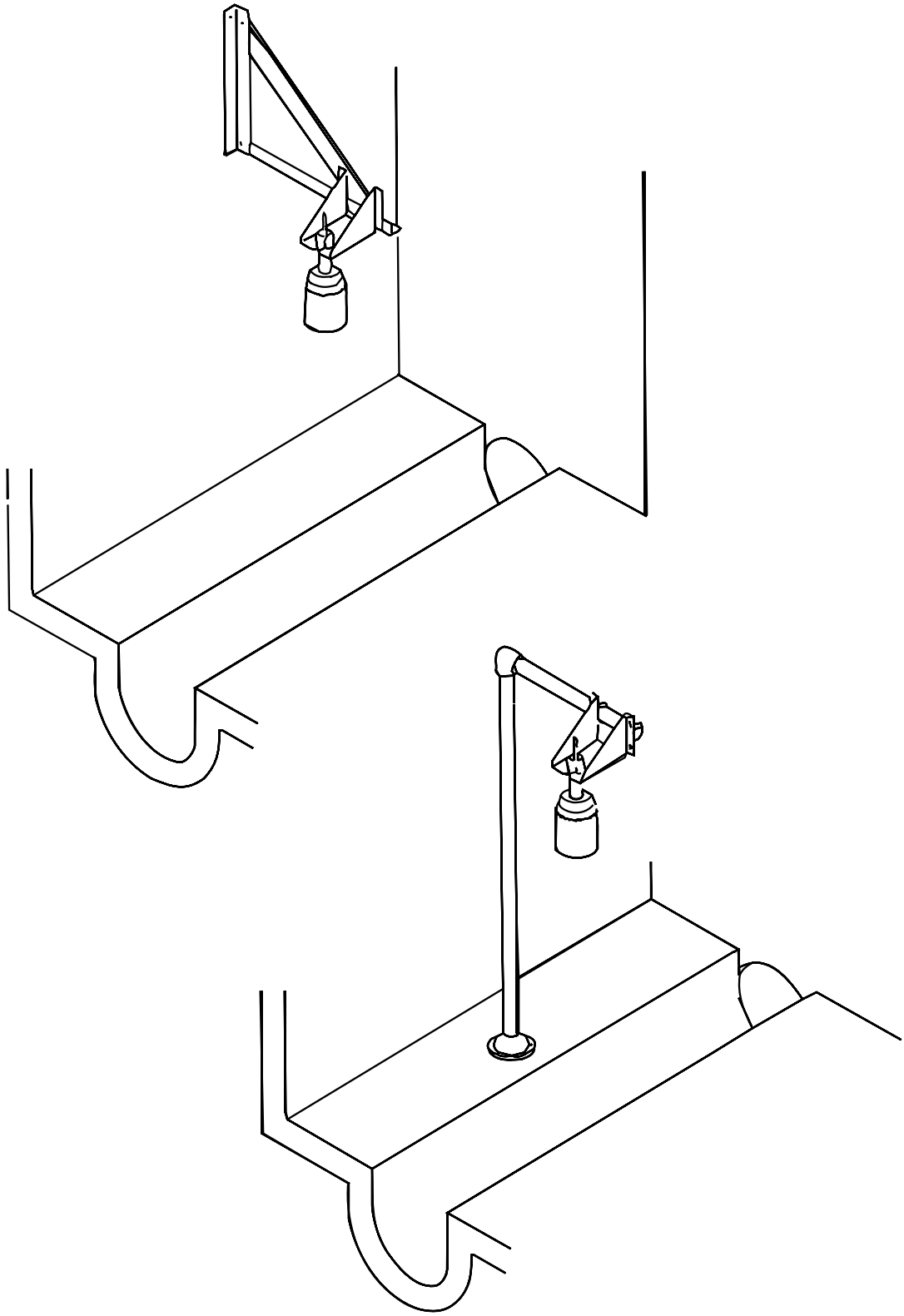


Figure 2-10 Mounting the Level Sensor (continued)

2.7 Connecting the 4110 to Samplers and Rain Gauges

A number of cables are available to connect the 4110 to samplers and the Isco Model 674 Rain Gauge.

To connect a sampler, attach the cable to the sampler's Flow Meter connector and the 4110's sampler connector. To select the right cable, refer to the diagram in Figure 2-11.

The 674 Rain Gauge has a cable attached to its base; no special cable is necessary. Attach the rain gauge cable to the 4110's rain gauge connector. Teledyne Isco provides a cable to connect non-Isco rain gauges to the 4110. See Appendix A Accessories List.

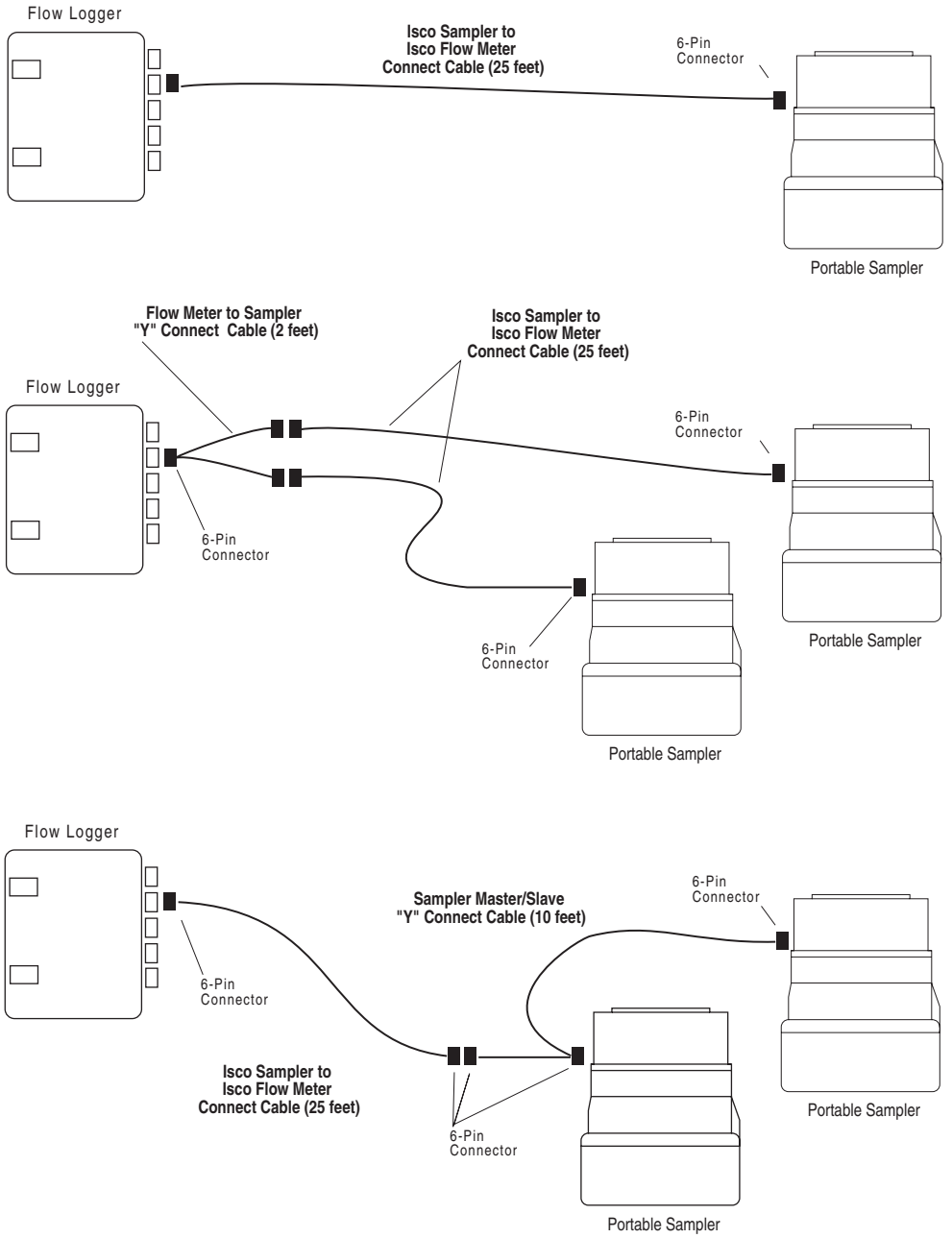


Figure 2-11 Connecting Samplers to the 4110

4110 Flow Logger

Section 3 Maintenance

The 4110 Flow Logger requires little routine maintenance. To keep the flow logger in good operating condition, observe the following:

- Keep all unused connectors capped. This prevents moisture and the chemicals found in harsh environments from damaging the pins in the connectors.
- Clean the flow logger and level sensor regularly.
- Check the condition of the desiccant regularly, regenerating it when necessary. (See *Recharging and Replacing the Desiccant* on page 3-1.)
- Replace or recharge the batteries as required. (See *About Power Sources* on page 2-1. For more information on recharging Isco batteries, refer to the *Isco Power Products Guide*.)

3.1 Cleaning the Flow Logger and Level Sensor

Both the 4110 and the USLS can be cleaned with soap and water. When cleaning, be sure to seal the connectors with the connector caps to prevent moisture from damaging the connectors. Be sure to seal the battery compartment door to prevent water from damaging the compartment's battery contacts and connectors.

Always clean the USLS after it has been submerged to remove any coating from its surface. The sensor cannot operate properly when the transmitting face of the transducer is dirty.

3.2 Recharging and Replacing the Desiccant

Because it is frequently installed din humid environments, the 4110 Flow Logger uses desiccators to prevent moisture damage to its components:

- A desiccant bag located in the electronics compartment
- A desiccant cartridge located inside the battery compartment

3.2.1 Recharging the Desiccant Bag

A paper humidity indicator on the rear of the case, labeled INTERNAL CASE HUMIDITY shows the relative humidity in the compartment. The desiccant should be recharged when the area marked "30" turns pink.

> **☑ Note**
>
> Teledyne Isco does not recommend recharging the desiccant bag yourself because you must open the case, breaking the NEMA 6 seal that prevents moisture and corrosive atmospheres from destroying the circuitry.
>
> If the desiccant bag requires recharging, contact Isco Customer Service for assistance. Excessive humidity in the case may indicate that the case or case seal requires repair.

3.2.2 When to Recharge the Desiccant Cartridge

The metal desiccant cartridge, located in the battery compartment, has an inspection window that shows the silica gel desiccant inside. The desiccant is blue or yellow when dry. Recharge the desiccant cartridge when the particles turn pink or green.

The desiccant cartridge requires periodic recharging to dry it after it becomes saturated with moisture. After repeated recharging, it eventually requires replacement. Table 3-1 shows you how to recharge the desiccant cartridge and when to replace it.

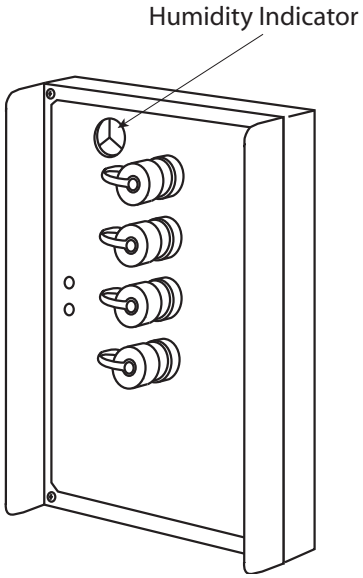


Figure 3-1 Humidity Indicator Location

Table 3-1 How to Recharge the Desiccant Cartridge

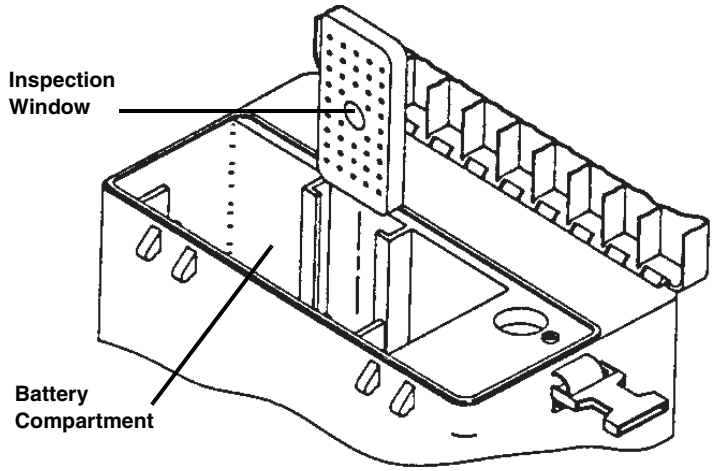


Figure 3-2 Location of Desiccant Cartridge

How to remove desiccator	Open compartment door and slide cartridge from slot.
When to recharge	Desiccant behind inspection window turns pink or green.
How to recharge	Heat cartridge in a conventional, vented oven.
Oven temperature	300° F (150° C)
How long to heat	3 hours Desiccant is recharged when the desiccant behind the inspection window turns blue or yellow.
When to replace	Desiccant particles no longer turn blue or yellow when recharged.

⚠ CAUTION

Desiccant may produce irritating fumes when heated. (Material Safety Data Sheets are in Appendix B.)
To safely regenerate the desiccant cartridge:
• Always use a vented, circulating forced air convection oven in a well-ventilated room.
• DO NOT use a microwave oven to recharge the desiccant cartridge. Heating the metal cartridge case in a microwave oven will damage the oven.
• Leave the room while heating the desiccant.
• Avoid heating the desiccant longer than necessary.
• Use the recommended temperature. Avoid heating the desiccant at higher than recommended temperatures.

3.3 Fuses

If your flow logger does not seem to be operating correctly, it may have one or two bad fuses or its circuit board may need repair. You can check for problems with sensors or fuses with Flowlink's Diagnostic window. The window contains two fields, Signal Strength and Spectrum Strength, that report errors when the flow logger has at least one bad fuse or when the circuit board is malfunctioning. If the window reports "ERR" in both the Signal Strength and Spectrum Strength fields, the flow logger may have a bad fuse. (More information on the diagnostic window appears in the Flowlink Help section.)

> ☑ ***Note***
>
> Teledyne Isco does not recommend replacing fuses yourself because you must open the case, breaking the NEMA 6 seal that prevents moisture and corrosive atmospheres from destroying the circuitry. If your flow logger requires repair, contact Teledyne Isco Customer Service for information on returning it to the factory.

Teledyne Isco, Inc.
P.O. Box 82531
Lincoln, NE 68501
Telephone Within U.S.A.
Toll free: (800) 228-4373
Outside U.S.A.:(402) 464-0231
Fax: (402) 465-3022
Technical Service: (800) 775-2965

IscoService@teledyne.com

3.4 Using Flash Update

Teledyne Isco manufactures a number of instruments - 4100 and 2100 Series Flow Loggers, 4200 Series Flow Meters, and 6700 Series Samplers - that use circuitry based on Flash EPROMs. Unlike earlier EPROMs that require UV erasure and were not easily field replaced, the Flash EPROM lets you upgrade the software in the instrument without opening the unit or returning it to the factory. You can now update the software with a disk from Teledyne Isco, an IBM®-compatible personal computer and a connect cable.

The disk contains UPDATE, a program specifically for flash memories, and a set of software files to update the Flash EPROM.

Each disk is labeled with:

- The instrument series number
- The software revision number for each instrument in the series
- The part number of the disk

3.4.1 Getting Started

The following instructions assume that:

- You have had some experience using the computer.
- You have a Computer Connect Cable. If you do not have the cable, order it from your sales representative or the factory. For more detailed information about hardware requirements, see Table 3-2 on page 3-7.
- You are familiar with Microsoft® Windows®. FLASH UPDATE uses the standard Windows user-interface for mouse and keyboard commands. If you are unfamiliar with DOS or Windows, please read your DOS or Windows user manuals.

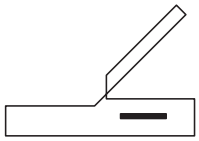
3.4.2 Before Running FLASH UPDATE

The windows in FLASH UPDATE contain all the instructions you need to update the instrument. However, there are a few things to consider before running the program.

- **Updating your instrument erases the data stored in its memory.** This includes all readings and most of the program settings. FLASH UPDATE replaces most program settings with factory settings. Before running the program, collect the data and record your program settings. Then, after updating the software, reprogram the instrument.
- **If you have Flowlink, Teledyne Isco strongly recommends using it to update 4100 Series Flow Loggers.** Flowlink lets you collect the data stored in the instrument before updating the software. It also leaves the program settings in the instrument unchanged, eliminating the need to reprogram them. Then Flowlink updates the software, it uses the update files on the FLASH UPDATE disk and disregards the FLASH UPDATE program. Refer to the Flowlink Help files for more information. Use FLASH UPDATE only if you do not have Flowlink available.
- The instructions in the following section, Running FLASH UPDATE, assume you are running the program from the update disk. However, you may prefer to copy the disk's contents to your hard disk. Before copying the disk, create a new directory for the FLASH UPDATE program and the update files. The program and the update files must be in the same directory. Furthermore, that directory must be the current directory when you run the program.
  If you receive several update disks over time, copy the update files and the program when copying the contents of a disk. This ensures that you have a current version of FLASH UPDATE as well as the new update files.
  Depending on your selection in the preferences window, you may see the window in the margin (left) listing all files in the directory. This window appears only when the directory or disk contains more than one version of the update files and the Preferences option for Show

Update File is “All Update Files.” (See About Preferences.)

3.4.3 Running FLASH UPDATE



Interrogator Port Icon

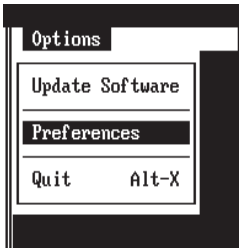
1. Connect the Computer Connect Cable to your computer’s serial port and the instrument’s interrogator connector (marked with the Interrogator icon).
2. Insert the update disk in the floppy disk drive.
3. Change the DOS prompt to the floppy disk letter prefix.
4. At the DOS command line, type: FLASHLD. The first window in FLASH UPDATE will be the Introduction window. Read it carefully before continuing.

3.4.4 About Preferences

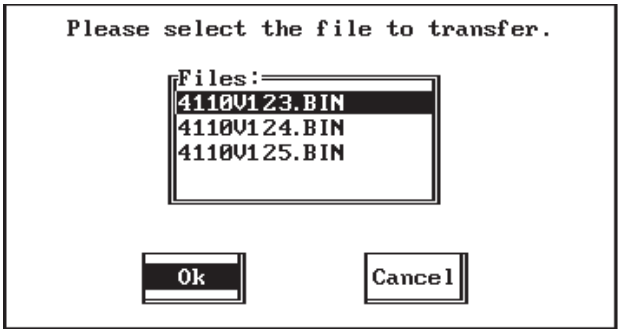
FLASH UPDATE has a set of factory settings that appear in Figure 3-3. Change them when your computer requires different settings.

To change preference settings:

1. Click Cancel in the Introduction window.
2. Select Preferences from the Options menu. The notes in Figure 3-3 explain the selections in the window. When you have selected your preferences, select OK.
3. Select Update Software from the Options menu, and follow the instructions in each window.



Options Menu



This window appears only when the directory or disk contains more than one version of the update files and the Preferences option for Show Update File is “all Update Files.” It lists the update files in the directory. The first four numbers in the file name are the instrument’s model number. The numbers following the “V” are the software version. If several versions appear in the window, select the version with the highest number unless otherwise instructed by Isco Technical Service.

Select the COM port that corresponds to the serial port used for the Computer Connect Cable.

Select Newest Version to see only the most recent update files in a directory. Select All Update Files to see all update files.

Select the color scheme that best matches your monitor.

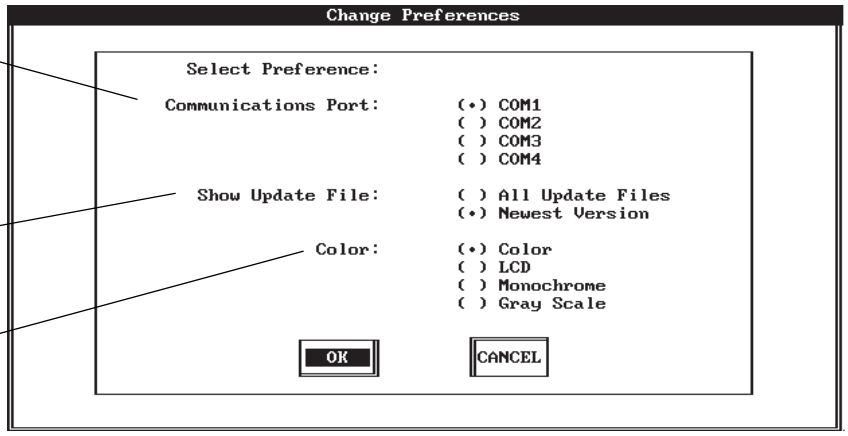


Figure 3-3 Preferences Window

Table 3-2 Minimum DOS and Computer Hardware Requirements

DOS	DOS 3.3 or later versions	DOS 5.0 or later versions recommended. Microsoft Windows not required.
CPU	80286, 80386, 80486	IBM PC or compatible. 80386 or 80486 recommended. (Must operate at 19,200 baud when communicating through the serial port.)
	640 kilobytes RAM (Random Access Memory), minimum	
	Serial port	For connecting the computer to Isco flow meters, flow loggers, or samplers.
Keyboard	Any compatible keyboard	
Hard disk	Not required.	
Floppy disk	$3^1/_2$-inch floppy drive (1.44 mega bytes)	At least one floppy disk drive.
Monitor	LCD, Gray Scale, Color, or Monochrome	IBM CGA, EGA, or VGA compatible.
Mouse	Microsoft®-compatible mouse	Optional. Mouse recommended.
Cabling	Isco Computer Connect Cable (9-pin: part #60-2544-044) (25-pin: part #60-2544-040)	For connecting the computer to flow meters, flow loggers, or samplers.

4110 Flow Logger

Section 4 Programming

To program the 4110, connect the 4110 to a computer and enter the 4110's program with Flowlink. Flowlink provides all programming instructions for the flow logger. For a summary of Flowlink's functions refer to Table 4-1. More information about programming the flow loggers is in Flowlink's Help section.

4.1 About the 4110's Memory

The 4110's memory contains 230 KB of nonvolatile, battery-backed RAM (Random Access Memory) which Flowlink divides into storage areas called partitions. Although the amount of data stored in each partition varies according to the type of data and the partition size, a 230 KB divided into three, equally sized partitions stores:

- More than 400 days of level, flow rate, or rainfall data at 15-minute intervals
- 5,000 sample-event readings

4.2 Sampler Enabling and Sampler Pacing

The 4110 offers two types of sampler control: sampler enable and sampler pacing. A 4110 programmed to enable or disable a sampler compares level, flow, time, or rainfall measurements to a set point, usually the reading measurement at which the 4110 is to enable or disable the sampler. Thus, a set point can be:

- At a specific time and date
- When the flow stream's level or flow rate passes a set point (for example, a level measurement of 0.3 foot)
- When the amount of rainfall exceeds a set point (1 inch of rain collected in 30 minutes)

Although you can program the 4110 to enable the sampler on a single data type's set point, you can also combine most data types with three logical operators: AND, OR, and NOT. Refer to Table 4-2. Using the operators, a flow logger can enable a sampler when reading two set points (level AND rainfall) or either set point (level OR rainfall).

The second type of sampler control, sampler pacing, determines how often the sampler will take a sample. The flow logger offers both flow-pacing and trigger-pacing.

To learn more about flow logger memory, sampler enabling, and sampler pacing, refer to Flowlink's Help section.

Table 4-1 Flowlink Tasks

Programming Instructions	Status Information	Data Management
• Sampler pacing • Sampler enable controls • Memory setup: number of partitions type of data interval between readings • Level calibration • Level-to-flow conversion	• Battery life • Flow-stream status: totalized flow current level flow rate • Sampler enabled or disabled • Memory status • 4110 clock • 4110 software version	• Data retrieval • Reports • Graphs • Data editing • Import/export data in ASCII format

Table 4-2 Sampler-Enable Data Types and Logical Operators

Data Type or Condition	Set Point	Logical Commands
Always ON	None (The Flow Logger will use this condition unless you specify otherwise.)	No
Always OFF	None	No
Level	Level reading	Yes
Flow	Flow rate	Yes
Time	Start time	Yes
Rainfall	Total rainfall measured in a specific period	Yes

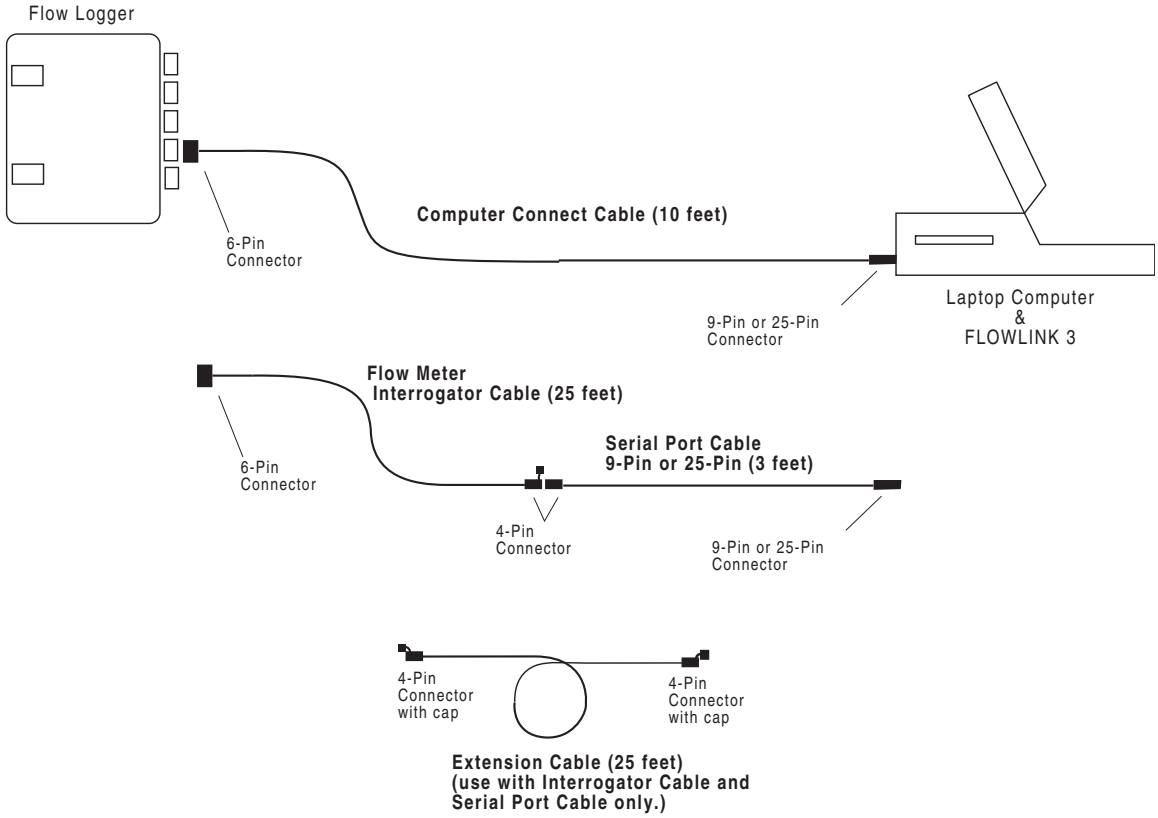


Figure 4-1 Connecting the 4110 for Programming

4110 Flow Logger

Appendix A Accessories List

The following table contains information about accessories. Accessories can be purchased by contacting Teledyne Isco's Customer Service Department.

Teledyne Isco, Inc.
Customer Service Department
P.O. Box 82531
Lincoln, NE 68501 USA

Phone: (800) 228-4373
(402) 464-0231
FAX:(402) 465-3022

E-mail:IscoCSR@teledyne.com.

Table A-1 Accessories

Part Description	Part Number
Power Sources and Battery Chargers	
6-Volt Alkaline Battery, Disposable, 6 volts; 2 required per flow logger	340-2006-02
Flow Logger Lead-Acid Battery, Rechargeable, 12 volts; 1 required per flow logger. Requires one of the battery chargers listed below. Also requires Flow Logger lead-acid battery charging adapter, part #68-3114-015.	60-3114-011
Lead-Acid Battery Pack	60-3004-106
Battery Backed Power Pack (120 VAC), AC power converter/battery charger with built-in battery	60-3004-130
Battery Backed Power Pack (240 VAC)	60-3004-160
High Capacity Power Pack (120 VAC)	60-1684-088
Battery Charger, 120 volts AC, 50/60 Hz	60-3004-059
Model 965 Five-Station Battery Charger, 120/240 V, with 120 V power cord.	68-3000-965
Model 965 Five-Station Battery Charger, 120/240 V, with 240 V power cord.	68-3000-966
Solar Panel Battery Charger, 5 watts	60-5314-478
Solar Panel Battery Charger, 40 watts	60-5314-347
Solar Panel Battery Charger, 90 watts	60-5314-399
Connect Cables	
Computer Connect Cable, 9-pin, 10 ft	60-2544-044
Computer Connect Cable, 25-pin, 10 ft	60-2544-040

Table A-1 Accessories (Continued)	
Part Description	**Part Number**
Flow Logger External 12-Volt DC Source Connect Cable, Connects flow logger to external 12-volt DC source. Terminates in heavy-duty battery clips.	60-3114-016
Flow Logger External Power Connect Cable	60-3114-002
Lead-Acid Battery Charging Adapter	60-3114-002
Solar Panel Connect Cable Only	60-3114-015
Solar Panel “Y” Connect Cable Only	60-3004-098
Flow Logger to External Power and Sampler “Y” Connect Cable, Connects a single flow logger to two Isco sampler-to-flow meter connect cables and to an external power source.	60-3114-001
Flow Meter to Sampler “Y” Connect Cable, Connects a single flow logger to an Isco sampler-to-flow meter connect cable.	60-3704-081
Isco Sampler to Flow Meter Connect Cable, 25-foot	60-3004-107
Rain Gauge (tipping bucket rain gauge with 50-ft cable and connector)	
Isco Model 674 Rain Gauge 0.01 inch tip	60-3284-001
Isco Model 674 Rain Gauge 0.1 mm tip	60-3284-006
Rain Gauge Connect Cable For Non-Isco Rain Gauges	60-3004-149
Flowlink	
Flowlink 4.1*	60-2544-052
Computer Connect Cable, 9-pin, 10 ft	60-2544-044
Computer Connect Cable, 25-pin, 10 ft	60-2544-040
4200T Modem**	factory-installed option
*For programming 4100 Series Flow Loggers and retrieving stored flow, rainfall, and sample data. Also generates a variety of graphs, reports, and summaries from stored data. Operates on IBM PC or compatible computer. Includes instruction manual. Requires one of the computer connect cables listed below. **Contact your sales representative or Teledyne Isco Customer Service.	

4110 Flow Logger

Appendix B Material Safety Data Sheets

This appendix provides Material Safety Data sheets for the internal desiccants used in the 4110 Flow Logger.

Specific questions regarding the use and handling of these products should be directed to the manufacturer listed in the MSDS

Material Safety Data Sheet

Indicating Silica Gel

Identity (Trade Name as Used on Label)

Manufacturer : MULTISORB TECHNOLOGIES, INC. (formerly Multiform Desiccants, Inc.)	MSDS Number* : M75
Address: 325 Harlem Road Buffalo, NY 14224	CAS Number* :
Phone Number (For Information): 716/824-8900	Date Prepared: July 6, 2000
Emergency Phone Number: 716/824-8900	Prepared By* : G.E. McKedy

Section 1 - Material Identification and Information

Components - Chemical Name & Common Names (Hazardous Components 1% or greater; Carcinogens 0.1% or greater)	%*	OSHA PEL	ACGIH TLV	OTHER LIMITS RECOMMENDED
Silica Gel SiO_2	98.0	6mg/m^3 (total dust)	10mg/m^3 (total dust)	
Cobalt Chloride	>2.0	0.05mg/m^3 (TWA cobalt metal dust & fume)	.05mg/m^3 (Cobalt, TWA)	
Non-Hazardous Ingredients				
TOTAL	100			

Section 2 - Physical/Chemical Characteristics

Boiling Point	N/A	Specific Gravity (H_20 = 1)	2.1
Vapor Pressure (mm Hg and Temperature	N/A	Melting Point	N/A
Vapor Density (Air =1)	N/A	Evaporation Rate (_____=1)	N/A
Solubility in Water	Insoluble, but will adsorb moisture.	Water Reactive	Not reactive, but will adsorb moisture.
Appearance and Odor	Purple crystals, no odor.		

Section 3 - Fire and Explosion Hazard Data

Flash Point and Methods Used	N/A	Auto-Ignition Temperature	N/A	Flammability Limits in Air % by Volume	N/A	LEL	UEL
Extinguisher Media	Dry chemical, carbon dioxide and foam can be used.						
Special Fire Fighting Procedures	Water will generate heat due to the silica gel which will adsorb water and liberate heat.						
Unusual Fire and Explosion Hazards	When exposed to water, the silica gel can get hot enough to reach the boiling point of water. Flooding with water will reduce the temperature to safe limits.						

Section 4 - Reactivity Hazard Data

STABILITY ☐**Stable** ☐**Unstable**	Conditions To Avoid	Moisture and high humidity environments.
Incompatibility (Materials to Avoid)	Water.	
Hazardous Decomposition Products	Carbon dioxide, carbon monoxide, water	
HAZARDOUS POLYMERIZATION ☐May Occur	Conditions To Avoid	None.

*Optional

Section 5 - Health Hazard Data

PRIMARY ROUTES OF ENTRY	☐Inhalation ☐Skin Absorption	☐Ingestion ☐Not Hazardous	**CARCINOGEN LISTED IN**	☐NTP ☐IARC Monograph	☐OSHA ☐Not Listed
HEALTH HAZARDS	Acute	May cause eye, skin and mucous membrane irritation.			
	Chronic	Prolonged inhalation may cause lung damage.			
Signs and Symptoms of Exposure	Drying and irritation.				
Medical Conditions Generally Aggravated by Exposure	Asthma.				
EMERGENCY FIRST AID PROCEDURES - Seek medical assistance for further treatment, observation and support if necessary.					
Eye Contact	Flush with water for at least 15 minutes.				
Skin Contact	Wash affected area with soap and water.				
Inhalation	Remove affected person to fresh air.				
Ingestion	Drink at least 2 glasses of water.				

Section 6 - Control and Protective Measures

Respiratory Protection (Specify Type)	Use NIOSH approved dust mask or respirator.		
Protective Gloves	Light cotton gloves.	Eye Protection	Safety glasses.
VENTILATION TO BE USED	☐ Local Exhaust	☐Mechanical (General)	☐Special
	☐Other (Specify)		
Other Protective Clothing and Equipment	None.		
Hygienic Work Practices	Avoid raising dust. Avoid contact with skin, eyes and clothing.		

Section 7 - Precautions for Safe Handling and Use/Leak Procedures

Steps to be Taken if Material Is Spilled Or Released	Sweep or vacuum up and place the spilled material in a waste disposal container. Avoid raising dust.
Waste Disposal Methods	Dispose in an approved landfill according to federal, state and local regulations.
Precautions to be Taken In Handling and Storage	Cover promptly to avoid blowing dust. Wash after handling.
Other Precautions and/or Special Hazards	Keep in sealed containers away from moisture. The silica gel will readily adsorb moisture.

*Optional Indicating Silica Gel

MULTISORB
Multisorb Technologies Inc.

MATERIAL SAFETY DATA SHEET

Effective Date March 8, 2005
MSDS Number M163

Section 1 – Product and Company Information

Product Name: **Silica gel, indicating, yellow**

Product Use: Desiccant, absorbent
Grades: Silica gel, indicating
Synonyms: Amorphous silica gel, SiO_2, silicon dioxide (amorphous)

Company; Multisorb Technologies, Inc.
Street Address: 325 Harlem Road
City, State, Zip, Country: Buffalo, NY 14224-1893 USA

Telephone Number: (716) 824 8900 [USA] Monday - Friday (8:00 - 5:00 EDT)
Fax Number: (716) 824 4091 [USA]
Website / E-Mail : multisorb.com

Section 2 – Composition / Information on Ingredients

Component Name	CAS Number	% by Weight
Synthetic amorphous silica gel (SiO_2)	112926-00-8	100
Phenolphthalein	77-09-08	100 ppm

While this material is not classified, this MSDS contains valuable information critical to the safe handling and proper use of this product. This MSDS should be retained and available for employees and other users of this product.

Section 3 – Hazard Identification

Emergency Overview: A yellow bead or granular material that poses little or no immediate hazard. This material is not combustible.

Potential Health Effects:

Eyes: Dust and or product may cause eye discomfort and irritation seen as tearing and reddening.

Skin: The product dust may cause drying of the skin. Silica gel may get hot enough to burn skin when it adsorbs moisture rapidly. Use an excess of water to cool the silica gel.

Ingestion: Material is not toxic and will pass through the body normally.

Inhalation: Slight irritation is possible but none is expected.

Medical Effects Generally Aggravated by Exposure: Respiratory ailments.

Chronic Effects/Carcinogenity: May cause eye, skin and mucous membrane irritation and drying.

Section 4 – First Aid Measures

Eyes: Rinse the eyes well with water while lifting the eye lids. If irritation persists, consult a physician.

Skin: Wash affected area with soap and water.

Ingestion: Ingestion is unlikely, this material will pass through the body normally.

Inhalation: Remove the affected person to fresh air and get medical attention if necessary.

Notes to Physician: Not applicable

Section 5 – Fire Fighting Measures

Flammable Properties: Not flammable

Flash Point: Not applicable **Method:** Not applicable

Flammable Limits: Not flammable

Lower Flammability Limit: Not applicable

Upper Flammability Limit: Not applicable

Autoignition Temperature: Not applicable

Hazardous Combustion Products: Not applicable

Extinguishing Media: Use extinguishing media that is appropriate for the surrounding fire. Silica gel is not combustible.

Fire Fighting Instructions: Not combustible

Unusual Fire and Explosion Hazards: None

Section 6 – Accidental Release Measures

Spill: Sweep or vacuum up and place the spilled material in a waste disposal container. Avoid raising dust. Wash with soap and water after handling.

Section 7 – Handling and Storage

Handling: Avoid raising dust and minimize the contact between worker and the material. Practice good hygienic work practices.

Storage: Store in a cool, dry location. Keep in sealed containers away from moisture. The silica gel will readily adsorb moisture.

Section 8 – Exposure Controls/Personal Protection

Engineering Controls: Use exhaust ventilation to keep the airborne concentrations below the exposure limits.

Respiratory Protection: Use NIOSH approved respirator when the air quality levels exceed the TLV's.

Skin Protection: Light gloves will protect against abrasion and drying of the skin.

Eye Protection: Safety glasses.

Component Name	Exposure Limits		
	OSHA PEL	**ACGIH TLV**	**Other Recommended Limits**
Silica gel	TWA 20 mppcf (80 mg / m^3 % SiO_2)	TWA 10 mg / m^3	NIOSH REL TWA 6 mg / m^3 IDLH 3000 mg / m^3
Phenolphthalein	Not Applicable	Not Applicable	Not Applicable

Section 9 – Physical and Chemical Properties

Appearance: Yellow beads or granules

Odor: None

Physical State: Solid bead

PH: Not applicable

Vapor Pressure: Not applicable

Vapor Density: Not applicable

Boiling Point: 4046° F (2230° C)

Melting Point: 3110° F (1710° C)

Solubility: Insoluble in water

Specific Gravity: 2.1

Section 10 – Stability and Reactivity

Stability: Stable

Conditions to avoid: Moisture and high humidity environments.

Incompatibility: Water, fluorine, oxygen difluoride, chlorine trifluoride

Hazardous Decomposition Products: None

Hazardous Polymerization: Will not occur

Section 11 – Toxicological Information

This product and its components are not listed on the NTP or OSHA Carcinogen lists.

Animal Toxicology Tests for DOT Hazard classification
(Tests Conducted on finely ground silica gel)

1 - hour LC_{50} (rat) > 2 mg / l
48 - hour oral LD_{50} (rat) est. > 31,600 mg / kg
48 - hour dermal LD_{50} (rabbit) est. > 2,000 mg / kg
Considered an ocular irritant

Human Toxicology Silica gel is a synthetic amorphous silica not to be confused with crystalline silica. Epidemiological studies indicate low potential for adverse health effects. In the activated form, silica gel acts as a desiccant and can cause a drying irritation of the mucous membranes and skin in cases of severe exposure. Multisorb Technologies Inc. knows of no medical conditions that are abnormally aggravated by exposure to silica gel. The primary route of entry is inhalation of dust.

Section 12 – Ecological Information

Not known to have any adverse effect on the aquatic environment. Silica gel is insoluble and non-toxic.

Section 13 – Disposal Information

Disposal Information If this product as supplied becomes a waste, it does not meet the criteria of a hazardous waste as defined under the Resource Conservation and Recovery Act (RCRA) 40 CFR 261. Materials of a hazardous nature that contact the product during normal use may be retained on the product. The user of the product must identify the hazards associated with the retained material in order to assess the waste disposal options. Dispose according to federal, state and local regulations.

Section 14 – Transportation Information

U.S. Department of Transportation Shipping Name: Not classified as a hazardous material. Not regulated.

Section 15 – Regulatory Information (Not meant to be all inclusive - selected regulations represented)

TSCA Listed: Yes

DSL/NDSL (Canadian) Listed: Yes

OSHA: TWA 20 mppcf (80 mg / m^3 % SiO_2) for Silica gel

NIOSH: REL TWA 6 mg / m^3 IDLH 3,000 mg / m^3 for silica gel
Animal tests conducted in 1976 - 1978. 18 month exposure at 15 mg / m^3 showed silica deposition in respiratory macrophages and lymph nodes, minimum lung impairment, no silicosis.

ACGIH: TLV - 10 mg / m^3 for Silica gel

DOT: Not classified as a hazardous material.

Section 16 – Other Information

HMIS – Hazardous Materials Identification System

HMIS Rating	
Health	0
Flammability	0
Reactivity	0

0 - minimal hazard, 1 - slight hazard, 2 - moderate hazard, 3 - serious hazard, 4 - severe hazard

This MSDS was prepared by: George E. Mckedy
Senior Applications Development Specialist
Multisorb Technologies, Inc.

This data and recommendations presented in this data sheet concerning the use of our product and the materials contained therein are believed to be correct but does not purport to be all inclusive and shall be used only as a guide. However, the customer should determine the suitability of such materials for his purpose before adopting them on a commercial scale. Since the use of our products is beyond our control, no guarantee, expressed or implied, is made and no responsibility assumed for the use of this material or the results to be obtained therefrom. Information on this form is furnished for the purpose of compliance with Government Health and Safety Regulations and shall not be used for any other purposes. Moreover, the recommendations contained in this data sheet are not to be construed as a license to operate under, or a recommendation to infringe, any existing patents, nor should they be confused with state, municipal or insurance requirements, or with national safety codes.

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MATERIAL SAFETY DATA SHEET -- September 28, 1998
SORB-IT®
Packaged Desiccant

SECTION I -- PRODUCT IDENTIFICATION

Trade Name and Synonyms:	Silica Gel, Synthetic Amorphous Silica, Silicon, Dioxide
Chemical Family:	Synthetic Amorphous Silica
Formula:	$SiO_2.x\ H_2O$

SECTION II -- HAZARDOUS INGREDIENTS

Components in the Solid Mixture

COMPONENT	CAS No	%	ACGIH/TLV (PPM)	OSHA-(PEL)
Amorphous Silica	63231-67-4	>99	PEL - 20 (RESPIRABLE), TLV – 5	LIMIT – NONE, HAZARD - IRRITANT ˝

Synthetic amorphous silica is not to be confused with crystalline silica such as quartz, cristobalite or tridymite or with diatomaceous earth or other naturally occurring forms of amorphous silica that frequently contain crystalline forms.

This product is in granular form and packed in bags for use as a desiccant. Therefore, no exposure to the product is anticipated under normal use of this product. Avoid inhaling desiccant dust.

SECTION III -- PHYSICAL DATA

Appearance and Odor:	White granules; odorless.
Melting Point:	>1600 Deg C; >2900 Deg F
Solubility in Water:	Insoluble.
Bulk Density:	>40 lbs./cu. ft.
Percent Volatile by Weight @ 1750 Deg F:	<10%.

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SECTION IV -- FIRE EXPLOSION DATA

Fire and Explosion Hazard - Negligible fire and explosion hazard when exposed to heat or flame by reaction with incompatible substances.

Flash Point - Nonflammable.

Firefighting Media - Dry chemical, water spray, or foam. For larger fires, use water spray fog or foam.

Firefighting - Nonflammable solids, liquids, or gases: Cool containers that are exposed to flames with water from the side until well after fire is out. For massive fire in enclosed area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn. Withdraw immediately in case of rising sound from venting safety device or any discoloration of the tank due to fire.

SECTION V -- HEALTH HAZARD DATA

Health hazards may arise from inhalation, ingestion, and/or contact with the skin and/or eyes. Ingestion may result in damage to throat and esophagus and/or gastrointestinal disorders. Inhalation may cause burning to the upper respiratory tract and/or temporary or permanent lung damage. Prolonged or repeated contact with the skin, in absence of proper hygiene, may cause dryness, irritation, and/or dermatitis. Contact with eye tissue may result in irritation, burns, or conjunctivitis.

First Aid (Inhalation) - Remove to fresh air immediately. If breathing has stopped, give artificial respiration. Keep affected person warm and at rest. Get medical attention immediately.

First Aid (Ingestion) - If large amounts have been ingested, give emetics to cause vomiting. Stomach siphon may be applied as well. Milk and fatty acids should be avoided. Get medical attention immediately.

First Aid (Eyes) - Wash eyes immediately and carefully for 30 minutes with running water.

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NOTE TO PHYSICIAN: This product is a desiccant and generates heat as it adsorbs water. The used product can contain material of hazardous nature. Identify that material and treat accordingly.

SECTION VI -- REACTIVITY DATA

Reactivity - Silica gel is stable under normal temperatures and pressures in sealed containers. Moisture can cause a rise in temperature which may result in a burn.

SECTION VII --SPILL OR LEAK PROCEDURES

Notify safety personnel of spills or leaks. Clean-up personnel need protection against inhalation of dusts or fumes. Eye protection is required. Vacuuming and/or wet methods of cleanup are preferred. Place in appropriate containers for disposal, keeping airborne particulates at a minimum.

SECTION VIII -- SPECIAL PROTECTION INFORMATION

Respiratory Protection - Provide a NIOSH/MSHA jointly approved respirator in the absence of proper environmental control. Contact your safety equipment supplier for proper mask type.

Ventilation - Provide general and/or local exhaust ventilation to keep exposures below the TLV. Ventilation used must be designed to prevent spots of dust accumulation or recycling of dusts.

Protective Clothing - Wear protective clothing, including long sleeves and gloves, to prevent repeated or prolonged skin contact.

Eye Protection - Chemical splash goggles designed in compliance with OSHA regulations are recommended. Consult your safety equipment supplier.

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SECTION IX -- SPECIAL PRECAUTIONS

Avoid breathing dust and prolonged contact with skin. Silica gel dust causes eye irritation and breathing dust may be harmful.

* No Information Available

HMIS (Hazardous Materials Identification System) for this product is as follows:

Health Hazard	0
Flammability	0
Reactivity	0
Personal Protection	HMIS assigns choice of personal protective equipment to the customer, as the raw material supplier is unfamiliar with the condition of use.

4110 Flow Logger

Appendix C General Safety Procedures

In field installations of Isco wastewater samplers and associated equipment, the safety of the personnel involved should be the foremost consideration. The following sections provide safety procedures for working in and around manholes and sewers. the first section offers general safety advice. The second section deals with the special problem of hazardous gases found in sewers.

⚠ WARNING

The 4110 has not been approved for use in hazardous locations as defined by the National Electrical Code.

⚠ CAUTION

Before any sampler is installed, the proper safety precautions must be taken. The following discussions of safety procedures are only general guidelines. Each situation in which you install a flow meter varies. You must take into account the individual circumstances you are in. Additional safety considerations, other than those discussed here, may be required.

C.1 Practical Safety Precautions

The following procedures are those used by Black & Veatch, a respected consulting firm, and are published here by permission.

Field personnel must keep safety uppermost in their minds at all times. When working above ground, rules of common sense and safety prevail. However, when entering manholes, strict safety procedures must be observed. Failure to do so could jeopardize not only your own life, but also the lives of other crew members.

C.1.1 Hazards

There are many hazards connected with entering manholes. Some of the most common hazards are:

Adverse Atmosphere – The manhole may contain flammable or poisonous gases or the atmosphere may be deficient in oxygen. orced ventilation may be necessary.

Deteriorated Rungs – Manhole steps may be corroded and not strong enough to support a man. It may be difficult to inspect the rungs because of poor lighting.

Traffic – Whenever manholes are located in the traveled way, barricades and warning devices are essential to direct traffic away from an open manhole.

Falling Objects – Items placed near the manhole opening may fall and injure a worker in the manhole.

Sharp Edges – Sharp edges of items in or near a manhole may cause cuts or bruises.

Lifting Injuries – Unless proper tools are used to remove manhole covers, back injuries or injuries to hands or feet may result.

C.1.2 Planning

Advance planning should include arrangements for test equipment, tools, ventilating equipment, protective clothing, traffic warning devices, ladders, safety harness, and adequate number of personnel. Hasty actions may result in serious injuries. Time spent in the manhole should be kept to a minimum.

C.1.3 Adverse Atmospheres

[Refer to Table C-1, Hazardous Gases, at the end of this appendix.] Before workers enter a manhole, tests should be made for explosive atmosphere, presence of hydrogen sulfide, and oxygen deficiency. Combustible or toxic vapors may be heavier than air, so the tests on the atmosphere must be run at least 3/4 of the way down the manhole.

Whenever adverse atmosphere is encountered, forced ventilation must be used to create safe conditions. After the ventilating equipment has been operated for a few minutes, the atmosphere in the manhole should be retested before anyone enters the manhole.

When explosive conditions are encountered, the ventilating blower should be placed upwind to prevent igniting any gas that is emerging from the opening. When a gasoline engine blower is used, it must be located so that exhaust fumes cannot enter the manhole.

If testing equipment is not available, the manhole should be assumed to contain an unsafe atmosphere and forced ventilation must be provided. It should never be assumed that a manhole is safe just because there is no odor or the manhole has been entered previously.

C.1.4 Entering Manholes

Since the top of the manhole is usually flush with the surrounding surface, there may not be anything for the person who is entering the manhole to grab on to steady himself. Persons who are entering manholes should not be permitted to carry anything in their hands as they enter the manhole, to ensure that their hands will be free to hold on or grab if they slip. A good method for entering a manhole is to sit on the surface facing the manhole steps or ladder, with the feet in the hole and the arms straddling the opening for support. As the body slides forward and downward, the feet can engage a rung, and the back can rest against the opposite side of the opening. If there is any doubt about the soundness of the manhole steps, a portable ladder should be used.

A person should never enter a manhole unless he is wearing personal safety equipment, including a safety harness and a hard hat. Two persons should be stationed at the surface continuously while anyone is working inside a manhole, to lift him out if he is

overcome or injured. One man cannot lift an unconscious man out of a manhole. The persons stationed at the surface should also function as guards to keep people and vehicles away from the manhole opening. To avoid a serious injury, a person should not be lifted out of a manhole by his arm unless it is a dire emergency.

When more than one person must enter a manhole, the first person should reach the bottom and step off the ladder before the next one starts down. When two men climb at the same time, the upper one can cause the lower one to fall by slipping or stepping on his fingers.

C.1.5 Traffic Protection

In addition to traffic cones, markers, warning signs, and barricades, a vehicle or a heavy piece of equipment should be placed between the working area and oncoming traffic. Flashing warning signals should be used to alert drivers and pedestrians. Orange safety vests should be worn by personnel stationed at the surface when the manhole is located in a vehicular traffic area.

C.1.6 Falling Objects

All loose items should be kept away from the manhole opening. This applies to hand tools as well as stones, gravel and other objects.

C.1.7 Removing the Covers

Manhole covers should be removed with a properly designed hook. Use of a pick ax, screwdriver, or small pry bar may result in injury. A suitable tool can be made from $^{3}/_{4}$-inch round or hex stock. Two inches of one end should be bent at a right angle and the other end should be formed into a D-handle wide enough to accommodate both hands. Even with this tool, care must be exercised to prevent the cover from being dropped on the toes. The 2-inch projection should be inserted into one of the holes in the cover, the handle grasped with both hands, and the cover lifted by straightening the legs which have been slightly bent at the knees.

C.1.8 Other Precautions

Other precautions which should be taken when entering a manhole are:

- Wear a hard hat.
- Wear coveralls or removable outer garment that can be readily removed when the work is completed.
- Wear boots or nonsparking safety shoes.
- Wear rubberized or waterproof gloves.
- Wear a safety harness with a stout rope attached.
- Do not smoke.
- Avoid touching yourself above the collar until you have cleaned your hands.

C.1.9 Emergencies

Every member of the crew should be instructed on procedures to be followed in cases of an emergency. It is the duty of each crew chief to have a list of emergency phone numbers, including the nearest hospital and ambulance service, police precinct, fire station, and rescue or general emergency number.

C.1.10 Field Equipment

The following equipment will be available for use:

Blowers	Gloves	Traffic cones
Breathing apparatus	Hard Hats	Coveralls
Harnesses	First aid kits	Manhole irons
Emergency flashers	Pick axes	Flashlights
Rain slickers	Mirrors	Ropes
Gas detectors	Safety vests	Gas masks
Waders”		

C.2 Lethal Atmospheres in Sewers

The following is an article written by Dr. Richard D. Pomeroy, and published in the October 1980 issue of ***Deeds & Data*** of the WPCF. Dr. Pomeroy is particularly well known for his studies, over a period of nearly 50 years, in the field of the control of hydrogen sulfide and other odors in sewers and treatment plants. He has personally worked in a great many functioning sewers. In the earlier years he did so, he admits, with little knowledge of the grave hazards to which he exposed himself.

It is gratifying that the subject of hazards to people working in sewers is receiving much more attention than in past years, and good safety procedures are prescribed in various publications on this subject. It is essential that people know and use correct procedures.

It is less important to know just what the hazardous components of sewer atmospheres are, as safety precautions should in general be broadly applicable, but there should be a reasonable understanding of this subject. It is disturbing to see statements in print that do not reflect true conditions.

One of the most common errors is the assumption that people have died from a lack of oxygen. The human body is able to function very well with substantially reduced oxygen concentrations. No one worries about going to Santa Fe, New Mexico, (elev. 2,100 meters), where the partial pressure of oxygen is equal to 16.2% (a normal atmosphere is about 21%) oxygen. When first going there, a person may experience a little ‘shortness of breath’ following exercise. People in good health are not afraid to drive over the high passes in the Rocky Mountains. At Loveland Pass, oxygen pressure is 13.2% of a normal atmosphere. At the top of Mt. Whitney, oxygen is equal to 12.2%t. Many hikers go there, and to higher peaks as well. After adequate acclimation, they may climb to the top of Mt. Everest, where oxygen is equal to only 6.7%.

The lowest oxygen concentrations that I have observed in a sewer atmosphere was 13 percent. It was in a sealed chamber, near sea level, upstream from an inverted siphon on a metropolitan trunk. A man would be foolish to enter the chamber. Without ventilation, he might die, but not from lack of oxygen.

It seems unlikely that anyone has ever died in a sewer from suffocation, that is, a lack of oxygen. Deaths have often been attributed to 'asphyxiation.' This is a word which, according to the dictionary, is used to mean death from an atmosphere that does not support life. The word has sometimes been misinterpreted as meaning suffocation, which is only one kind of asphyxiation.

In nearly all cases of death in sewers, the real killer is hydrogen sulfide. It is important that this fact be recognized. Many cities diligently test for explosive gases, which is very important, and they may measure the oxygen concentration which usually is unimportant, but they rarely measure H_2S. Death has occurred where it is unlikely that there was any measurable reduction in the oxygen concentration. Waste water containing 2 mg per liter of dissolved sulfide, and at a pH of 7.0, can produce, in a chamber with high turbulence, a concentration of 300 PPM H_2S, in the air. This is considered to be a lethal concentration. Many people have died from H_2S, not only in sewers and industries, but also from swamps and from hot springs. In one resort area, at least five persons died from H_2S poisoning before the people were ready to admit that H_2S is not a therapeutic agent. Hardly a year passes in the U.S. without a sewer fatality from H_2S as well as deaths elsewhere in the world.

The presence of H_2S in a sewer atmosphere is easily determined. A bellows-and-ampoule type of tester is very satisfactory for the purpose, even though it is only crudely quantitative. When using a tester of this type, do not bring the air to the ampoule by way of a tube, as this may change the H_2S concentration. Hang the ampoule in the air to be tested, with a suction tube to the bulb or bellows.

Lead acetate paper is very useful as a qualitative indicator. It cannot be used to estimate the amount of sulfide, but it will quickly turn black in an atmosphere containing only a tenth of a lethal concentration.

Electrodes or other similar electrical indicating devices for H_2S in air have been marketed. Some of them are known to be unreliable, and we know of none that have proved dependable. Do not use one unless you check it at frequent intervals against air containing known H_2S concentrations. A supposed safety device that is unreliable is worse than none at all.

Remember that the nose fails, too, when it comes to sensing dangerous concentrations of H_2S.

Various other toxic gases have been mentioned in some publications. It is unlikely that any person has been asphyxiated in a sewer by any of those other gases, except possibly chlorine. The vapor of gasoline and other hydrocarbons is sometimes present in

amounts that could cause discomfort and illness, but under that condition, the explosion hazard would be far more serious. The explosimeter tests, as well as the sense of smell, would warn of the danger. Pipelines in chemical plants might contain any number of harmful vapors. They, too, are sensed by smell and explosimeter tests if they get into the public sewer. Such occurrences are rare.

The attempt to instill a sense of urgency about real hazards is diluted if a man is told to give attention to a long list of things that in fact are irrelevant.

Be very careful to avoid high H_2S concentrations, flammable atmospheres, and hazards of physical injuries. Remember that much H_2S may be released by the stirring up of sludge in the bottom of a structure. Obey your senses in respect to irritating gases, such as chlorine (unconsciousness comes suddenly from breathing too much). Be cautious about strange odors. Do not determine percent oxygen in the air. There is a danger that the result will influence a man's thinking about the seriousness of the real hazards. Most important, use ample ventilation, and do not enter a potentially hazardous structure except in a good safety harness with two men at the top who can lift you out."

C.3 Hazardous Gases

The following table contains information on the properties of hazardous gases.

Table C-1 Hazardous Gases

Gas	Chemical Formula	Common Properties	Specific Gravity or Vapor Density Air =1	Physiological Effect	Max Safe 60 Min. Exposure ppm	Max. Safe 8 Hour Exposure ppm	Explosive Range (% by vol. in air) Limits lower/upper	Likely Location of Highest Concentration	Most Common Sources	Simplest and Cheapest Safe Method of Testing
Ammonia	NH_3	Irritant and poisonous. Colorless with characteristic odor.	0.60	Causes throat and eye irritation at 0.05%, coughing at 0.17%. Short exposure at 0.5% to 1% fatal.	300 to 500	85	16 25	Near top. Concentrates in closed upper spaces	Sewers, chemical feed rooms.	Detectable odor at low concentrations
Benzene	C_6H_6	Irritant, colorless anesthetic	2.77	Slight symptoms after several hours exposure at 0.16% to 0.32%. 2% rapidly fatal.	3,000 to 5,000	25	1.3 7.1	At bottom.	Industrial wastes, varnish, solvents.	Combustible gas indicator
Carbon Bisulfide	CS_2	Nearly odorless when pure, colorless, anesthetic. Poisonous.	2.64	Very poisonous, irritating, vomiting, convulsions, psychic disturbance.	—	15	1.3 44.0	At bottom	An insecticide	Combustible gas indicator

Table C-1 Hazardous Gases (Continued)

Gas	Chemical Formula	Common Properties	Specific Gravity or Vapor Density Air =1	Physiological Effect	Max Safe 60 Min. Exposure ppm	Max. Safe 8 Hour Exposure ppm	Explosive Range (% by vol. in air) Limits lower/upper	Likely Location of Highest Concentration	Most Common Sources	Simplest and Cheapest Safe Method of Testing
Carbon Dioxide	CO_2	Asphyxiant, Colorless, odorless. When breathed in large quantities, may cause acid taste. Non-flammable. Not generally present in dangerous amounts unless an oxygen deficiency exists.	1.53	Cannot be endured at 10% more than a few minutes, even if subject is at rest and oxygen content is normal. Acts on respiratory nerves.	40,000 to 60,000	5,000	— —	At bottom; when heated may stratify at points above bottom.	Products of combustion, sewer gas, sludge. Also issues from carbonaceous strata.	Oxygen deficiency indicator
Carbon Monoxide	CO	Chemical asphyxiant. Colorless, odorless, tasteless. Flammable. Poisonous.	0.97	Combines with hemoglobin of blood. Unconsciousness in 30 min. at 0.2% to 0.25%. Fatal in 4 hours at 0.1%. Headache in few hours at 0.02%.	400	50	12.5 74.0	Near top, especially if present with illuminating gas.	Manufactured gas, flue gas, products of combustion, motor exhausts. Fires of almost any kind.	CO ampoules.
Carbon Tetra-Chloride	CCl_4	Heavy, ethereal odor.	5.3	Intestinal upset, loss of consciousness, possible renal damage, respiratory failure.	1,000 to 1,500	100	— —	At bottom.	Industrial wastes, solvent, cleaning	Detectable odor at low concentrations.
Chlorine	Cl_2	Irritant. Yellow-green color. Choking odor detectable in very low concentrations. Non-flammable.	2.49	Irritates respiratory tract. Kills most animals in a very short time at 0.1%.	4	1	— —	At bottom.	Chlorine cylinder and feed line leaks.	Detectable odor at low concentrations.
Formaldehyde	CH_2O	Colorless, pungent suffocating odor.	1.07	Irritating to the nose.	—	10	7.0 73.0	Near bottom.	Incomplete combustion of organics. Common air pollutant, fungicide.	Detectable odor.
Gasoline	C_5H_{12} to C_9H_{20}	Volatile solvent. Colorless. Odor noticeable at 0.03%. Flammable.	3.0 to 4.0	Anesthetic effects when inhaled. Rapidly fatal at 2.4%. Dangerous for short exposure at 1.1 to 2.2%.	4,000 to 7,000	1,000	1.3 6.0	At bottom.	Service stations, garages, storage tanks, houses.	1. Combustible gas indicator. 2. Oxygen deficiency indicator.**
Hydrogen	H_2	Simple asphyxiant. Colorless, odorless, tasteless. Flammable	0.07	Acts mechanically to deprive tissues of oxygen. Does not support life.	—	—	4.0 74.0	At top.	Manufactured gas, sludge digestion tank gas, electrolysis of water. Rarely from rock strata.	Combustible gas indicator.
Hydrogen Cyanide	HCN	Faint odor of bitter almonds. Colorless gas	0.93	Slight symptoms appear upon exposure to 0.002% to 0.004%. 0.3% rapidly fatal.	—	10	6.0 40.0	Near top.	Insecticide and rodenticide.	Detector tube

Table C-1 Hazardous Gases (Continued)

Gas	Chemical Formula	Common Properties	Specific Gravity or Vapor Density Air =1	Physiological Effect	Max Safe 60 Min. Exposure ppm	Max. Safe 8 Hour Exposure ppm	Explosive Range (% by vol. in air) Limits lower/upper	Likely Location of Highest Concentration	Most Common Sources	Simplest and Cheapest Safe Method of Testing
Gas	Chemical Formula	Common Properties	Specific Gravity or Vapor Density Air = 1	Physiological Effect*	Max Safe 60 Min. Exposure ppm	Max. Safe 8 Hour Exposure ppm	Explosive Range (% by vol. in air.) Limits lower/upper	Likely Location of Highest Concentration	Most Common Sources	Simplest and Cheapest Safe Method of Testing
Hydrogen Sulfide	H_2S	Irritant and poisonous volatile compound. Rotten egg odor in small concentrations. Exposure for 2 to 15 min. at 0.01% impairs sense of smell. Odor not evident at high concentrations. Colorless. Flammable.	1.19	Impairs sense of smell, rapidly as concentration increases. Death in few minutes at 0.2%. Exposure to 0.07 to 0.1% rapidly causes acute poisoning. Paralyzes respiratory center.	200 to 300	20	4.3 45.0	Near bottom, but may be above bottom if air is heated and highly humid.	Coal gas, petroleum, sewer gas. Fumes from blasting under some conditions. Sludge gas.	1. H_2S Ampoule. 2. 5% by weight lead acetate solution.
Methane	CH_4	Simple asphyxiant. Colorless, odorless, tasteless, flammable.	0.55	Acts mechanically to deprive tissues of oxygen. Does not support life.	Probably no limit, provided oxygen percentage is sufficient for life.	—	5.0 15.0	At top, increasing to certain depth.	Natural gas, sludge gas, manufactured gas, sewer gas. Strata of sedimentary origin. In swamps or marshes.	1. Combustible gas indicator 2. Oxygen deficiency indicator.
Nitrogen	N_2	Simple asphyxiant. Colorless, tasteless. Non-flammable. Principal constituent of air. (about 79%).	0.97	Physiologically inert.	—	—	— —	Near top, but may be found near bottom.	Sewer gas. sludge gas. Also issues from some rock strata.	Oxygen deficiency indicator.
Nitrogen Oxides	NO N_2O NO_2	Colorless Colorless, sweet odor. Reddish-brown. Irritating odor. Deadly poison	1.04 1.53 1.58	60 to 150 ppm cause irritation and coughing. Asphyxiant. 100 ppm dangerous. 200 ppm fatal.	50	10	— —	Near bottom.	Industrial wastes. Common air pollutant.	NO_2 detector tube.
Oxygen	O_2	Colorless, odorless, tasteless. Supports combustion.	1.11	Normal air contains 20.8% of O_2. Man can tolerate down to 12%. Minimum safe 8 hour exposure, 14 to 16%. Below 10%, dangerous to life. Below 5 to 7% probably fatal.	—	—	— —	Variable at different levels.	Oxygen depletion from poor ventilation and absorption, or chemical consumption of oxygen.	Oxygen deficiency indicator.
Ozone	O_3	Irritant and poisonous. Strong electrical odor. Strong oxidizer. Colorless. At 1 ppm, strong sulfur-like odor.	1.66	Max. naturally occurring level is 0.04 ppm. 0.05 ppm causes irritation of eyes and nose. 1 to 10 ppm causes headache, nausea; can cause coma. Symptoms similar to radiation damage.	0.08	0.04	— —	Near bottom.	Where ozone is used for disinfection.	Detectable odor at 0.015 ppm.

Table C-1 Hazardous Gases (Continued)

Gas	Chemical Formula	Common Properties	Specific Gravity or Vapor Density Air =1	Physiological Effect	Max Safe 60 Min. Exposure ppm	Max. Safe 8 Hour Exposure ppm	Explosive Range (% by vol. in air) Limits lower/upper	Likely Location of Highest Concentration	Most Common Sources	Simplest and Cheapest Safe Method of Testing
Sludge Gas	—***	Mostly a simple asphyxiant. May be practically odorless, tasteless.	Variable	Will not support life.	No data. Would vary widely with composition.		5.3 19.3	Near top of structure.	From digestion of sludge.	See components.
Sulfur Dioxide	SO_2	Colorless, pungent odor. Suffocating, corrosive, poisonous, non-flammable.	2.26	Inflammation of the eyes. 400 to 500 ppm immediately fatal.	50 to 100	10	— —	At bottom, can combine with water to form sulfurous acid.	Industrial waste, combustion, common air pollutant.	Detectable taste and odor at low concentration.
Toluene	C_5H_{12} to C_9H_{20}	Colorless, benzene-like odor.	3.14	At 200-500 ppm, headache, nausea, bad taste, lassitude.	200	100	1.27 7.0	At bottom.	Solvent.	Combustible gas indicator.
Turpentine	$C_{10}H_{16}$	Colorless, Characteristic odor.	4.84	Eye irritation. Headache, dizziness, nausea, irritation of the kidneys.	—	100		At bottom.	Solvent, used in paint.	1. Detectable odor at low concentrations. 2.Combustible gas indicator.
Xylene	C_8H_{10}	Colorless, flammable	3.66	Narcotic in high concentrations. less toxic than benzene.	—	100	1.1 7.0	At bottom.	Solvent	Combustible gas indicator.

* Percentages shown represent volume of gas in air.
** For concentration over 0.3%.
***Mostly methane and carbon dioxide with small amounts of hydrogen, nitrogen, hydrogen sulfide, and oxygen; occasionally traces of carbon monoxide.

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Teledyne Isco One Year Limited Factory Service Warranty *

Teledyne Isco warrants covered products against failure due to faulty parts or workmanship for a period of one year (365 days) from their shipping date, or from the date of installation by an authorized Teledyne Isco Service Engineer, as may be appropriate.

During the warranty period, repairs, replacements, and labor shall be provided at no charge. Teledyne Isco's liability is strictly limited to repair and/or replacement, at Teledyne Isco's sole discretion.

Failure of expendable items (e.g., charts, ribbon, tubing, lamps, glassware, seals, filters, fittings, and wetted parts of valves), or from normal wear, accident, misuse, corrosion, or lack of proper maintenance, is not covered. Teledyne Isco assumes no liability for any consequential damages.

This warranty does not cover loss, damage, or defects resulting from transportation between the customer's facility and the repair facility.

Teledyne Isco specifically disclaims any warranty of merchantability or fitness for a particular purpose.

This warranty applies only to products sold under the Teledyne Isco trademark and is made in lieu of any other warranty, written or expressed.

No items may be returned for warranty service without a return authorization number issued from Teledyne Isco.

The warrantor is Teledyne Isco, Inc.
4700 Superior, Lincoln, NE 68504, U.S.A.

*** This warranty applies to the USA and countries where Teledyne Isco Inc. does not have an authorized dealer. Customers in countries outside the USA, where Teledyne Isco has an authorized dealer, should contact their Teledyne Isco dealer for warranty service.**

In the event of instrument problems, always contact the Teledyne Isco Service Department, as problems can often be diagnosed and corrected without requiring an on-site visit. In the U.S.A., contact Teledyne Isco Service at the numbers listed below. International customers should contact their local Teledyne Isco agent or Teledyne Isco International Customer Service.

Return Authorization

A return authorization number must be issued prior to shipping. Following authorization, Teledyne Isco will pay for surface transportation (excluding packing/crating) both ways for 30 days from the beginning of the warranty period. After 30 days, expense for warranty shipments will be the responsibility of the customer.

Shipping Address: Teledyne Isco, Inc. - Attention Repair Service
4700 Superior Street
Lincoln NE 68504 USA

Mailing address: Teledyne Isco, Inc.
PO Box 82531
Lincoln NE 68501 USA

Phone: Repair service: (800)775-2965 (lab instruments)
(800)228-4373 (samplers & flow meters)
Sales & General Information (800)228-4373 (USA & Canada)

Fax: (402) 465-3001

Email: iscoservice@teledyne.com **Web site:** www.isco.com

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