3020 Submerged Probe Flow Transmitter

Installation and Operation Guide

TELEDYNE ISCO
A Teledyne Technologies Company

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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.

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3020 Flow Transmitter

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3020 Flow Transmitter

Section 1 Introduction

The first section of the 3020 instruction manual provides a general introduction to the flow meter. It includes a brief discussion of the organization of the manual, an overall description of the flow transmitter, and technical specifications.

1.1 Manual Organization

The purpose of this manual is to provide the user with the information necessary to operate, maintain, and service the 3020 Submerged Probe Flow Transmitter. To accomplish this, the manual is organized into five sections. The first section is a general introduction to the flow transmitter. The second section contains information on operation, programming the flow transmitter, and operating examples. The third section provides installation details. The fourth section describes available options and their uses. The fifth section contains information on routine maintenance and servicing to assist the user in correcting problems that may occur.

1.2 Description

The 3020, shown in Figure 1-1, uses a submerged probe for level measurement. The flow transmitter will normally be used with some type of primary measuring device to measure flow in an open channel. The 3020 uses level-to-flow rate conversions derived from stored equations, which cover the vast majority of open channel flow measurement situations. Also, the user may enter the coefficients and powers of the flow equation. However, most standard weirs and flumes are accommodated without the need for this equation.

Figure 1-1 3020 Flow Transmitter

Programming the 3020 is done in two ways:

- Select the number of a choice listed on the flow transmitter front panel label and enter that number on the keypad
- Enter a numeric value for steps requiring a value be selected from a given range.

A six-digit LCD (Liquid Crystal Display) prompts the user through setup, displays the choice for the current programming step, and displays level and flow rate.

1.3 Associated Equipment

The 3020 Flow Transmitter may be used with the following equipment:

Interfacing

- 3700 and 6700 Series Portable and Refrigerated Samplers
- GLS Compact Portable Sampler
- Glacier Refrigerated Compact Sampler
- 2410 Circular Chart Recorder

Optional Accessories

- *Resettable* 7-digit mechanical flow totalizer. (A non-resettable flow totalizer is a standard feature of the 3020.)
- High-Low Alarm Relay Box
- Extension Cables for the submerged probe in lengths of 25 and 50 feet. (7,6-15,2 m)
- Quick-Disconnect Box
  Allows probe installation up to 1000 feet (304,8 m) from flow transmitter.
- Expansion rings and extension plates for mounting probe
- Remote Totalizer
- Flow Transmitter-to-Sampler Connect Cable

1.4 The Submerged Probe

The submerged probe, used by the 3020 Flow Transmitter as a level sensor, is shown in Figure 1-2, and is mounted in the flow stream. It measures liquid level by sensing changes in hydrostatic pressure as level increases or decreases above it. The submerged probe consists of a differential IC (integrated circuit) pressure transducer mounted inside the probe assembly and a shielded cable, which connects the submerged probe to an encapsulated electronics package containing an amplifier. The probe body contains several ports which carry the hydrostatic pressure of the flow stream directly to the transducer surface.

The cable contains not only the power and signal wires, but also a hollow vent tube which serves to reference the differential port of the pressure transducer to atmospheric pressure. A ground wire in the cable keeps the flow transmitter ground and the grounding point of the submerged probe at the same electric potential. Circuitry inside the 3020 converts pressure changes sensed by the submerged probe into level and flow rate.

Figure 1-2 Submerged Probe Level Sensor (shown with standard tip)

1.5 Labels

Adhesive labels are provided with the 3020 to allow the display and the mechanical totalizer to express values which are greater than the number of digits available in the unit. Where extremely large flow volumes are involved, trailing zeroes may be added to the display to make more meaningful numbers. Labels for units of measure are also provided to serve as a visual reminder for what units of measure the 3020 was programmed.

⚠ CAUTION

If the submerged probe is disassembled for cleaning, do not touch the exposed stainless steel diaphragm inside the probe with either fingers or instruments. The transducer, mounted behind the diaphragm in silicone oil, is fragile. The diaphragm is made from very thin material (0.003” thick). Deforming it even slightly may cause a permanent offset to be placed on the transducer, or may damage or break the chip bonding wires, ruining the transducer. Flush the stainless steel diaphragm with gently running water only.

☑ Note

Various accessories for use with the 3020 Flow Transmitter, such as connect cables, etc., are mentioned throughout this manual. The part numbers for these items are listed on an Accessory Parts List, which will be found at the back of the manual. Part numbers for other equipment may be obtained from the factory.

1.6 Controls, Indicators, and Terminal Blocks

The controls, indicators, and terminal blocks of the 3020 Flow Transmitter are listed in Table 1-1, and their functions are briefly described. Refer to Figure 1-3 for a view of the controls and indicators, and Figure 1-4 for a view of the connectors.

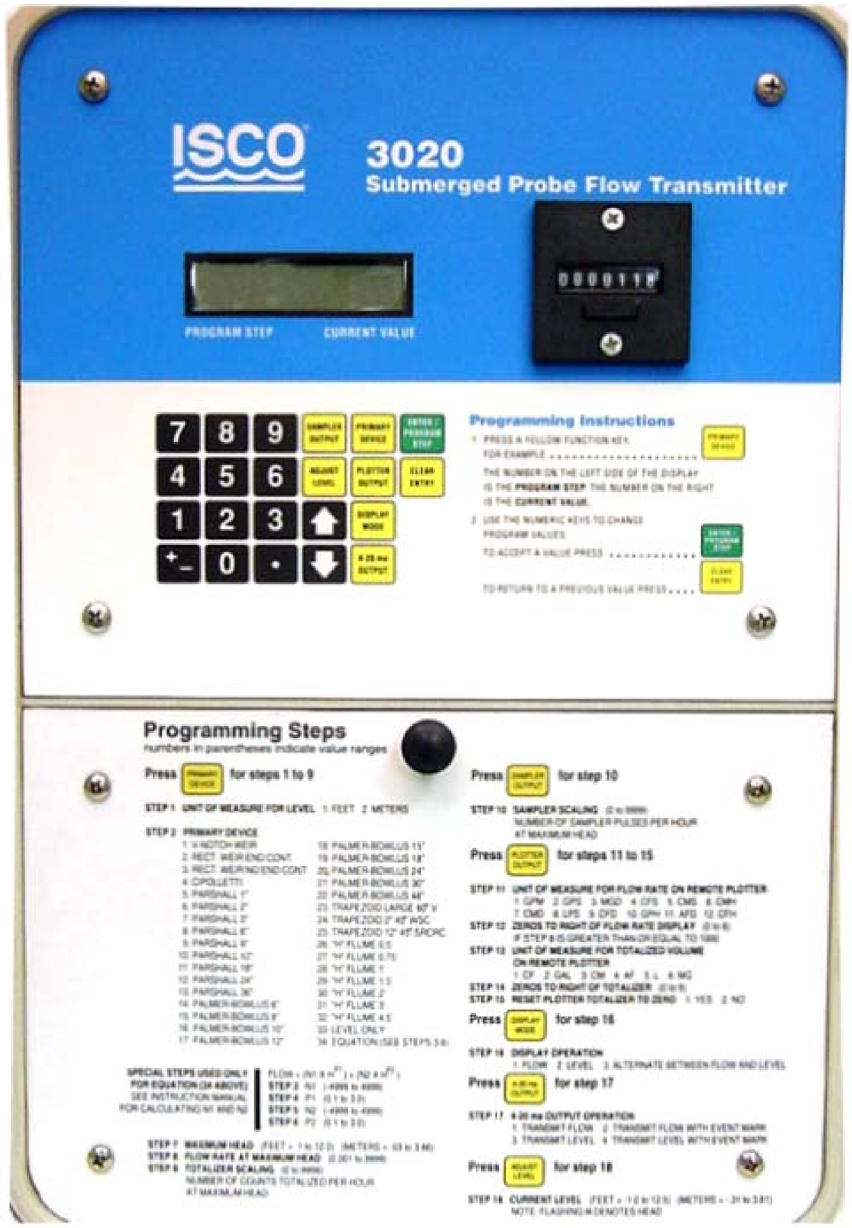


Figure 1-3 3020 Control Panel

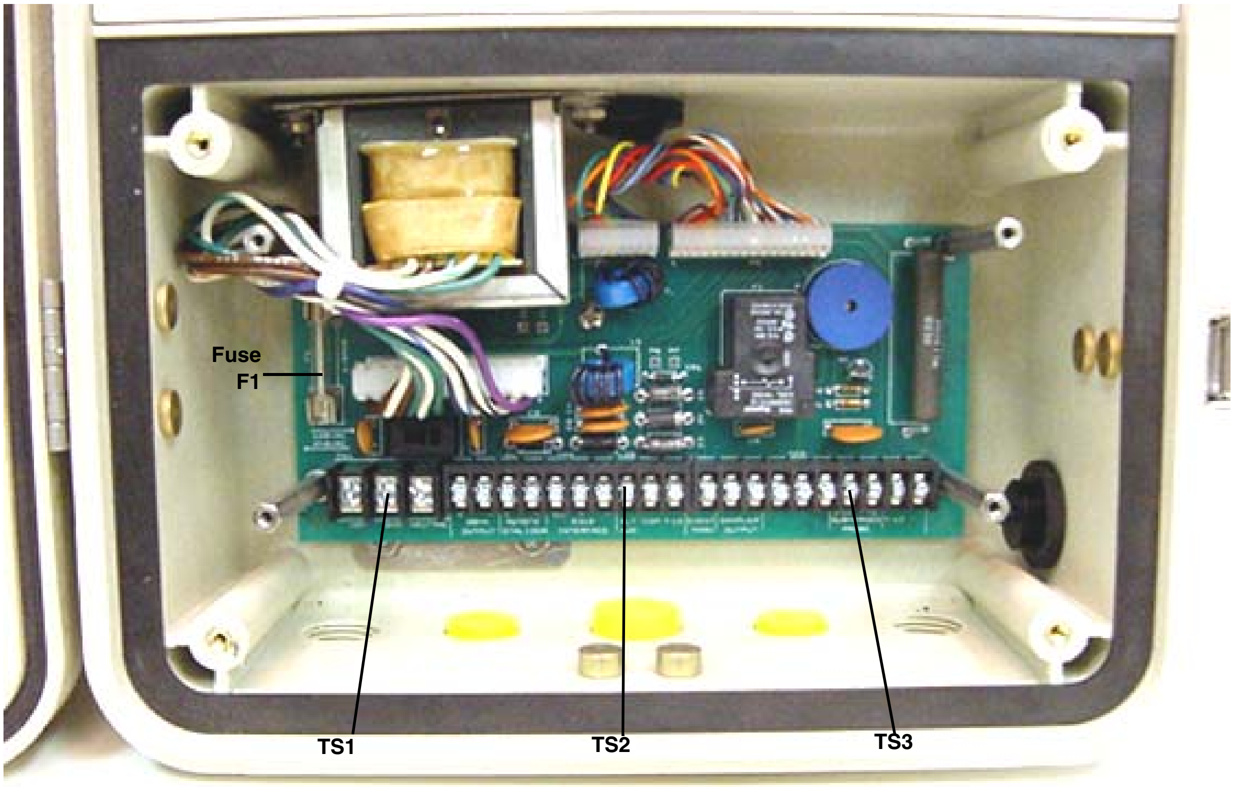


Figure 1-4 3020 Interior, Terminal Blocks

Table 1-1 3020 Controls, Indicators, and Terminal Blocks

Controls		Function
Keypad		22-Key, 6-column matrix. User programs flow transmitter through series of keystrokes prompted by messages on the display.
Indicators		**Function**
Display		6-digit, 7-segment liquid crystal display (LCD). Prompts user through program setup; displays current menu selections, displays level.
Terminal Blocks	**Type**	**Function**
Power	3 #8 screws on Block TS1 **Large** Terminals 1, 2, and 3	Connects 120/240 VAC power to flow transmitter. #1 = Hot. #2 = Ground. #3 = Neutral.
4-20 mA Output	2 #6 Screws on Block TS2 Terminals 4 and 5	Provides standard 4-20 mA current loop output (variable with level or flow rate) to be used to control compatible equipment such as a chart recorder or a chlorinator.
Remote Totalizer	2 #6 screws on Block TS2 Terminals 6 and 7	Connects flow transmitter to external mechanical remote totalizer.

Table 1-1 3020 Controls, Indicators, and Terminal Blocks (Continued)		
2312 Interface	3 #6 screws on Block TS2 Terminals 8 (data), 9 (+), and 10(-)	Originally for connecting the 3020 to the Model 2312 strip chart plotter (obsolete). Currently used for connecting to other external serial devices or an alarm relay box.
Bottle Number (BLT)	2 #6 screws on Block TS2 Terminals 11 (bottle #) and 12 (common)	Provides bottle number input signal to flow transmitter from an Isco automatic wastewater sampler.
Event Mark	2 #6 screws on Block TS 2 Terminal 13: +12 VDC Terminal 14: Event Mark	Provides Event Mark input signal to flow transmitter from an Isco Wastewater Sampler.
Sampler Output	2 #6 screws on Block TS3 Terminal 15: } Sampler Out Terminal 16:	Provides flow pulse from flow transmitter to enable/flow pace an Isco sampler.
Submerged Probe Level Sensor	4 #6 screws on Block TS3 Terminal 20: + In (white) Terminal 21: - In (black) Terminal 22: + 12V (red) Terminal 23: - (green and shield)	Provides connection for submerged probe. The probe reference port requires venting to atmospheric pressure either at flow transmitter or quick-disconnect box.Connects submerged probe to flow transmitter.

1.7 Technical Specifications

The technical specifications for the 3020 Flow Transmitter and 3222 Submerged Probes are found in Tables 1-2 and 1-3.

Table 1-2 3020 Flow Transmitter Technical Specifications	
Size (Height x Width x Depth)	$15^{1}/4$” x $10^{5}/8$” x $7^{3}/8$ (38.7 cm x 27 cm x 18.7 cm)
Weight	10 pounds (4.5 kg)
Material	High-impact molded polystyrene structural foam.
Type	Self-certified NEMA 4X enclosure.
Power	104-127 VAC, 0.075 Amp., 50 - 60 Hz
Overcurrent Protection	$^{1}/2$ Amp. slow-blow fuse
Display Type	6 character, 7 segment, alphanumeric backlit liquid crystal.
Display Modes	Level, flow rate, and alternate between level and flow rate.
Built-in Level-to-Flow Rate Conversions	Weirs: V-notch, Rectangular with and without end contractions, Cipolletti. Flumes: Parshall, Palmer-Bowlus, Trapezoidal, “H”. Equation: Two term power equation.
Level-to-Flow Conversion Accuracy	1% of full scale
Sampler Output	Isolated contact closure, rated 1 Amp. at 48 VDC.
Sampler Input	Event marks, bottle numbers.
Analog Output	Isolated 4-20 mA into 0 to 1,000 ohms; level or flow rate, with or without sampler event marks. Accuracy: 1% of full scale.
Serial Data Port	Compatible with Isco Model 2312 Plotter (no longer sold) and High-Low Alarm Relay Box.
Compatible Isco Recording Device	2410 Circular Chart Recorder, 2312 Plotter (no longer sold)
Totalizer	7 digit mechanical counter, non-resettable

Table 1-2 3020 Flow Transmitter Technical Specifications (Continued)	
External Totalizer Output	12 VDC pulse
Operating Temperature	- 20° F to 140° F (- 30°C to 65° C)
Storage Temperature	- 50° F to 150° F (- 60° C to 65° C)

Table 1-3 3222 Submerged Probe Technical Specifications	
Physical Specifications	
Dimensions	7⁄8" diameter × 9½" long (2.2 × 24.1 cm).
Weight	3 lb (including amplifier box and cable) (1.4 kg).
Body Material	CPVC (chlorinated polyvinyl chloride) housing, stainless steel.
Cable Length	Standard Sensor: 25 ft. (7.6 m).
Operating Temperature	32° to 160°F (0° to 71°C).
Storage Temperature	–40° to 160°F (–40° to 71°C).
Maximum Distances (between flow meter and level sensor)	Standard Sensor: 75 feet (22.7 m) with optional extension cables. 1,000 feet (305 m) with optional Quick-Disconnect Box.
Level Measurement Specifications	
Measurement Range	Standard Sensor 0.1 to 10.0 ft. (0.03 to 3.05 meters).
Maximum Level	Standard Sensor: 20.0 ft. (6.1 m).
Measurement Accuracy	0.033 to 5.0 ft: ±0.008 ft/ft (0.01 to 1.52 m: ±0.008 m/m) >5.0 ft: ± 0.012 ft/ft (>1.52 m: ±0.012 m/m) @ 77° F (25° C). Includes non-linearity, repeatability, and hysteresis, but does not include temperature coefficient.
Compensated Temperature Range	32° to 122°F (0° to 50° C).
Temperature Error (over compensated temperature range)	0.1 to 4.0 ft. (0.03 to 1.2 m) ±0.005 ft. per degree F 4.0 to 10.0 ft. (1.2 to 3.1 m) ±0.007 ft. per degree F

3020 Flow Transmitter

Section 2 Operation and Programming

This section of the manual contains detailed information on the operation, controls and indicators, programming, and set up procedures for the flow transmitter. Operating examples are also provided.

2.1 Theory of Operation

2.1.1 3020 Transmitter

Following is a description of the overall operating theory of the flow transmitter. When measuring flow rate, the 3020 is normally used with a primary measuring device (weir or flume) or other open channel flow arrangement where a known relationship exists between level and flow rate. The level measuring device is a submerged probe which measures the liquid level in the flow stream. The flow transmitter electronically converts the level reading into a properly-scaled flow rate value. The flow transmitter also provides standard flow-related output signals to be used for:

- Flow-proportional sampler pacing.
- Recording flow rate information on an external printer/plotter or circular chart recorder.
- Connection to a 4-20 mA compatible device.

The flow transmitter contains microprocessor-controlled circuitry to make the computations necessary to calculate level and flow rates from the signals produced by the ultrasonic level sensor, store programming instructions from the user, and operate the display. A backlit alphanumeric liquid crystal display (LCD) is provided both to show level and flow rate information, and to prompt the user in programming the flow transmitter during initial set up or subsequent program changes. Other equipment which may be used with the 3020 connects to the barrier blocks mounted on the power supply board in the bottom section of the flow transmitter's case.

2.1.2 The Submerged Probe

The submerged probe is mounted in the flow stream and measures liquid level by changing output in response to changes in hydrostatic pressure placed on the submerged probe's transducer by the flow stream. The submerged probe consists of an enclosure which contains an IC (integrated circuit) differential pressure transducer. This transducer provides an output signal which changes proportionally to the pressure placed against it by the flow stream.

2.1.3 Transducer Operation

The transducer in the submerged probe contains a resistance bridge on a thin silicon diaphragm. Pressure against one side of this diaphragm causes it to flex slightly. This flexing causes the resistors on one side of the bridge to stretch slightly, while the resistors on the other side of the bridge compress slightly. The result is an unbalance in the current across the bridge, which is proportional to the increase of hydrostatic pressure caused by an increase in level of the flow stream. This bridge is fed from a constant-voltage source, therefore, the output voltage changes.

2.1.4 Amplifier

The output from the transducer is quite low and the impedance is high, so an amplifier is provided to boost the signal so that it will still be usable by the flow transmitter even when extension cables are used with the transducer. This amplifier is encapsulated in the plastic box mounted near the connector end of the submerged probe's cable.

2.2 Controls and Indicators

The controls of the 3020 Flow Transmitter are shown in Figure 1-3. The operation and use of the keypad are described in detail in the following sections. Access to the keypad is possible only when the door is opened. The LCD and totalizer are visible through the window in the front door of the cabinet.

2.2.1 Keypad Layout and Functions

The keypad is mounted in the middle of the left side of the 3020 front panel. It is visible when the cabinet door is closed. The keypad has 23 keys arranged in six vertical columns. The function of each key is as follows:

↓ (ARROW DOWN) - This key is used in the LEVEL ADJUST step of the program; it can be used in place of the number keys to decrease the level shown on the display.

↑ (ARROW UP) - This key is used in combination with the display in the LEVEL ADJUST step of the program; it can be used instead of the number keys to increase the level shown on the display.

CLEAR ENTRY - This key provides the user with a way to return to a previous entry of a program step. NOTE: Pressing the key twice in succession allows the user to exit the program.

. (DECIMAL) - This key is used with the number keys when entering numeric values into the program.

ENTER/PROGRAM STEP - Pressing this key will allow the user to enter changes made to the program into memory. To access the program it is first necessary to press one of the yellow FUNCTION KEYS. Pressing one of the yellow FUNCTION KEYS stops the program and allows the user to make changes. After the change is made and appears on the display, pressing ENTER/PROGRAM STEP will cause the change to be entered to the flow transmitter's memory. It is also possible to step through the program held in memory by pressing this key. The number of the program step will appear on the left side of the display and the number of the current selection (or value entered) will be shown.

NUMBER KEYS - The number keys are used to enter numeric values into the program. They may also be used to make a selection from the options displayed on the label.

+/- (PLUS OR MINUS) - This key is used to enter positive or negative numbers when programming an equation.

Yellow FUNCTION KEYS - These keys are used to enter the program of the 3020 at various points of the programming sequence so the user may enter or change menu selections or numerical values. Since these keys are tied to specific programming steps of the flow transmitter, they need not be described individually here. Refer to Section 2.3.3 for the detailed descriptions of the program steps.

2.2.2 Display

The flow transmitter display shows programming choices made by the user and, after programming and installation are complete, displays the current flow rate and/or level. That is, there are three operating modes for the display; level, flow rate, or an alternation between level and flow rate. The display may be viewed through the window of the flow transmitter's cabinet when the door is closed. The display is a six digit, seven segment, backlit liquid crystal. The letter H on the left side of the display indicates level (or Head). For improved legibility in low light conditions, the LCD is backlit.

2.2.3 Power Failures

If there is a power failure, the LCD will go blank and the flow transmitter will cease operation. Momentary power failures (less than three seconds) should not affect the operation of the unit, as power stored in the filter capacitors will provide some carry-over for a brief period of outage. However, if power is off long enough for the display to go blank, flow pulses to the sampler will stop, as will the mechanical totalizer and the totalizer signal sent to an external 2312 Plotter (if used), which will be reset. The unit will be unable to recognize changes in level during the time power is off. However, the program selections made during setup will be retained, and when power is restored, it will not be necessary to reprogram the flow transmitter. The flow transmitter's program is stored in memory.

2.3 Programming

The 3020 Flow Transmitter is programmed with the aid of the display. The keypad is used to enter program quantities and to control certain flow transmitter functions. The display is used to show selections chosen. (The number of the selected entry will show on the display.) The display also indicates operational status, and guides the user through the flow transmitter programming sequence by showing the step being programmed. Each time a key is pressed an audible signal is emitted. Refer to Figure 2-1 for a simplified flowchart showing the programming procedure. At the back of this manual is a worksheet on which program selections may be written.

2.3.1 Programming Overview

First, the user should remember that the flow transmitter always has a program stored in memory, even if it is only the default program installed at the factory. In programming the

3020, first select one of the yellow FUNCTION KEYS and press it. The display will show the step number on the left and the number of the choice currently selected (or the numerical value entered for steps requiring a value) on the right. Not all steps will be used in programming. For example, if there is no remote plotter, Steps 11-15, which are involved with operation of the plotter, will be skipped.

The program steps are printed on the flow transmitter label, and normally programming proceeds in a logical manner, starting with Step 1, which selects the units used for level measurement, feet or meters. Step 2 is the selection of the primary measuring device. Then maximum head, flow rate at maximum head, and totalizer scaling are selected. If no other equipment is used with the 3020, only Step 16, DISPLAY OPERATION, and Step 18, LEVEL ADJUST, must be programmed. Then the LEVEL ADJUST step is used to calibrate the ultrasonic level sensor.

Programming in Steps 10 through 15 and 17 occurs when the flow transmitter is used with other equipment. Step 10 governs the relationship between the flow transmitter and an associated wastewater sampler. Steps 11 - 15 control the output to an Isco High-Low Alarm Relay Box (a device to turn equipment on or off when flow reaches or falls below preset levels), or a 2312. The 2312 is an electro-mechanical printer which records level or flow information from the 3020 on a strip chart to provide a hard copy of information measured by the flow transmitter. The 2312 printer is no longer sold by Teledyne Isco.

Step 17 determines the operation of the 4-20 mA current loop output. Examples of equipment which would be connected to the 4-20 mA current loop are the Isco 2410 Circular Chart Recorder or process equipment, such as a chlorinator.

If the flow transmitter is already installed and has been programmed, it is not necessary to completely re-program the unit to enter any changes. Instead, simply select the yellow FUNCTION KEY where the change needs to be made and press ENTER/PROGRAM STEP until the desired step is reached; then enter the change.

Automatic Program Advance – After the ENTER/PROGRAM STEP key has been pressed, the display will automatically advance to the next step and show the current choice or value entered for that step; the process continues until the user has made selections for all steps necessary to complete the yellow FUNCTION KEY selected, or presses the CLEAR ENTRY key twice to exit the program.

All programming for the 3020 can be done in the shop, except for the ADJUST LEVEL step, which must be done at the job site.

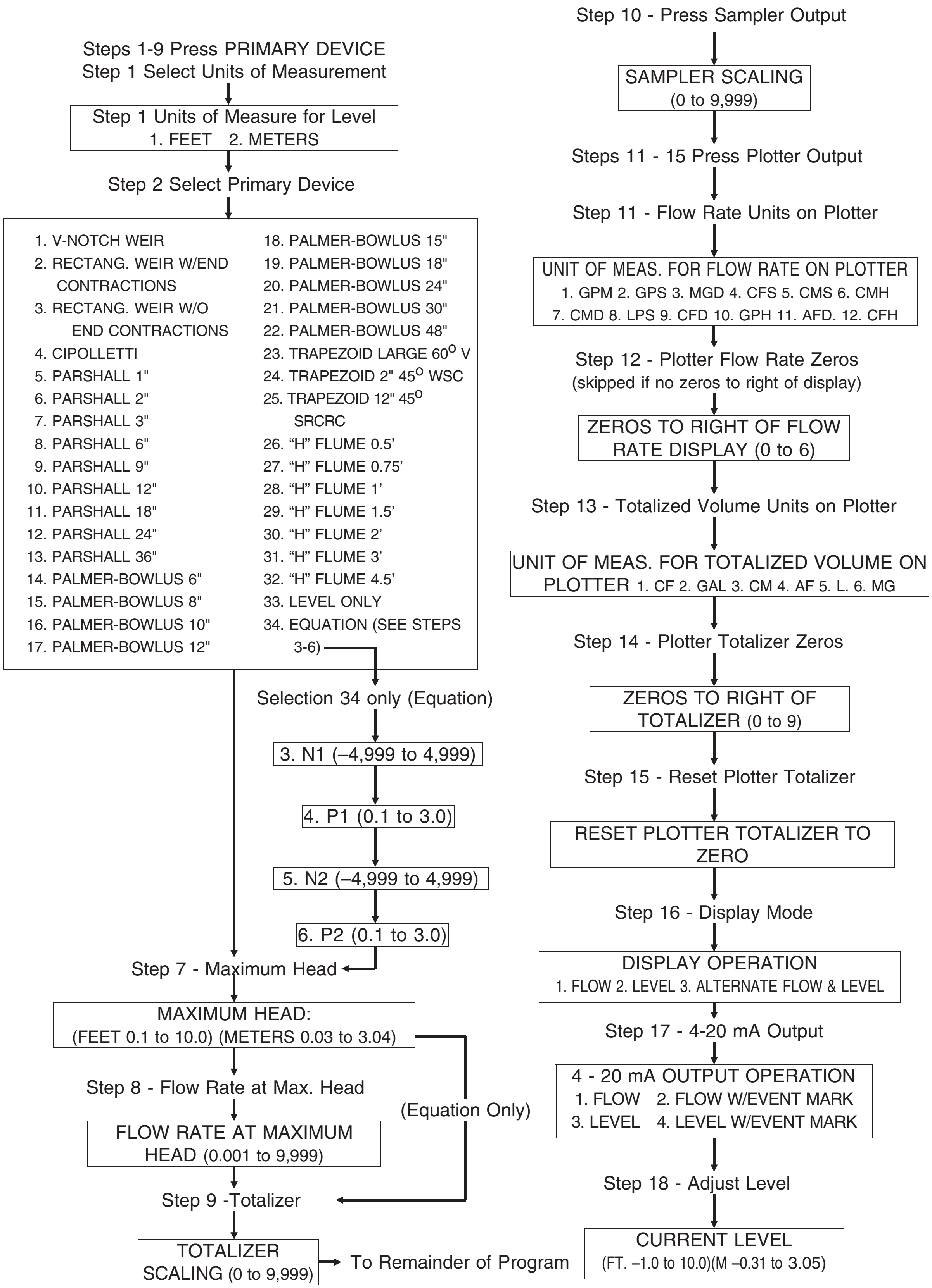


Figure 2-1 Simplified Flowchart Programming Flowchart for the 3020

2.3.2 List of Program Steps

Following is a list of the program steps used in the 3020 along with the choices available or applicable range of values. Following the list is a detailed explanation of the purpose for each step and the choices offered.

1. Select Units of level measurement. 1. Feet 2. Meters
2. Primary Device. (See list of devices above or refer to front panel label.)

> **☑ Note**
> Steps 2 - 5 are programmed only if #34, Equation, is chosen in Step 1.

3. N1 (-4,999 to 4,999)
4. P1 (0.1 to 3.0)
5. N2 (-4,999 to 4,999)
6. P2 (0.1 to 3.0)
7. Maximum Head in Feet (0.1 to 12.0)
8. Flow Rate at Maximum Head (0.001 to 9999)
9. Totalizer Scaling (Number of counts totalized per hour of flow at maximum head; 0-9,999.)

> **☑ Note**
> Step 10 is programmed only if the flow transmitter is connected to a sampler.

10. Sampler Scaling (Number of sampler pulses per hour at maximum head; 0-9,999.)

> **☑ Note**
> Steps 11 to 15 are programmed only if an Isco 2312 Plotter is installed.

11. Unit of Measure for Flow Rate on Remote Plotter
    1. GPM 2. GPS 3. MGD4. CFS 5. CMS 6. CMH
    7. CMD 8. LPS 9. CFD 10. GPH 11. AFD 12. CFH
12. Zeros to Right of Flow Rate Display (0 to 6) if value of Step 7 is $\geq$ 1000
13. Unit of Measure for Totalized Volume on Remote Plotter
    1. CF 2. GAL 3. CM 4. AF 5. L 6. MG
14. Zeros to Right of Totalizer (0 to 9)
15. Reset Plotter Totalizer to Zero (1.Yes 2. No)
16. Display Operation (1. Flow rate 2. Level 3. Alternate between the flow and level.)

☑ Note

Step 17 is programmed only if the 3020 is connected to external equipment which operates with the standard 4-20 mA current loop.

17. 4-20 mA Output Operation (level, flow rate, with or without event mark.)

    1. Transmit Flow Rate 2. Transmit Flow Rate with Event Mark 3. Transmit Level 4. Transmit Level with Event Mark

18. Adjust Level - Current Level in: (Feet -1.0 to 12.5) (Meters -0.31 to 3.81.)

2.3.3 Description of Program Steps

Following is an explanation for the program steps from the list above.

Step 1 – In the first step of the program, select the units used for level measurement, feet or meters.

Step 2 – In the second step of the programming sequence, identify the primary measuring device used; then choose the number referring to that device from the list printed on the label or in the table on the next page. Thirty-two common primary measuring devices are supported by the 3020. If the flow transmitter is used to measure level only, select #33. If an equation is to be used, select #34, and continue as follows.

Steps 3 - 6 – These steps will only appear on the display and be used when #34, Equation, is selected and allow the user to program the values N1, P1, N2, and P2 for the general flow equation:

$$Q(\text{flowrate}) = K \times (N1 \times H^{P1} + N2 \times H^{P2})$$

(See Section 2.4.3 for a detailed discussion about the equation.) With any choice but #34 in Step 2, the program advances automatically to Step 7.

Step 7 - MAXIMUM HEAD – The flow transmitter will request entry of a value for MAXIMUM HEAD. The flow transmitter will display the value already in memory. Possible values entered here will range from 0.1 to 12 feet (0.03 - 3.7 m). Always select a value for maximum head which is reasonable for your particular application, rather than the maximum value allowable, as the accuracy of the level-to-flow rate conversion will be based on this value.

Step 8 – Step 8 requests entry of flow rate at maximum head. Values range from of 0.001 to 9,999. Remember to base the flow rate at maximum head on the value you entered in Step 7, rather than the maximum head allowable for the device. This information is available from the manufacturer of the primary measuring device used. The information is also available from tables published for specific devices in the *Isco Open Channel Flow Measurement Handbook*.

If the value you must enter is greater than 9,999, you must round it off and reduce it to a number which can be displayed by the flow transmitter. For example 32,537 GPM is greater than the four digits available on the display. So, first we round the number to 32,540 and then enter the four most significant digits into the flow transmitter: 3 - 2 - 5 - 4. To show the overflow from the display we attach a **0** label to the right of the display to indicate the value displayed is in tens of gallons rather than gallons. Finally, attach a label for the appropriate units, in this case, **GPM**.

If the installation includes a 2312 Plotter, these same flow rate units will be entered in Step 11 and the number of zeroes will be entered in Step 12. For the example of 32,537 GPM, you would enter 1 (GPM) in Step 11 and 1 in Step 12.

Step 9 – The flow transmitter will ask for scaling for the flow totalizer. This is the number of counts on the totalizer per hour of flow at maximum head. The value entered ranges from 0 to 9,999. The selection of the number of counts per hour is based on flow at maximum head, so the actual number of counts may be much lower.

If the installation includes a 2312 Plotter, the units of measure selected for this step will also be entered for the 2312 in Step 13 and the number of zeroes in Step 14. For example, if you want to totalize in cubic feet and the flow rate at maximum head is 72.5 CFS:

72.5 CFS x 60 sec./min. x 60 min./hr. = 261,000 cubic feet per hour (CFH)

For this example, each count on the totalizer equals 1,000 cubic feet.

261,000 CFH ÷ 1,000 CF/count = 261 counts per hour

You would then enter 2 - 6 - 1 for this step. In this instance you would place three **0** labels and the **CF** label to the right of the display. If the 3020 is connected to a 2312, you would then enter 1 (CF) in Step 13 and 3 in Step 14.

Step 10 – The flow transmitter requests selection of sampler scaling (flow pulses to the sampler). This step need not be programmed unless the 3020 is being used with an associated wastewater sampler. The purpose of this program step is to provide signals to the associated sampler to take flow-paced samples. The range is from 0 to 9,999 pulses per hour. The number is determined in the same way as in Step 9, above. Selection of the number of flow pulses to the sampler per hour is based on flow rate at maximum head, so the actual number of pulses per hour may be considerably lower. The number chosen should be determined by the volume of flow that must pass through the primary device before a sample is taken, rather than a particular interval of time.

For example, assume the flow rate at maximum head for a particular installation is 32,540 GPM.

32,540 GPM x 60 min./hr. = 1,952,400 gallons/hour (GPH)

We want to send a flow pulse to the associated wastewater sampler every 10,000 gallons.

1,952,400 GPH ÷ 10,000 gallons/pulse = 195 pulses/hour

You would then enter 1 - 9 - 5. If the associated wastewater sampler is programmed to take a sample every 50 pulses, it will be taking a sample every 500,000 gallons.

10,000 gallons /pulse x 50 pulses per sample = 500,000 gallons/sample

If the sampler is programmed to take a sample every 200 pulses, it will be taking a sample every 2,000,000 gallons.

10,000 gallons/pulse x 200 pulses per sample = 2,000,000 gallons/sample

Steps 11 to 15 – Plotter Output - These steps need to be programmed only if the 3020 is used with an Isco 2312 Plotter. Selections made in Steps 11 - 15 will determine the operation of the 2312. The selections made here do not affect the way the 3020 operates. However, values chosen should be consistent with choices made for earlier steps.

Step 11 – Units of Measure for Flow Rate on Remote Plotter - Several selections for units-of-measure are provided here, which will be the units printed out on the chart of the 2312. Units selected should be the same as selected for Step 8.

Step 12 – Zeros to the Right of the Flow Rate Display (0 to 6) - This step is programmed with the number of zeroes overflowing the display from the value entered in Step 8. The remote plotter displays flow rate with scientific notation. For example, a plotter display of 5.57E+3 would equal 5.57×10^3, which is the same as 5.57 x 1,000 and that is 5,570.

Step 13 – Units of Measure for Totalized Volume on Remote Plotter - Again, selection is dependent on the units of measure selected for a previous step, in this case, Step 9.

Step 14 – Zeros to Right of Totalizer (0 to 9) - This step allows for the addition of the correct number of trailing zeros to be added to the plotter's totalizer to make meaningful numbers where large flow rates are involved. The number selected is the same as the number of zeroes overflowing the display in Step 9. Again, these are actually expressed on the plotter's display in terms of scientific notation, so there is no need to add stickers to the plotter's display.

Step 15 – Reset Plotter Totalizer to Zero - This step allows the user the option to reset the totalizer on the remote plotter. It does not affect the mechanical totalizer on the 3020. An example of where this might be used is studies of flow over specific periods of time. It might be convenient to reset the flow totalizer between each study. This is a user/application- determined option. The totalizer is reset whenever power is turned off.

Step 16 – Display Operation - This step offers the option of choosing the method of display which is most useful for a particular application. Choose between: **1. Flow Rate** or **2. Level** being displayed, or select **3. Alternate**, which will cause the display to switch between level and flow rate. This step defines the display when the flow transmitter is in normal operation. The appearance of the letter H on the left side of the display designates level (or Head).

Step 17 – 4-20 mA Output Operation - This step determines how associated external equipment connected to the 3020 through the 4-20 mA current loop will operate. The selection of **1. Flow Rate** and **3. Level** are user/application specified. The selections of **2. Flow Rate with Event Mark** and **4. Level with Event Mark** are specifically intended for use only with the Isco 2410 Circular Chart Recorder to indicate on the chart that an associated wastewater sampler has taken a sample.

⚠ CAUTION

Do not transmit level or flow rate with event marks to any equipment other than a circular or strip chart recorder. Transmission of event marks causes momentary jumps of the 4-20 mA loop current to 100% (full-scale) operation. This could cause erratic operation of some process control equipment and could possibly have hazardous consequences with certain equipment.

This output, which is a variable DC current of 4-20 mA, changes with the level or flow rate measured by the 3020: 4 mA = 0% flow or 0 level; 20 mA = 100% flow rate, full-scale, or maximum head. The 4-20 mA current output is an industrial control standard and is used to provide an analog (variable) signal reflecting changing levels or flow rates to related equipment which responds to the changing conditions measured by the flow transmitter. This operation can be compared to a lamp controlled by a dimmer. The lamp can burn at various levels of brightness between fully off and fully on. Contrast this with equipment controlled by being turned completely on or off.

Step 18 – Adjust Level - This step allows for the adjustment of displayed level in the 3020. There are various ways to calibrate the ultrasonic level sensor after it has been installed, depending on the device used. Then, measurement from the zero (level) point of the primary device to the surface of the flow stream is done, very carefully, to determine the level in the flow stream. Commonly this is done by using a measuring staff.

You may enter this level into the 3020 by adjusting the displayed level with the up and down arrow keys, or by entering the desired value with the numeric keys. The flashing letter **H** denotes head (level).

> ☑ **Note**
>
> If the flow transmitter shows negative level or flow rate during initial setup and displays codes with EE on the left side of the display, the level should be adjusted (Step 18) to a positive value and then answer all the questions associated with selecting a primary device. This should stabilize the display.

2.3.4 Equations Used in Flow Conversion

The equations used in the flow conversions built into the 3020 Flow Transmitter are shown in Table 2-1. For those primary devices for which the flow conversions consist of data only (Palmer-Bowlus flumes, "H" flumes, and Trapezoidal flumes), the equations used are approximations which fit the manufacturer's listed data within 1% of full-scale flow rate. If you desire to use level-to-flow rate conversions other than those built into the flow transmitter, #34, equation should be selected in Step 1. Section 2.4.3 has a discussion of the use of the equation followed by two programming examples, including a rectangular weir with end contractions.

2.3.5 Default Program

You will program the flow transmitter with selections from the menus appropriate to your particular installation. When the flow transmitter is shipped, there is already a default program in memory, which was used to test the unit. Understand that this is only an example program to allow testing of the unit as it is manufactured. It is not intended to fit any particular application.

Table 2-1 Equations Used in the 3020

Type and # of Device	Flow Equation
1. V-Notch Weir	$Q = KH^{2.5}$
2. Rectangular Weir with End Contractions	$Q = K(1.034H^{1.5} - 0.034H^{2.5})$ (see Section 2.4.3)
3. Rectangular Weir without End Contractions	$Q = KH^{1.5}$
4. Cipolletti Weir	$Q = KH^{1.5}$
5-13. Parshall Flume	
5. 1”	$Q = KH^{1.55}$
6. 2”	$Q = KH^{1.55}$
7. 3”	$Q = KH^{1.55}$
8. 6”	$Q = KH^{1.58}$
9. 9”	$Q = KH^{1.53}$
10. 12”	$Q = KH^{1.52}$
11. 18”	$Q = KH^{1.53}$
12. 24”	$Q = KH^{1.53}$
13. 36”	$Q = KH^{1.54}$
14-22. Palmer-Bowlus Flume	
14. 6”	$Q = KH^{1.9}$**
15. 8”	$Q = KH^{1.9}$
16. 10”	$Q = KH^{1.9}$
17. 12”	$Q = KH^{1.9}$
18. 15”	$Q = KH^{1.9}$
19. 18”	$Q = KH^{1.9}$
20. 24”	$Q = KH^{1.9}$
21. 30”	$Q = KH^{1.9}$
22. 48”	$Q = KH^{1.9}$
23-25. Trapezoidal Flume*	
23. Large 60° V	$Q = KH^{2.58}$**
24. 2” 45° WSC	$Q = KH^{2.32}$
25. 12” 45° SRCRC	$Q = KH^{2.29}$
26-32. “H” Flume	
26. 0.5’	$Q = KH^{2.31}$**
27. .75’	$Q = KH^{2.31}$
28. 1.0”	$Q = KH^{2.31}$
29. 1.5’	$Q = KH^{2.31}$
30. 2.0’	$Q = KH^{2.31}$
31. 3.0’	$Q = KH^{2.31}$
32. 4.5’	$Q = KH^{2.31}$

* Palmer-Bowlus and Trapezoidal Flumes manufactured by Plasti-Fab, Tualatin, Oregon.
**Flow equations for Palmer-Bowlus, “H,” and Trapezoidal Flumes are approximations that fit data within 1% of full-scale flow rate.

2.4 Programming Examples

In the following sections programming examples are described to show with keystroke entries how the 3020 Flow Transmitter is set up for proper operation in specific applications. When programming the flow transmitter, note that the number on the left side of the display is the PROGRAM STEP while the number on the right is the current value.

2.4.1 Programming for a Parshall Flume

In this example, we will go through the programming steps necessary to select a **6" Parshall flume** with a **maximum head of 1.5 feet**. Flow rate will be displayed in **GPM**. The flow rate at maximum head in GPM is **1754 GPM**. This value is available either from the manufacturer of the flume, or can be found in the *Isco Open Channel Flow Measurement Handbook*. The totalizer will be set to totalize in gallons, and the 4-20 mA output will be set up to transmit level with **100 percent** equal to **1.5 feet**. Assume that the level, which would be measured with a staff gauge or other measuring device, is **0.75 feet**. Attach the **GPM** sticker to the right of the display.

Calculations for example 1 – The totalizer will read out in **gallons**. To find the flow per hour at maximum head multiply the flow in GPM by 60 (1754 gallons per minute x 60 minutes per hour = **105,240** gallons per hour). The totalizer scaling value can only be a value from 0 to 9,999. Since 105,240 is larger than 9,999, we divide by 100 (105,240 ÷ 100 = 1,052).

1. Press PRIMARY DEVICE.
2. Select units of measure for level. To select feet, press 1.

1	1

Press ENTER.

3. Select the primary device from the list shown on the front panel. To select a 6-inch Parshall Flume, press 8.

2	8

Press ENTER.

4. Enter the maximum expected head in feet. For this example, press 1, (decimal), 5.

7	1.5

Press ENTER.

5. Enter the flow at maximum head, 1754 GPM. Press 1, 7, 5 4.

8 1754

Press ENTER. Place the "GPM" label to the right of the display.

6. To enter the totalizer scaling, calculated above, press 1, 0, 5, 2.

9 1052

Press ENTER.

The totalized flow in gallons would be the totalizer value x 100, so attach two "0" labels and the "GAL" label to the right of the display.

H XXXX	H is for Height (level).

7. Press the DISPLAY OPERATION key to set the display. Press 1.

16 1

Press ENTER.

XXXX	(Flow Rate)

8. Press the 4-20 MA OUTPUT key to select the information to transmit. For this example, we want to transmit level. To select "transmit level," press 3.

17 3

Press ENTER.

XXXX	(Flow Rate)

9. Press the ADJUST LEVEL key to set the current level in feet. To set the liquid level or head to 0.75 feet, press . (decimal) - 7 - 5.

H .75

The "H" will flash.

Press ENTER.

XXXX	(Flow Rate)

2.4.2 Programming for a Cipolletti Weir

In this example, we will go through the programming steps necessary to select a **10 foot Cipolletti weir** with a **maximum head of 2 feet**. Flow rate will be displayed in **GPM**. The flow rate at maximum head, found in the *Isco Open Channel Flow Measurement Handbook*, is **42,740 GPM**. The totalizer will totalize in cubic feet and a flow pulse will be sent to the sampler every 1,000 gallons. The plotter output will transmit flow rate units of **GPM** and flow units of **cubic feet**. The display will **alternate** between level and flow rate. The 4-20 mA output will be set up to transmit **flow rate with event marks**, with 100% equal to flow rate at maximum head. Assume the level, measured with a staff gauge or other measuring device, to be **1.5 feet**.

Calculations for Example 2 – The flow rate at maximum head, **42,740 GPM**, is larger than four digits. Divide by ten so that flow rate at maximum head is less than **9,999**. The value entered into the 3020 will then be only four digits long (42,740 ÷ 10 = 4,274). Place one **0** label and the **GPM** label to the right of the display.

For this example, the totalizer will be programmed to read out in cubic feet. To do this, find the total flow per hour at maximum head. The flow rate at maximum head in CFS is **95.23 CFS**. 95.23 CFS x 60 seconds per minute x 60 minutes per hour = **342,828 cubic feet per hour (CFH)**.

The number entered into the 3020 to totalize in cubic feet would be **3,428** (342,828 x 100 = 3,428), which is the above result rounded to four digits. Place two **0** labels and the **CF** label to the right of the totalizer. A flow pulse will be sent to the sampler every **1,000 gallons**. First, we must find the flow per hour of flow at maximum head. 42,740 GPM x 60 minutes per hour = **2,564,400 gallons per hour (GPH)**.

We want to send a flow pulse to the sampler every 1,000 gallons. 2,564,400 gallons per hour ÷ 1,000 gallons per flow pulse = **2,564 flow pulses per hour**. If the sampler is programmed to take a sample every 5,000 pulses, a sample will be taken every 5,000,000 gallons. (1,000 gallons per pulse x 5,000 pulses per sample = 5,000,000 gallons per sample.)

1. Press PRIMARY DEVICE.

2. Select units of measure for level. To select feet, press 1.

1	1

Press ENTER.

3. Select the correct primary device from the list shown on the front panel. To select a Cipolletti weir, press 4.

2	4

Press ENTER.

4. Enter the maximum head in feet that you expect to see at the primary measuring device. For this example, the maximum head is 2 feet. Press 2.

7	2

Press ENTER.

5. Enter the flow rate at maximum head. The value for this is 4,274, so press 4, 2, 7, 4.

8	4274

Press ENTER. The flow rate will be the value shown on the display times 10. Place a "0" label and the "GPM" label to the right of the display.

6. Enter the totalizer scaling. To totalize the flow in cubic feet, enter 3, 4, 2, 8.

9	2428

Press ENTER. The totalized flow in cubic feet will be the totalizer value x 100. Place two "0" labels and the "CF" label to the right of the totalizer.

XXXX	(Flow Rate)

7. Press SAMPLER OUTPUT to program sampler pacing. To enter the number calculated above, press 2, 5, 6, 4.

10 2564

Press ENTER.

XXXX

(Flow Rate)

8. Press PLOTTER to set up the output for the plotter. The first requirement is to select the units of flow rate displayed on the plotter. Press 1 to select GPM.

11	1

Press ENTER.

9. Enter the number of zeros to the right of the display for flow. Since the maximum flow rate was 4,274 in tens of gallons per minute and the actual flow was 42,740 GPM, there is one zero to the right of the display. Press 1.

12	1

Press ENTER.

10. The unit of measure for totalized flow was cubic feet, selection 1 on the front panel; press 1.

13	1

Press ENTER.

11. Totalized flow in Step 9 was hundreds of cubic feet. Since hundreds would have two zeros to the right of the totalizer, press 2.

14	2

Press ENTER.

12. To reset the totalizer on the remote plotter (Isco Model 2312) to 0, press 1.

```
15      1
```

Press ENTER.

```
XXXX
```

(Flow Rate)

13. Press DISPLAY. To alternate between level and flow rate, press 3.

```
16      3
```

Press ENTER.

```
XXXX
```

(Flow Rate)

```
H  XXXX
```

(H = Height, or level)

14. Press 4-20 MA OUTPUT to select the information transmitted.

To transmit flow rate with event mark, press 2.

```
17     2
```

Press ENTER.

```
XXXX
```

(Flow Rate)

15. Press ADJUST LEVEL to set the current level in feet. To set the liquid level to 1.5 feet, press 1, (decimal), 5.

```
H     1.5
```

The H will flash.

Press ENTER.

XXXX	(Flow Rate)

2.4.3 Programming with the Equation (Device #34)

This equation is used to calculate flow in applications where the standard devices programmed in the 3020 are not used. The special equation is also used with *rectangular weirs with end contractions* if a more accurate level-to-flow rate conversion than that programmed into the 3020 is required. When designing the 3020, the coefficients of the flow equation for the rectangular weir with end contractions were selected for a crest-to-maximum-head ratio of **2.5** to **1** (crest length divided by maximum head equals 2.5). This gives an equation equal to that in the flow transmitter only when this ratio is met. However, it is within 2% of full flow accuracy for crest-to-maximum-head ratios of 2 to 10. If more accuracy is required, then you must select #34, the equation. (See Section 2.4.3)

The equation programmed into the 3020 is in the general form:

$$Q = N1(H^{P1}) + N2(H^{P2})$$

Where:

Q = flow rate

N1, N2 = constants for the programmed equation

H = normalized head = actual head in feet ÷ maximum head in feet

P1, P2 = exponents

Your own specific equation will begin in the form:

$$Q = n1(h^{P1}) + n2(h^{P2})$$

Where:

Q = flow rate

n1, n2 = constants for your equation

h = actual head in feet

P1, P2 = exponents

To convert your equation into the one that you will program into the 3020, you must calculate the constants N1 and N2:

$$\mathbf{N1 = n1(H_{max}P^{1})}$$
$$\mathbf{N2 = n2(H_{max}P^{2})}$$

Where:

H_{max} = maximum head in feet.

N1 + N2 = flow rate at maximum head.

2.4.4 Programming Example Using an Equation

The following example involves programming the 3020 with an equation. The installation has a device whose level-to-flow rate conversion follows the equation:

$$\text{Flow} = 4.3 \times \text{level}^{2.5} + 0.6 \times \text{level}^{1.3}\text{GPS}$$

The maximum head is **2.5** feet. Flow rate will be displayed in **GPS**. The totalizer will totalize in **gallons**. The display will be set to alternate between level and flow rate. Assume the level is **0.75 feet**.

Calculations for example 3 – From the equation, we can see that:

n1 = 4.3

P1 = 2.5

n2 = 0.6

P2 = 1.3

We also know that **H_{max} = 2.5**.

We must calculate **N1** and **N2**.

$N1 = n1(H_{max}^{P1}) = 4.3(2.5^{2.5}) = 4.3(9.88) = 42.49$

$N2 = n2(H_{max}^{P2}) = 0.6(2.5^{1.3}) = 0.6(3.29) = 1.97$

Therefore, the values programmed into the 3020 are:

N1 = 42.49

P1 = 2.5

N2 = 1.97

P2 = 1.3

These values correspond to the equation:

$$Q = 42.49H^{2.5} + 1.97H^{1.3}\text{GPS}$$

Flow rate at maximum head is **N1 + N2 = 42.49 + 1.97 = 44.46 GPS**

Place the **GPS** label to the right of the display.

To totalize in gallons, find the flow at maximum head in gallons per hour (44.46 GPS x 60 seconds per minute ö 60 minutes per hour = 160,056 gallons per hour (GPH)). To make each count on the totalizer equal to 1000 gallons, divide 160,056 GPH by 1,000 (160,056 GPH ÷ 1,000 gallons per count = 160 counts per hour). The result, 160, is the value entered into the 3020. Place three **0** labels and the **GAL** label to the right of the totalizer.

1. Press PRIMARY DEVICE.
2. Select units of measure for level. To select feet, press 1.

1	1

Press ENTER.

3. Select entry of an equation (#34) from the list of primary devices shown on the front panel; press 3, 4.

2	34

Press ENTER.

4. To enter the value for N1, press 4, 2, (decimal), 4, 9.

3	42.49

Press ENTER.

5. To enter the value for P1, press 2, (decimal), 5.

4	2.5

Press ENTER.

6. To enter the value for N2, press 1, (decimal), 9, 7.

5	1.97

Press ENTER.

7. To enter the value for P2, press 1, (decimal), 3.

6	1.3

Place the “GPS” label to the right of the display.

Press ENTER.

8. To enter the maximum expected head for the above equation, press 2, (decimal), 5.

7 2.5

Press ENTER.

9. To program the totalizer, enter the constant calculated above by pressing 1, 6, 0.

9 160

Press ENTER. The totalizer will now totalize in thousands of gallons. Place 3 “0” labels and the “GAL” label to the right of the totalizer.

XXXX	(Flow Rate)

10. Press DISPLAY MODE and press 3 to set the display to alternate between flow rate and level.

16 3

Press ENTER.

XXXX	(Flow Rate)
H XXXX	(H = Height, or level)

11. Press ADJUST LEVEL. Enter the value for the head by pressing (decimal), 7, 5.

H .75

Press ENTER.

XXXX	(Flow Rate)

H XXXX	(H = Height, or level)

2.4.5 Rectangular Weirs with End Contractions

The conversion for rectangular weirs with end contractions is:

$$Q = 3.33(L - 0.2h)h^{1.5}CFS$$

Where:

Q = flow rate in CFS

h = actual head in feet

L = length of the crest of the weir in feet

The coefficients of the standard flow rate equation for the rectangular weir with end contractions, in primary device 2, are for a crest-to-maximum head ratio of 2.5 to 1 (crest length ÷ maximum head = 2.5). Thus, the equation is equal to that in the flow meter only when this ratio is exactly 2.5. However, it is accurate within 2% of full scale for crest-to-maximum head ratios of 2 to 10. If more accuracy than this is needed, you must use the special equation. This equation is of the general form:

$$Q = N1(H^{P1}) + N2(H^{P2})$$

Where:

Q = flow rate

N1, N2 = constants

H = normalized head = actual head in feet / maximum head in feet

P1, P2 = exponents

To change the level-to-flow rate conversion for a rectangular weir with end contractions into an equation that can program into the 3020, calculate the constants **N1** and **N2**:

N1 = 3.33(L)($H_{max}^{1.5}$)

N2 = 3.33(-0.2)($H_{max}^{2.5}$)

Where:

L = length of the crest of the weir in feet

Hmax = maximum head in feet

N1 + N2 = flow rate at maximum head

If a flow rate other than CFS is desired, it is necessary to convert these values from CFS to the desired units of measure. For example, consider a **4 foot rectangular weir with end contractions** and a maximum head of **2 feet**. For flow rate in **CFS**, the values for **N1** and **N2** would be:

$$\mathbf{N1 = 3.33(4)(2^{1.5}) = 37.67}$$
$$\mathbf{N2 = 3.33(-0.2)(2^{2.5}) = -3.767}$$

For a rectangular weir with end contractions, always use:

P1 = 1.5
P2 = 2.5

Therefore, the following equation would be programmed into the flow transmitter for a four foot rectangular weir with end contractions and a maximum head of one foot:

$$Q = 37.67(H^{1.5}) - 3.767(H^{2.5})CFS$$

For your convenience, the values for N1 and N2 for various crest lengths and maximum heads are provided in Tables 2-2 and 2-3. Note that these values are for flow rates in CFS. Again, if a flow rate other than CFS is desired, it is necessary to convert these values from CFS to the desired units of measure.

Table 2-2 Values of N1 for Flow Rate in CFS

Max. Head (H^{max})	**Crest Length in Feet**									
	1.00	1.50	2.00	2.50	3.00	4.00	5.00	6.00	8.00	10.00
0.50	1.177	1.766	2.355	2.943	3.532	4.709	5.887	7.064	9.419	11.77
0.75		3.244	4.326	5.407	6.489	8.652	10.81	12.98	17.30	21.63
1.00			6.660	8.325	9.990	13.32	16.65	19.98	26.64	33.30
1.25				11.63	13.96	18.62	23.27	27.92	37.23	46.54
1.50					18.35	24.47	30.59	36.71	48.94	61.18
2.00						37.67	47.09	56.51	75.35	94.19
2.50							65.81	78.98	105.3	131.6
3.00								103.8	138.4	173.0
4.00									213.1	266.4
5.00										372.3

Table 2-3 Values of N2 for Flow Rate in CFS

H_{max}	0.50	0.75	1.00	1.25	1.50	2.00	2.50	3.00	4.00	5.00
N2	-0.118	-0.324	-0.666	-1.163	-1.835	-3.767	-6.581	-10.38	-21.31	-37.23

2.4.6 Programming Example for a Rectangular Weir with End Contractions

The following example will show how to enter an equation (#34) for a rectangular weir with end contractions. This example will use a **6 foot rectangular weir with end contractions** with a maximum head of **2 feet**. Flow rate will be displayed in **GPM**. Flow will be totalized in **cubic feet**. Assume that the level is **0.75 feet**.

Calculations for example 4: – From the tables above, find the values for **N1** and **N2** for a rectangular weir with end contractions with a **6 foot crest length** and maximum head of **2 feet**:

N1 = 56.51

N2 = -3.767

For a rectangular weir with end contractions, always use:

P1 = 1.5

P2 = 2.5

Because these values are in CFS, we must convert from CFS to GPM by multiplying by 448.8.

N1 = 56.51 x 448.8 = 25,362

N2 = -3.767 x 448.8 = -1,691

Because N1 and N2 must be in the range of -4,999 to 4,999, we must divide both these numbers by 10.

N1 = 25,362 ÷ 10 = 2,536

N2 = -1691 ÷ 10 = -169

Therefore, we have:

N1 = 2,536

P1 = 1.5

N2 = -169

P2 = 2.5

Flow rate at maximum head is:

N1 + N2 = 56.51 - 3.767 = 52.74 CFS

or

N1 + N2 = 25,362 - 1,691 = 23,672 GPM

Place one **0** label and the **GPM** label to the right of the display.

To totalize in cubic feet, we must first calculate the total flow per hour of flow rate at maximum head. 52.74 CFS x 60 seconds per minute x 60 minutes per hour = 189,864 cubic feet per hour (CFH). For each count on the totalizer to be equal to 1,000 cubic feet, divide by 1,000. 189,864 CFH ÷ 1000 cubic feet per count = 190 counts per hour (rounded off). Therefore, enter 190 for the totalizer scaling. Place three **0** labels and the **GAL** label to the right of the totalizer.

1. Press PRIMARY DEVICE.
2. Select units of measure for level. To select feet, press 1.

1	1

Press ENTER.

3. Select entry of a user equation from the list of primary devices shown on the front panel. Press 3, 4.

2	34

Press ENTER.

4. To enter the value for N1, press 2, 5, 3, 6.

3	2536

Press ENTER.

5. To enter the value for P1, press 1, (decimal), 5.

4	1.5

Press ENTER.

6. To enter the value for N2, press +/-, 1, 6, 9.

5	-169

Press ENTER.

7. To enter the value for P2, press 2, (decimal), 5.

6	2.5

Place one "0" label and the "GPM" label to the right of the display.

Press ENTER.

8. To enter the maximum head, press 2.

7	2

Press ENTER.

9. To program the totalizer in thousands of cubic feet, enter 190. Press 1, 9, 0.

9	190

Place 3 "0" labels and the "GAL" label to the right of the totalizer.

Press ENTER. The flow rate and/or the level (H) will be displayed.

10. Press DISPLAY MODE and press 1 to display flow rate.

16	1

Press ENTER.

XXXX

(Flow Rate)

11. Press ADJUST LEVEL to set the current level in feet. Press (decimal), 7, 5.

H	.75

(the H will flash.)

Press ENTER.

XXXX

(Flow Rate)

3020 Flow Transmitter

Section 3 Installation

In this section, installation of the 3020 Flow Transmitter and the submerged probe level sensor is described in detail. Information is also provided on wiring between the 3020 and an automatic wastewater sampler.

3.1 General Comments on Installation

While the 3020 may be used for portable or temporary flow monitoring, it is generally intended for permanent installation, as connection to a commercial power source is necessary. You may install the flow transmitter either inside or outside, but inside installation is preferable, particularly in areas with severe climate extremes of heat, cold, or moisture. The flow transmitter is housed in a strong weather-resistant plastic case, but installation where the case will be exposed to full sunlight should be avoided, particularly in warm climates, to prevent overheating the electronic components. (The flow transmitter contains heaters to help maintain proper operating temperatures for the electronics in severely cold weather.)

3.1.1 Avoid Possibility of Submersion and Installation in Unsecured Locations

The flow transmitter has a seal on the door, and operation in wet environments is acceptable, but never install the unit where there is any possibility of submersion of the case. This is not only bad for the flow transmitter, but also creates the possibility of a shock hazard due to the presence of 120 VAC power. Always make outside installations in areas which are at least relatively secure to avoid the possibility of tampering or vandalism. Always keep the flow transmitter case closed, latched, and locked, except when programming, wiring, or servicing.

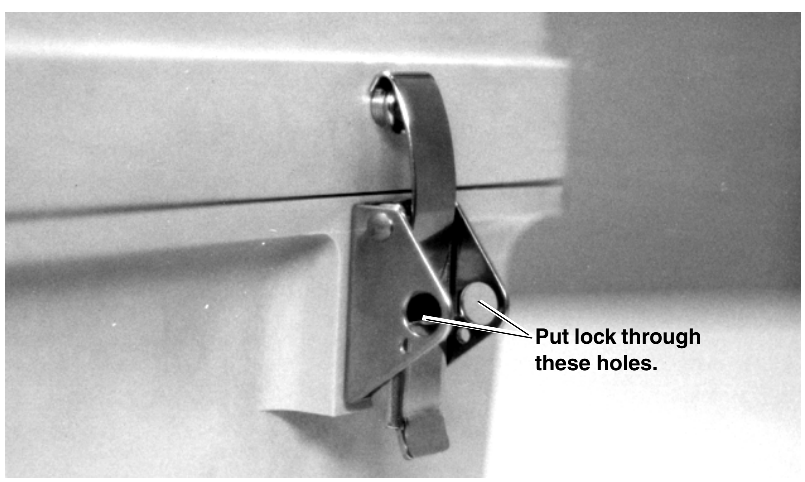


Figure 3-1 View of Case Latch, Showing Lock Shackle

3.1.2 Location of the Flow Transmitter

Because it uses a submerged probe level sensor, the 3020 Flow Transmitter does not have to be mounted directly above the primary device, or even close to the flow stream. You can install the flow transmitter in a convenient, protected location, and the level sensor cable can run to the place where the submerged probe is mounted. For example, if you install the probe in a manhole, you can mount the flow transmitter above ground for protection and easy accessibility. If you do this, you need to enter the manhole only once, for submerged probe installation. Locate the flow transmitter within **75 feet** (22.9 m) of the submerged probe, unless you use the Quick-Disconnect Box, which extends the allowable distance to 1000 feet (305 m).

3.1.3 Portable Operation

The 3020 can be used for temporary monitoring of a flow stream, limited by the 75 ft. distance to the transducer and, more importantly, by the availability of 120 VAC power for the flow transmitter. If you wish to use the 3020 as a portable instrument, attach a six ft. (or longer) three-wire AC power cord to the power input terminals on **TS1**. Connect Line or Hot to **TS1-1**; Ground to **TS1-2**, and Neutral to **TS1-3**. Use Stahlin fittings (see Section 3.2.2) to seal the line cord and level sensor cable and relieve strain where they enter the case. This allows the unit to plug into an electrical outlet like any appliance. Teledyne Isco does not recommend the use of a line cord and wall outlet for permanent installations, for reasons of both safety and reliability. If you do use the flow transmitter as a portable instrument, pay attention to the safety of others working in the area during installation. Do not run cables carelessly so they cause people to trip over them, or are damaged by other activity in the area.

3.2 General Wiring Comments

In the following sections information is provided on wiring the 3020 to the submerged probe and other equipment. Section 4 provides wiring information for the various accessories. The 3020 and associated equipment use different types of wire for interconnection. In some instances, you may supply your own cable; in others, you must use Teledyne Isco-supplied cable. When a user-supplied cable is described, match this cable as closely as possible and stay within the given distance limits. In some locations, where there is electrical background noise, some distances given may not be possible, especially for data lines. In some jurisdictions, all wiring to the flow transmitter must be installed in conduit; in others, only the AC power source. Where wiring may be damaged, Teledyne Isco recommends using conduit for protection. All wiring entering the 3020 should be through watertight fittings.

3.2.1 Mounting and Wiring

The 3020 has a stainless steel mounting bracket attached to its back and this bracket mounts the cabinet securely to a wall, or other vertical surface. Use hardware suitable for the surface where the flow transmitter is mounted. The mounting plate has three - $^3/_8$" holes three inches apart. Since the holes are slotted (keyholed), the case may be hung over $^3/_{16}$" hardware, or if a more secure mounting is desired, up to $^5/_{16}$" hardware may be screwed directly through the holes. The bottom of the case has five holes which are threaded for either conduit fittings or, if applicable codes permit, Stahlin fittings.

3.2.2 Stahlin Fittings

Stahlin fittings (available from Teledyne Isco) are non-metallic, threaded, compression-type cable fittings which permit the entry of cables into an electrical enclosure. Use these fittings if the flow transmitter is not wired with conduit. Four of the holes in the bottom of the flow transmitter cabinet are threaded for $^1/_2$" conduit, and one hole is sized for $^3/_4$" conduit. Since the 3020 is an AC-powered device, intended for permanent connection to a commercial power source, it must be installed in accordance with all applicable codes.

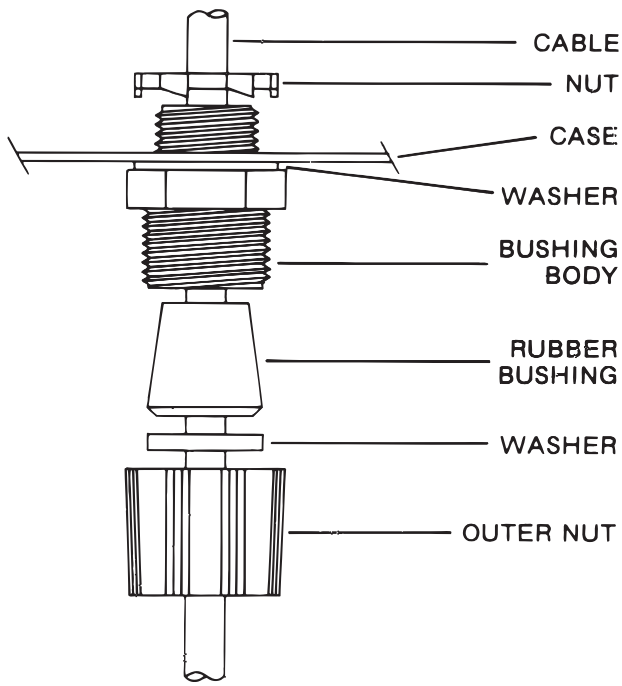


Figure 3-2 Stahlin Fittings (Compression Bushings)

⚠ WARNING

The 3020 and its submerged probe level sensor are NOT APPROVED for use in hazardous locations as defined by the National Electrical Code. Install the 3020 in NON-HAZARDOUS areas only, in compliance with the National Electrical Code, or with local codes, whichever authority has jurisdiction.

3.2.3 Connection to a Power Source

The 3020 requires a 120- or 240-volt, 50-60 Hz alternating current power input. Teledyne Isco recommends connecting the 3020 to its own separate branch circuit in the main circuit breaker panel or local branch panel. Label the breaker with its use. A 15 Ampere breaker is sufficient. A separate cutoff switch next to the main panel, clearly labeled, is also acceptable. In any case, connect the flow transmitter to the commercial power supply so that accidental shut-off or shut-off brought about by the failure of other equipment does not occur. Mark the circuit for the flow transmitter so no one connects any other equipment to it later. Do not attach the flow transmitter to a circuit which already feeds other equipment. Do not connect the 3020 to a circuit controlled by an ordinary wall switch; if a switch is necessary, use a key switch instead.

3.2.4 Voltage Selector Switch

A slide switch above TS1 selects 120- or 240-volt operation. Make sure this switch is in the right position for the available voltage. If the switch is in the wrong position either the fuse will blow or inadequate voltage will prevent the flow transmitter from operating correctly. Connect Black (or whatever color serves as hot) to Terminal 1 (Hot), Ground to Terminal 2 (Ground), and White (neutral) to Terminal 3 (Neutral) of TS1.

Black (or other color	**TS1-1**	**Line or hot**
Green	**TS1-2**	**Ground**
White	**TS1-3**	**Neutral**

⚠ WARNING

HAZARD OF ELECTROCUTION! You can be KILLED if you accidentally contact the 120 VAC power supplied to the 3020. Do not attempt to wire the 3020 live or perform any work on the unit with power connected and the protective covers removed.

Use particular care working around the three large terminals on **TS1**, where 120 VAC power is brought in. Turn off the breaker or cutoff switch if it is necessary to change the wiring, to replace the fuse, or do any other service requiring removal of the covers. Be particularly careful if the flow transmitter is located in a wet area.

⚠ WARNING

POSSIBLE EXPLOSION HAZARD - DO NOT introduce AC wiring or the 3020 into an environment where flammable liquids or explosive vapors may be present. Organic solvents, oils, and fuels would be examples. Electric sparks made during connection or operation of the unit, or the transmission of flow pulses to a sampler could ignite the fumes, causing fire or an explosion.

3.2.5 Wiring the Submerged Probe

(Detailed instructions on mounting and installing the submerged probe level sensor are found in Section 3.7. This section covers the wiring only.) The flow transmitter has two different options for connecting the submerged probe. You specify which option you desire when you order the flow transmitter.

Option 1 – Direct attachment to the probe connector or to an extension cable. In this option, the flow transmitter has an external, pig-tailed 5-pin female M/S connector for direct attachment to the probe's 5-pin male M/S connector. A desiccator cartridge vents the probe's reference port to the atmosphere. Use this option where the probe is used by itself or with one of the extension cables; maximum distance 75 feet. **Not for conduit installations.**

Option 2 – No external connector for the probe. (The probe is hard-wired.) Use this option **only** with the Quick-Disconnect Box, as there is no provision for venting the probe's reference port tube. Attach the cable from the Quick-Disconnect Box to the SUBMERGED PROBE terminals on **TS3**; maximum distance 1000 feet.

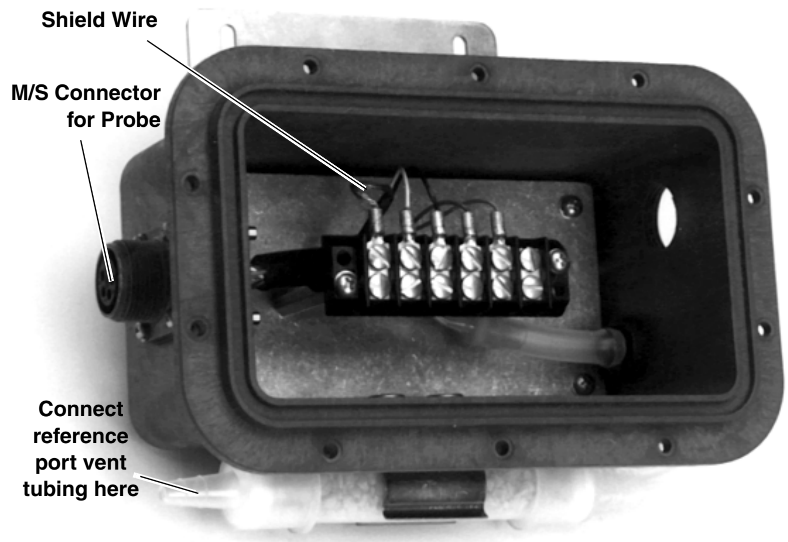


Figure 3-3 Quick-Disconnect Box (cover removed)

3.2.6 Distances Up to 75 Feet

The cable supplied with the submerged probe is 25 feet (7.6 m) long. Use only with **Option 1**. At the end of the probe cable is an encapsulated box and a threaded, 5-pin male M/S connector. Plug this connector into the mating M/S connector coming out of the 3020 cabinet. Make sure the connectors are threaded tightly together. The allowable distance between the flow transmitter and the submerged probe is increased to 75 feet (22.8 m) if the **optional extension cables** are used. These cables, available in 25 and 50 foot (15.2) lengths, have mating M/S connectors at the ends similar to the M/S connector on the submerged probe cable. Attach the connector on the extension cable to the M/S connector at the flow transmitter. Attach the other end of the cable to the connector on the submerged probe cable. Coil extra cable neatly and leave it by the flow transmitter. Do not let extra cable dangle in the flow stream, where it could become tangled or cause clogging as a result of backing up debris.

> **Note**
>
> The maximum distance between the flow transmitter and the submerged probe is 75 feet using extension cables. This is because the probe's reference port air tube *must* vent to the atmosphere. **Do not cut these cables to length or attempt to splice them together. Do not attempt to remove or modify the M/S connectors on the cable ends.** If it is necessary to exceed 75 feet, you must use the Quick-Disconnect Box.

3.3 Using the Quick-Disconnect Box

Option 2 only. For distances over 75 feet (22.8 m), you must use the Quick-Disconnect box. You must also use the Quick-Disconnect Box where the authorities require installation of wiring in conduit. The submerged probe M/S connector attaches to a matching M/S connector mounted on the side of the Quick-Disconnect Box. The Quick-Disconnect Box contains a terminal strip. Cable attached to these terminals may run as far as 1000 feet (305 m) to connect to the flow transmitter. Teledyne Isco has suitable cable available for this purpose, or you can supply your own cable. For longer distances or installations where there is a high level of electrical noise, the use of shielded cable is suggested.

Minimum specifications for the cable are:

> **#22 AWG, two twisted pairs (four wires), jacketed, optionally shielded**

3.3.1 Reference Port

The Quick-Disconnect Box also contains a vent for the reference port air tube coming from the submerged probe. The vent passes through a desiccator cartridge mounted on the side of the Quick-Disconnect Box to the atmosphere to provide a pressure reference for the transducer in the submerged probe. Since the probe's reference port vents at the Quick-Disconnect Box, the cable from the Quick-Disconnect Box to the flow transmitter does not need to have the air vent tube.

3.3.2 Mounting the Quick-Disconnect Box

Attached to the back of the Quick-Disconnect Box is a stainless steel mounting plate with two - $^1/_2$" keyhole mounting holes on 3" centers. $^3/_{16}$" to $^3/_8$" hardware is sufficient to mount the Quick-Disconnect Box. Install the wiring between the flow transmitter and the Quick-Disconnect Box with Stahlin fittings, or install the wiring in $^1/_2$" EMT conduit if required.

> **Note**
>
> If properly sealed, the Quick-Disconnect Box will withstand submersion. However, Teledyne Isco recommends mounting the box above the maximum expected water level. If this cannot be guaranteed, attach a $^1/_4$" ID vinyl tube to the open end of the desiccant cartridge and route the tube to a location higher than the maximum expected level. Water drawn into the vent tube will cause erratic operation of the probe and will be very difficult to remove.

3.3.3 Preparing Shielded Cable

If you use shielded cable to connect the flow transmitter to the Quick-Disconnect Box, use care preparing the ends. Avoid cutting too deeply and nicking the insulation on the wires or damaging the braided shield. Use a sharp knife to score the outer jacket about 2½ inches back from the end; then bend the end of the cable in your hand to break through the score line. Do not cut completely through the jacket; the shield or the wires inside may be nicked. Pull off the jacket and separate the wires in the braided shield by pulling the wires inside the shield through a hole made in the shielding ¾ of the way into the stripped area. Do not try to slit or tear the shielding, as it will fall apart. Instead, separate it with a screwdriver or a probe at least two inches back from the end. Twist the wires of the shield together to form a single conductor.

3.3.4 Connecting the Level Sensor Cable to the QD Box

Using a suitable cable (Belden #8424 in this instance) the following list of wire colors can be matched color for color at the Quick-Disconnect Box and the flow transmitter. With the Quick-Disconnect Box installed so the desiccator is on the bottom, connect to the terminal strip inside the box from left to right as follows: Refer to Figure 1-4 for location of **TS3**.

Terminal 1	**Shield**	**- 12V**	**TS3**
Terminal 2	**White**	**+ IN PROBE**	**TS3**
Terminal 3	**Black**	**- IN PROBE**	**TS3**
Terminal 4	**Red**	**+ 12V**	**TS3**
Terminal 5	**Green**	**- 12V**	**TS3**
Terminal 6	**No Connection**	**-**	**-**

☑ ***Note***

IMPORTANT! The cable used in this example (Belden #8424) has a braided shield wire. If the cable you are using is unshielded, you must connect a jumper wire from Terminal 1 (Shield) to Terminal 5 (Green). Even if the cable between the Quick-Disconnect Box and the Flow Transmitter is unshielded, the cable between the probe and the Quick-Disconnect Box is shielded and must be terminated appropriately.

3.3.5 Connecting the Cable from the QD Box to the 3020

The cable from the Quick-Disconnect Box attaches to the last four terminals of **TS3** on the right side of the flow transmitter terminal strip board. They are labeled **SUBMERGED PROBE +IN -IN** and **12 V+ -**. The signals are low energy, consisting of a variable DC level on the submerged probe inputs and 12 VDC on the other two wires. The wiring should be installed in conduit if there is any hazard of the cable being damaged.

3.4 Connection to a Sampler

The 3020 can control a sampler in a flow-paced sampling mode. Flow-paced sampling means that the 3020 signals the sampler after a specific flow volume has passed rather than after a period of time. In this way, the sampler and flow transmitter are able to compensate for varying flow rates. The flow transmitter works with any of the Isco samplers listed in Section 1. If you use the 3020 with an Isco sampler in a flow-paced sampling system, you must connect them together. The Flow transmitter sends a signal to the sampler. You can connect an Isco sampler and the flow transmitter together two different ways.

3.4.1 Sampler Located Within 22 Feet

If the Isco Sampler is located within 22 feet of the 3020 Flow Transmitter, a 22 foot (7.6 m) connect cable is available from Teledyne Isco that has wire terminations on one end and a 6-pin M/S Connector on the other. The M/S connector is plugged into the sampler and the wire terminations are attached to the appropriate terminals of the 3020. There are two wires in the cable. Connect the wires to the 3020 as follows:

Black	**Sampler Output**	**TS3**
White	**Sampler Output**	**TS3**

3.4.2 Sampler Located Over 22 Feet

For distances greater than 22 feet, Teledyne Isco has a kit consisting of a 6-pin M/S connector which is to be attached to a user-supplied cable. The connector plugs into the sampler. Wire the cable to the flow transmitter terminals as above. The cable should meet the following specifications:

- Two-wire, #18 AWG minimum conductor size
- 1000 feet maximum length
- Sheathed cable suggested for non-conduit installations (to protect the wires)

If the wire colors are the same as described for the Teledyne Isco-supplied cable above, the following order of connection to the M/S connector in the kit is recommended:

Black	**Pin A**	**12 Volts**
White	**Pin C**	**Flow Pulse**

If the wire colors are different from those of Teledyne Isco's connect cable, it will be your responsibility to see that the connection to the pins of the M/S connector are proper. Fill the backside of the M/S connector with a non-corrosive RTV silicone sealant to ensure watertightness.

3.4.3 Connection to a Non-Isco Sampler

It is possible to connect the 3020 to a non-Isco Sampler. Most samplers of other manufacturers require a different flow-proportional signal from Isco Samplers, usually an isolated contact closure. The SAMPLER OUTPUT terminals on **TS3** provide an isolated contact closure rated for up to 1 Ampere at 48 VDC. Wire the sampler and flow transmitter according to the sampler manufacturer's instructions.

3.5 Connection to Other Equipment

There are other optional accessories which may be used with the 3020 Flow Transmitter. These devices are discussed in detail in Section 4. Among these devices are:

- Remote Totalizer
- 2410 Circular Chart Recorder
- High/Low Alarm Relay Box

3.6 Safety Considerations

While the 3020 Flow Transmitter will generally be installed above ground in a safe environment, the location of the submerged probe may be in a sewer or manhole. Before installing the probe in such a location, review the following safety information. In field installations of flow transmitters and associated equipment, the safety of the personnel involved is the foremost consideration. No project is so important or deadline so critical to justify the risk of human life. See Appendix C for safety procedures for working in and around manholes and sewers.

⚠ WARNING

The 3020 Flow Transmitter has not been approved for use in hazardous locations as defined by the National Electrical Code.

3.7 Installing the Submerged Probe

The following sections describe installation of the submerged probe. The first section presents general mounting considerations common to all submerged probe mounting techniques. The following sections describe probe installation using the two systems available for mounting the submerged probe in pipes or round-bottomed flow streams. For pipes up to 15 inches (38.1 cm) in diameter, spring stainless steel self-expanding mounting rings are available. For pipes 18 inches in diameter and larger, Teledyne Isco offers the **Universal Mounting Ring**. For use in similarly-sized manhole inverts, you can use the **base** and **extension sections** of the Universal Mounting Ring without the scissors section. The straps are held in place by studs installed in the wall of the flow stream using a power-activated stud gun. Submerged probes are also installed in primary measuring devices.

3.8 General Mounting Considerations

The location of the probe in the stream is usually dependent on the flow rate conversion used. For example, if you are using the probe with a primary measuring device (WEIR/FLUME flow conversion when programming the 3020), there is a *specific location* for the probe with each primary device. The *Isco Open Channel Flow Measurement Handbook* provides much useful information in this regard.

If you want to measure flow using a gravity flow equation, such as the Manning equation, you will generally install the probe in the entrance (upstream) pipe of a manhole. If you want to measure flow by calibrating a manhole invert, you would probably locate the probe directly in the manhole invert.

In any case, you must determine the appropriate location of the probe, based on the hydraulic characteristics of the site and the method of level-to-flow rate conversion used.

You do not have to install the submerged probe at the bottom of the flow stream. Although the bottom is the normal position, the Adjust Level step in the program allows you to mount the probe at any vertical location in the stream, and then adjust the indicated level to match the actual level. (The flow meter can indicate negative levels.)

A location other than the bottom of the flow stream may be useful for various reasons: to avoid heavy concentrations of silt, sand, or other solids; to make installation easier in tight locations; to maximize level resolution over a specific level range; to avoid hydraulic obstructions in the flow stream, etc.

The probe has several ports through which liquid enters the body to contact the pressure transducer. The only way for the probe to malfunction is for all the ports to be completely blocked. Most substances likely to cover the probe are somewhat porous, which still allows the hydrostatic pressure of the flow stream over the probe to reach the transducer.

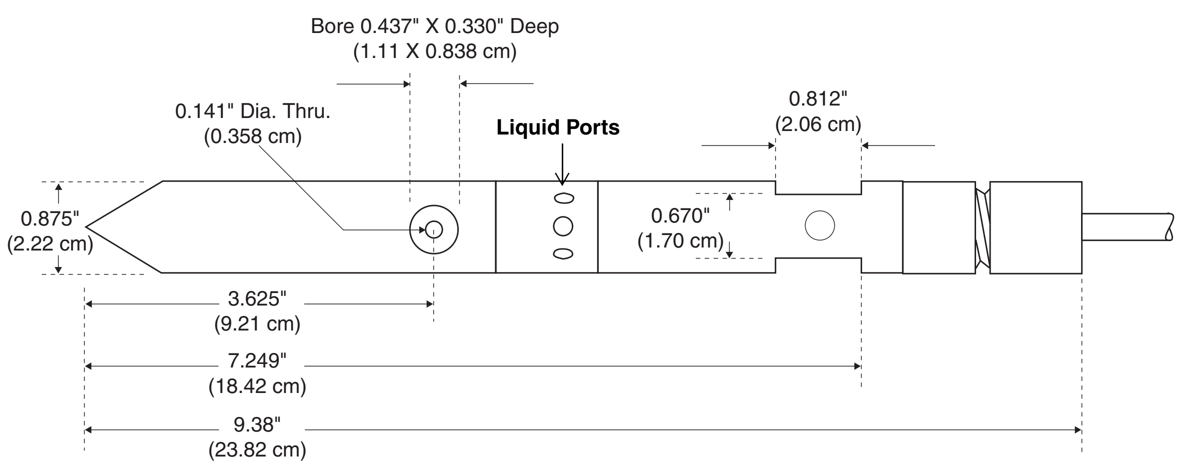


Figure 3-4 Submerged Probe Dimensions

3.8.1 Functionality Under Solids

Consequently, the probe will normally continue to function even when covered with several inches of silt or sand. Note however, that porous solids, such as wood chips or other organic material that may swell considerably when soaked in water, can interfere with the correct operation of the pressure transducer. In extreme cases, swelling material can put enough pressure on the diaphragm of the pressure transducer to deform it. This will ruin the submerged probe by introducing a permanent offset to the pressure transducer.

☑ Note

Always install the probe where it will be under water, even if only an inch or so. The probe cannot measure levels that fall below its location in the stream.

3.8.2 Minimum Reliable Detection Level

It is important to note that there is a practical minimum water level below which the submerged probe cannot reliably measure level. This minimum level is approximately equal to the height of the probe body, 0.1 ft. (1.3 in. or 0.030 m).

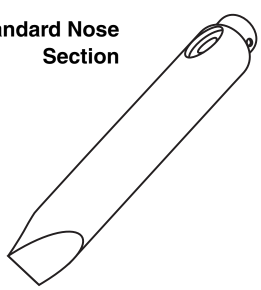
Liquid levels lower than this will be below the levels used to calibrate the sensor. The submerged probe level sensor will continue to measure levels less than 0.1 ft.; however, the accuracy of the measurement in this range is not guaranteed. Consequently, you should always use the submerged probe with caution in very low flow situations.

3.9 Submerged Probe Nose Sections

Teledyne Isco provides three nose sections, each designed for specific flow stream conditions.

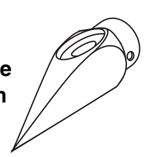
A complete list of nose sections and their part numbers can be found in Appendix A.

Standard Nose Section



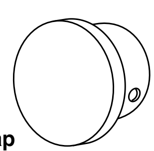
Standard Nose Section – The standard nose section works in any flow stream and will be installed on your probe unless otherwise specified in your order. It is particularly well suited for flow streams with high velocities because its shape overcomes hydraulic problems that develop in these flow streams. At velocities exceeding 5 feet per second (1.5 meters per second), localized low-pressure areas form near the submerged probe, which can result in erroneous level readings. The length of the nose section (3.87 inches or 9.84 cm) minimizes low-pressure areas by allowing the flow stream to stabilize before it reaches the probe's entrance ports.

Slanted Nose Section



Slanted Nose Section – Under certain conditions - low flow rates in debris-laden small sewers, for example - the submerged probe may catch and retain the debris, obstructing the flow stream and causing erroneous level readings. To avoid this problem, use the slanted nose section. This nose section has a slanted leading edge that tends to shed debris more readily than the standard nose section.

Use the slanted nose section with caution, however. Under conditions of low flow and high velocity, the slanted nose section may induce a hydraulic "jump" in the flow stream that can cause erroneous level readings.



Flume Cap

Flume Cap – The flume cap is a small, blunt cap that replaces the nose section. Most flume manufacturers can supply flumes with a small cavity to accept an Isco probe. The probe cap protects the transducer while minimizing the total length

3.9.1 Attaching the Nose Section

After cleaning, reinstall the nose section and tighten the screws. **The mounting hole must be aligned with the grounding point.**

Figure 3-5 Alignment of Grounding Point

3.10 Circular Channels

Consult your Isco Mounting Rings Installation and Operation Guide for detailed hardware information.

The following sections describe sensor installation using the two options available for mounting sensors in pipes or round-bottomed flow streams. For pipes up to 15" (38.1 cm) in diameter, **stainless steel self-expanding mounting rings** (**Spring Rings**) are available. For pipes larger than 15" in diameter, Teledyne Isco offers the **Scissors Rings (Universal Mounting Rings)**.

3.10.1 Spring Rings

To install a spring ring, you compress the ring, slip it inside the pipe, and then allow it to spring out to contact the inside diameter of the pipe. The inherent outward spring force of the ring firmly secures it in place. A typical self-expanding mounting ring (with a probe mounted on it) is shown in Figure 3-6.

These mounting rings are available for use in pipes with inside diameters of 6" (15.2 cm), 8" (20.3 cm), 10" (25.4 cm), 12" (30.5 cm), and 15" (38.1 cm). The Teledyne Isco part numbers for the various size mounting rings available are listed in Appendix B. These part numbers include not only the ring, but also the miscellaneous hardware necessary to mount the sensor on the ring.

⚠ CAUTION

Always wear leather gloves when handling the rings (either type). The metal is finished, but there is still a possibility of cutting your hands on the edges.

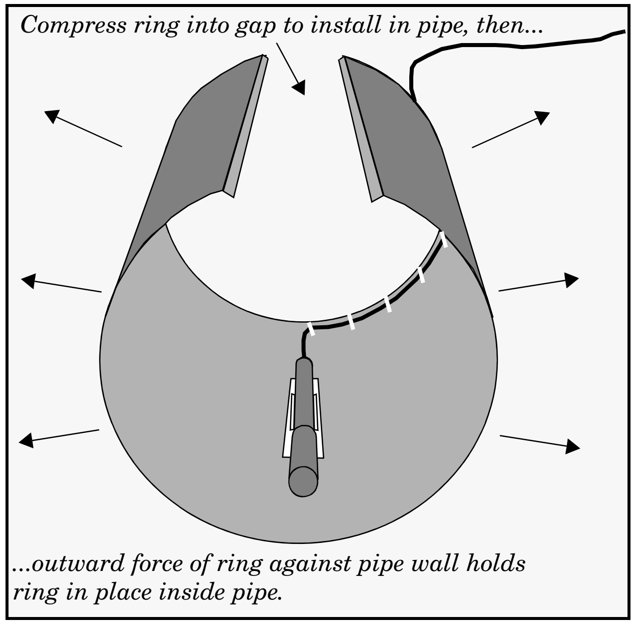


Figure 3-6 Sensor Installed on a Spring Ring

Attaching the Sensor to the Ring

Attach the probe to the ring either by using two 4-40 x 3/16" countersink screws or by snapping the optional probe carrier to the ring. This second method of attaching the sensor allows for easy removal in case service is needed later.

⚠ CAUTION

Make sure the slots on the probe carrier are completely pressed onto the tabs on the ring. This is particularly important where there is any possibility of reverse flows, or where flows are of high velocity. If the probe is not fully pressed onto the mounting ring tabs, it might come loose in the stream, and could possibly be damaged or lost.

To complete the sensor-spring ring assembly procedure, attach the sensor cable to the downstream edge of the ring. Follow the cable routing shown in Figure 3-6. Other routing directions may affect measurement accuracy. The cable can actually create a stilling well downstream from the sensor, causing the level to read low. Use the self-locking plastic ties supplied with the ring. Install the ring in the pipe by compressing it. Press inward on both sides and slide the ring into the pipe.

Route the sensor cable out of the stream and secure it in position by placing the ties through the holes in the mounting ring and then locking them around the cable, as shown. To prevent debris from catching on the cable, it is important to attach the cable to the mounting ring so it offers as little resistance to the flow as possible.

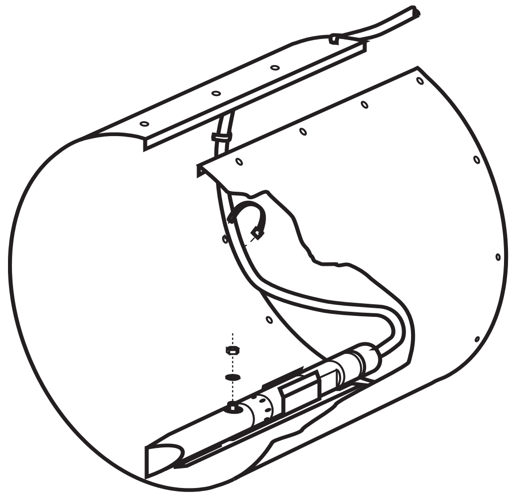


Figure 3-7 Spring Ring Preparation

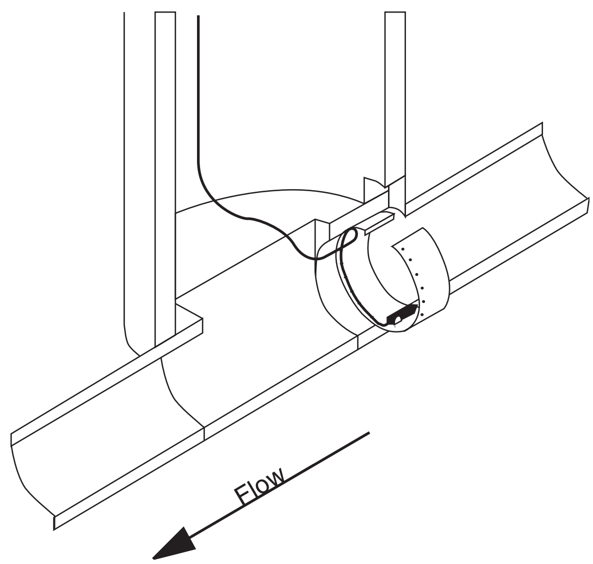


Figure 3-8 Mounting Ring in a Round Pipe

⚠ CAUTION

Make sure the sensor cable is securely fastened along the back (downstream) edge of the ring. Otherwise, the sensor may provide **inaccurate level readings** under conditions of high velocity.

Do not overtighten the plastic cable ties; they should be tightened just enough to secure the cable in place, without greatly indenting the cable. Overtightening the plastic ties may collapse the reference tube in the cable, blocking it.

The spring ring may need anchoring. Under conditions of high velocity (greater than 5 feet per second or 1.5 meters per second), the ring may not have sufficient outward spring force to maintain a tight fit inside the pipe. The ring may start to lift off the bottom of the pipe in a waving fashion, or may even be carried downstream.

This problem is more prevalent in the larger diameter pipes (10", 12", and 15", and in pipes with smooth inside surfaces, such as plastic pipes). If any of these conditions are present, or if movement of the mounting ring is detected or suspected, you must anchor the ring in place. You can do this by setting screws through the ring into the pipe, or by other appropriate means. If there is a problem with the smaller diameter rings, it may be sufficient to simply increase the outward spring force of the ring by bending it into a less round configuration.

3.10.2 Scissors Rings

For pipes larger than 15" in diameter, Teledyne Isco offers the adjustable Scissors Ring (also known as the Universal Mounting Ring). This device consists of two or more metal strips that lock together with tabs to form a single assembly. There is a base section where the sensors are mounted, one or more extension sections (usually), and a scissors section at the top that expands the entire assembly and tightens it inside the pipe. The scissors mechanism includes a long screw that increases the width as it is tightened.

The assembled rings fit pipe diameters from 16" to 80". Secure the unit in place by tightening the scissors mechanism with a 5/8" socket wrench or other suitable tool. Ring sections are .040" thick half-hard 301 stainless steel sheet. All other parts are also stainless steel, except for the plastic cable ties in the hardware kit.

Each extension, 1, 2, 3, and 4, adds 9.0", 21.5", 31.5", or 41.5", respectively, to the circumference of the ring. Used alone, the base section fits pipe that is approximately 16" to 18" in diameter. The 9.0" (the smallest) extension exists so that in larger pipe sizes, where large variations in circumference can occur, you can use one or two of these extensions to take up or remove slack, to bring the scissors mechanism into a position where it can be effectively tightened.

Mounting ring kits are available for different pipe sizes. A kit is also available for partial pipe applications (see your *Isco Mounting Rings Installation and Operation Guide*). For a listing of part numbers and ordering information, see Appendix B.

⚠ CAUTION

Do not overtighten the plastic cable ties; they should be tightened just enough to secure the cable in place, without greatly indenting the cable. Overtightening the plastic ties may collapse the reference tube in the cable, blocking it.

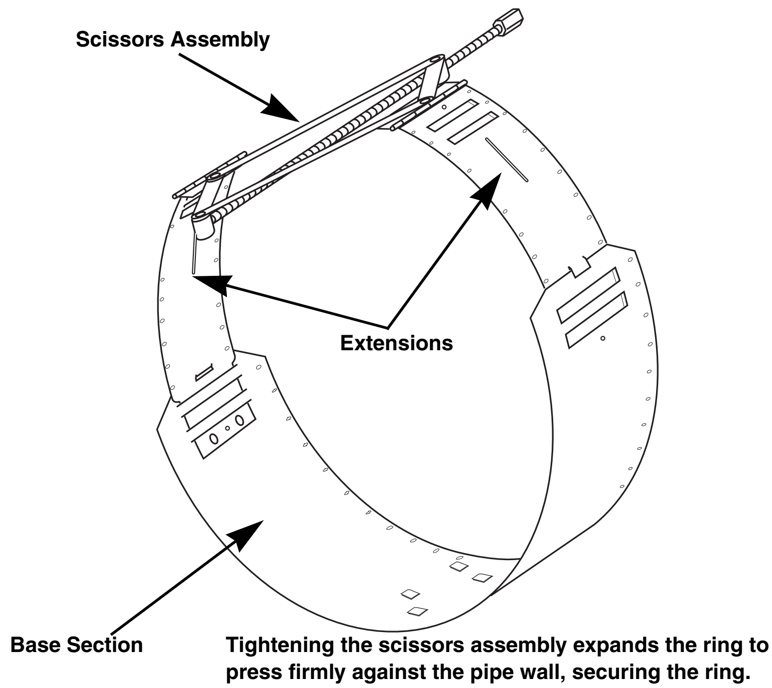


Figure 3-9 Universal Mounting Ring Adjustment

3.11 Other Mounting Techniques

Many installations require mounting methods other than mounting rings. Some alternative mounting methods are described below. Contact Teledyne Isco for assistance in determining your specific installation needs.

3.11.1 Rectangular and Trapezoidal Channels

A flat, anchored mounting plate is a common mounting choice for installing sensors in rectangular or trapezoidal channels. You can also install the probe in rectangular channels by bending a mounting ring to fit the channel. Attach the ring to the channel wall with studs. Consult your *Isco Mounting Rings Installation and Operation Guide* for more information.

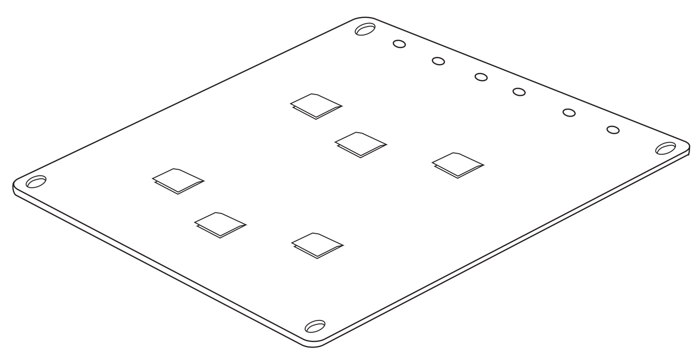


Figure 3-10 Isco Rectangular Mounting Plate

3.11.2 Stilling Wells or Streams with Very Low Velocity

In flow streams with a minimal flow velocity or in a stilling well, simply attach the probe to a weighted plate and submerge the plate in the stream or stilling well.

3.11.3 Securing Probe with a Weighted Plate

In situations with a minimal flow velocity (for example, in a stilling well), you can simply attach the probe to a weighted plate and submerge it in the flow.

3.11.4 Weirs and Flumes

The 4220 Flow Meter is generally used with some type of primary measuring device, such as a weir or flume. The placement of the submerged probe in the primary device is determined by the type of primary device. You can use one of Isco's mounting rings to install the probe in many weirs and flumes. If the mounting ring are not suitable, you must build your own mounting hardware. Figure 3-4 shows the dimensions of the probe for your reference when building your own hardware. Figure 3-11 shows the probe installed in several primary devices.

Certain flume manufacturers produce flumes with built-in cavities for Isco's submerged probe. Contact the flume manufacturer for details on the special flumes.

☑ **Note**

Always install the submerged probe pointing toward normal flow at the head-measuring point of the device. The location of the measuring point varies with each device. Refer to Table 3-1 or to the Isco Open Channel Flow Measurement Handbook.

Table 3-1 Locating the Head-Measuring Point

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 by half the pipe diameter.

☑ **Note**

When installing the probe with custom hardware, remember to attach the probe securely to the side or bottom of the flow stream and tie the cable down so that it does not collect debris.

For many primary measuring device installations, the submerged probe mounting rings or base sections discussed previously may be used to mount the probe at the appropriate location. In many installations, though, the mounting rings or bases may not be suitable.

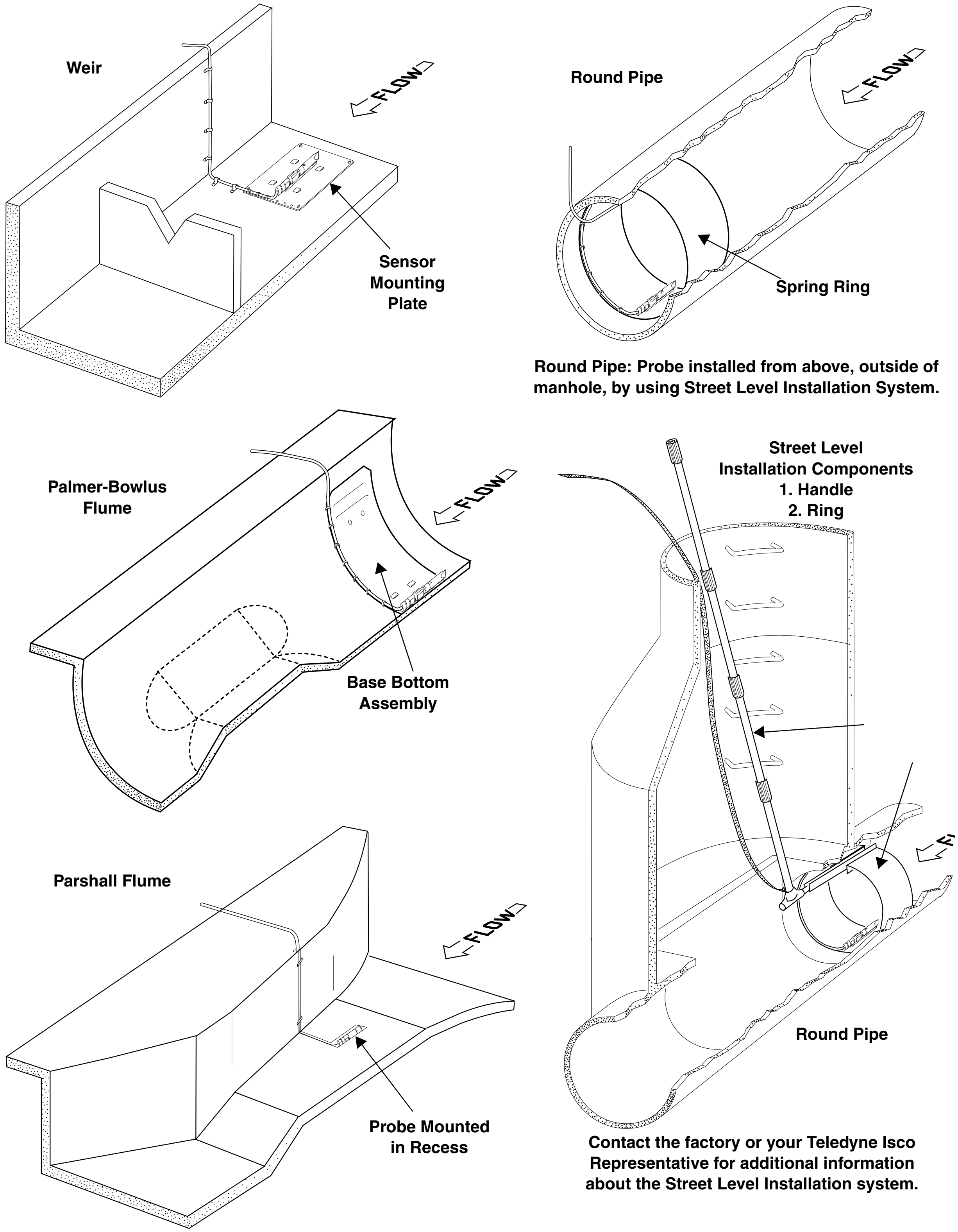


Figure 3-11 Typical Primary Device Installations

Mounting hardware may have to be fabricated locally to allow the level sensor to be mounted at the correct location in the primary device. The only requirements for custom mounting hardware are:

- The probe must be securely attached to the side or bottom of the flow stream.
- The cable must be tied down and led out of the flow stream in an orderly manner.
- The hardware be made from corrosion-resistant materials.

It should be noted that the mounting rings may be used to install the probe in rectangular channels by simply putting right angle bends in them at the appropriate locations. It should be noted that certain flume manufacturers produce flumes with built-in cavities designed specifically for use with Isco submerged probe level sensors. Typically, these are Parshall or Palmer-Bowlus flumes. Contact the manufacturer for details on these flumes.

3.12 Completing the Probe Installation

The submerged probe installation is finished by coiling any excess sensor cable and securing it using cable clamps or other means. The reference tube inside the cable can be restricted or blocked if the cable is kinked, sharply bent, or otherwise pinched. The probe cable should be handled and mounted with care. Also, if there is any appreciable distance between the point where the probe cable leaves the mounting apparatus and the location of the flow meter, be sure to attach the cable to the flow stream wall to prevent it from vibrating, moving around, tangling, or possibly collecting debris.

⚠ CAUTION

Under no circumstances should you leave any extra length of sensor cable dangling freely in the flow stream where it could trap debris or become tangled.

Use gloves and eye protection when assembling and installing the rings in a pipe. Though deburred, the edges of the stainless steel can cut if improperly handled. *Please read the information on how best to install this device.*

Observe general safety procedures when entering any manhole. See “General Safety Procedures” in the back of the manual for more information on general hazards and necessary precautions.

3020 Flow Transmitter

Section 4 Options and Accessories

This section of the 3020 Instruction Manual describes optional equipment available for use with the flow transmitter and how to connect the options to the 3020. The following user-installed options are available:

- High-Low Alarm Relay Box
- Remote Totalizer
- Quick-Disconnect Box
- Extension Cables for the Submerged Probe Level Sensor
- 2410 Circular Chart Recorder

⚠ CAUTION

All wiring between the 3020 Flow Transmitter and related equipment must conform to the National Electrical Code or local codes, whichever authority has jurisdiction. You should make installations suitable for wet locations.

⚠ WARNING

Hazard of electrocution! You can be killed if you accidentally contact the AC power supplied to the 3020. Do not attempt to wire or troubleshoot while the flow transmitter is "live." Disconnect power at the breaker panel or cutoff switch before performing any work on the flow transmitter.

4.1 High-Low Alarm Relay Box

Teledyne Isco offers an alarm box that monitors flow rate information provided by the 3020 (see Figure 4-1). Relays trip when flow rate falls below or exceeds preset limits. High and low set points are user-selected and range from 0% to 99% in 1% increments. Output from the unit is the switching of form C (SPDT) relay contacts. Two relays are provided: one for high alarm and the other for low. The availability of form C contacts (both NO [normally open] and NC [normally closed] contacts) means that you can either turn loads on or off. Relay contacts are rated for 3 amperes maximum at 24 volts AC or DC. The unit operates on 12

VDC supplied from the 3020. Current consumption in standby condition is approximately 10 mA. In alarm condition (if both relays are operated), current increases to 190 mA.

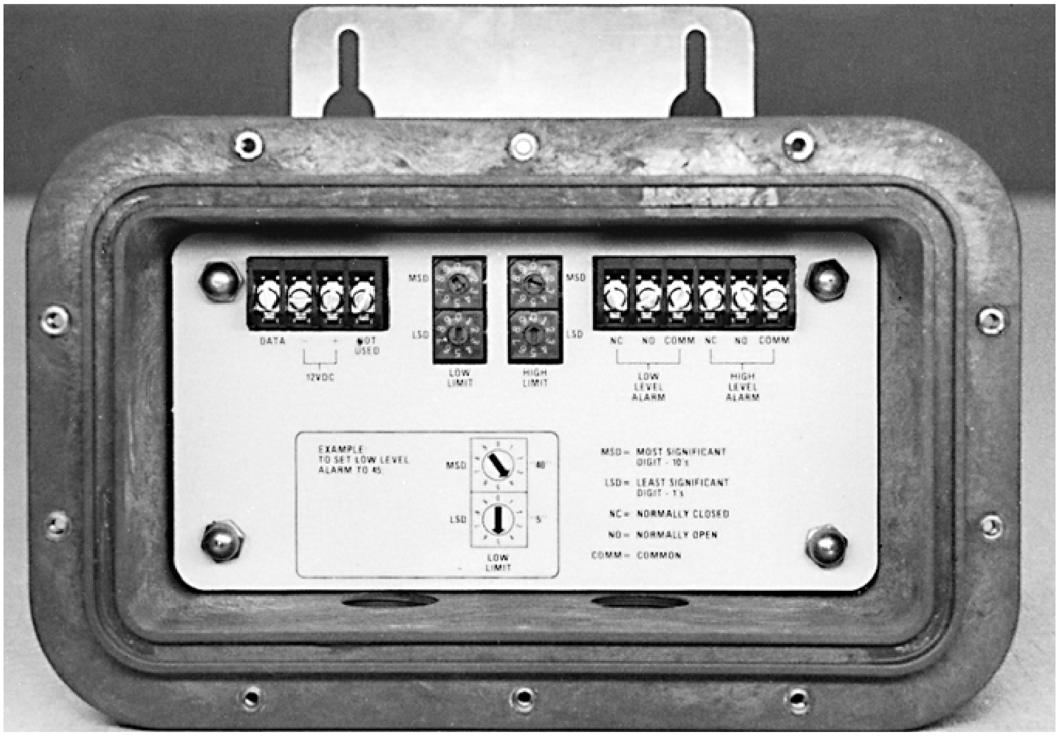


Figure 4-1 High-Low Alarm Relay Box (cover removed)

4.1.1 Setting the Limit Switches

The High-Low Alarm Relay Box contains a microprocessor that compares serial data from the 3020 to set values for high and low alarm trip-points for the relays. Rotary switches inside the alarm box set the trip points. There are two rotary switches for each limit. The switches labeled **MSD** (most significant digit) determine the first digit of the percentage entered as a set point. For example, if you want to enter a low limit of 18%, you would set the **LOW LIMIT MSD** switch to **1**. Then you set the **LOW LIMIT LSD** (least significant digit) switch to **8**. Use the same method to program the **HIGH LIMIT** switch. Suppose you want to set the high limit at 79%. You would set the **HIGH LIMIT MSD** switch to **7** and the **HIGH LIMIT LSD** switch at **9**.

4.1.2 Installation of the Alarm Box

Mount the alarm box with the 2 slotted holes in the stainless steel plate on the back of the case. The slots accommodate up to $^{3}/_{16}$" hardware. Drill 2 mounting holes on 3" centers. Threaded holes in the box allow the use of either $^{1}/_{2}$" conduit fittings or Stahlin fittings (see Section 3.2.2). The alarm box is suitable for use in damp locations, but do not install it where there is possibility of submersion. In low temperature ambients, install the alarm box indoors or in a heated location. The minimum operating temperature of the microprocessor is 32° F (0° C).

4.1.3 Wiring the Alarm Box

Connecting the Alarm Box to a flow transmitter requires three wires. A three wire cable typically has the following wires in it: black, white, and another color, such as red or green. Connect the wires as follows:

Table 4-1 3000 Series Wiring Instructions

Terminals in 3000 Series Flow Transmitter	Terminal Strip#	Wire Colors	Terminals in Alarm Box
2312 INTERFACE +	TS2	BLACK	+12VDC
2312 INTERFACE -	TS2	WHITE	-12VDC
2312 INTERFACE OUT	TS2	(OTHER)	DATA

You can use up to four alarm boxes with the same flow transmitter. Wire all the boxes in **PARALLEL** to the same connections shown in the table above. The wire colors shown are for example only. Any color of wire or cable is acceptable, but ***make sure*** the connections end up the same as those shown. The maximum recommended distance between the 3020 and the alarm box is 250 feet (76 meters). The recommended wire gauge for interconnection cable is #18 AWG. In electrically noisy environments, Teledyne Isco suggests use of shielded cable.

To connect external devices to the high level or low level alarm relay:

Use **NO** and **COMM** for devices to turn **ON** when the alarm trips. Use **NC** and **COMM** for devices to turn **OFF** when the alarm trips.

Wire gauge and the length of the cable run depend on the device being controlled. Recommended limits for wiring to the **relay contacts only** are 1000 feet maximum cable run and #18 AWG wire size.

⚠ WARNING

For safety, do not connect line-powered devices (120 VAC or higher) directly to the relay contacts. Use the alarm box for low-voltage (>30 volts) pilot control only.

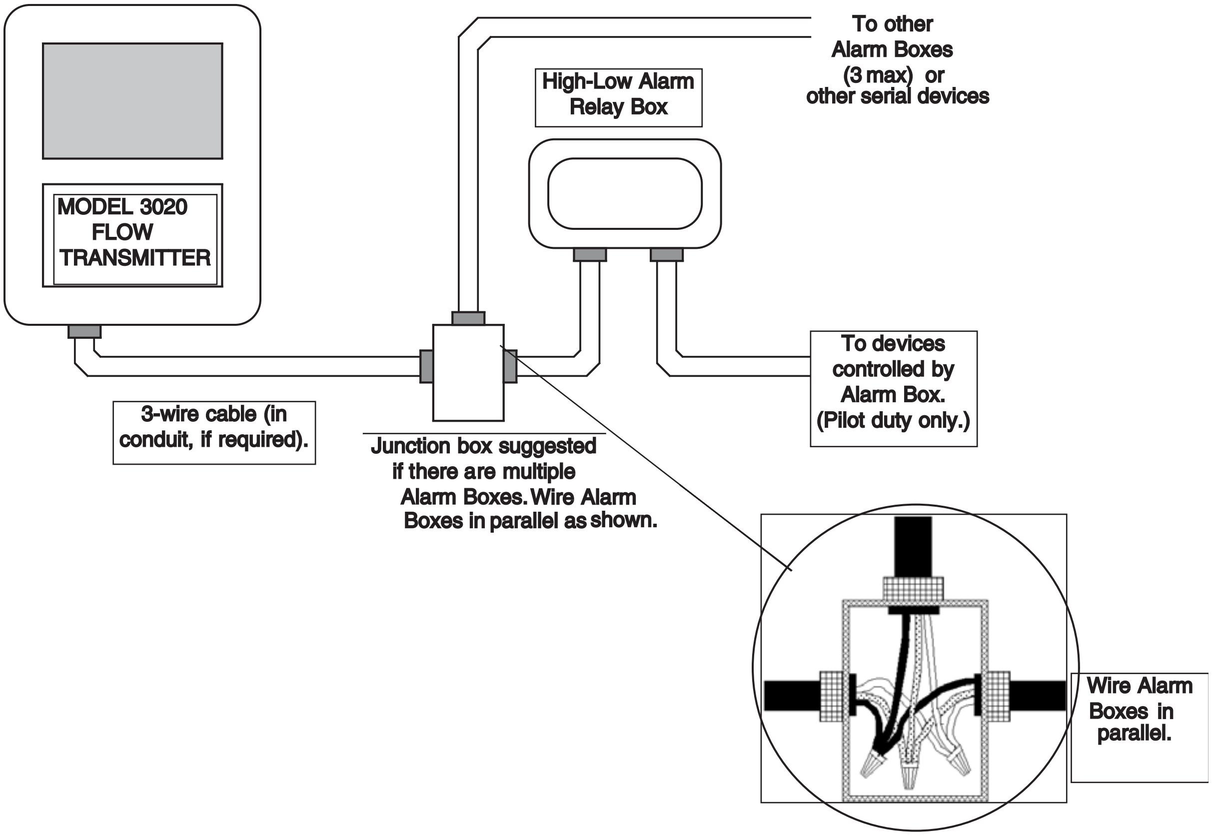


Figure 4-2 Interconnection of 3020 and Alarm Boxe(s)

4.2 Connection to External Serial Devices

The terminals marked 2312 INTERFACE were originally designed for the Model 2312 stripchart recorder, which Teledyne Isco no longer sells. However, these terminals can also be used as a simplex serial output port providing ASCII level and flow rate data for remote transmission. Every 30 seconds, the 3020 transmits a line of data which includes level, units of level measurement, percentage of maximum flow rate, maximum flow rate, a total-flow value, units of flow, sample number, and bottle number. If you are using the flow transmitter with an Isco sampler, the data line also includes an indication of a sampling event. You can transmit this data line to a computer, or connect it locally (within 250 feet) to a device capable of interpreting serial data, such as a video display terminal or a printer. The specifications for this serial data output are as follows: **300 baud, 7 data bits, 2 stop bits, even parity**. The printed (or displayed) line contains 110 characters and will appear similar to the following:

```
+01.409F 100.00% 2.500+0 CFS 0001533+0 CF 00 00
```

The first number is the level in feet. The second number is the percentage of flow rate at maximum head. The third number is maximum flow rate; the fourth is units of flow. The fifth is total flow and units of total flow. The sixth and seventh numbers are sample number and bottle number. The last two characters (not displayed) are a 'CR' (carriage return) and an 'LF' (line feed). The large gaps between some of the words indicate extra character spaces which are defined for a 2312 plotter, but not for the 3020.

4.3 Remote Totalizer

Teledyne Isco offers a remote totalizer for use with the 3020. It consists of a 7-digit, non-resettable mechanical counter mounted in a plastic enclosure similar to the alarm box and the Quick Disconnect Box. Mount the remote totalizer the same way as those units.

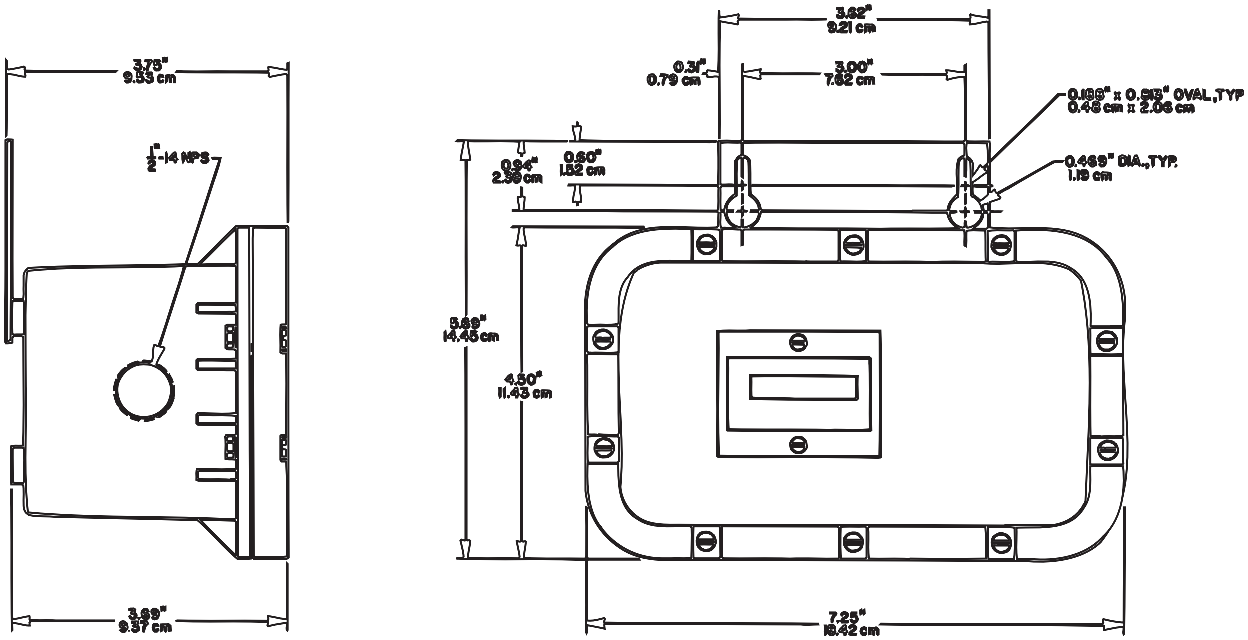


Figure 4-3 Remote Totalizer

4.3.1 Wiring the Remote Totalizer

Connect the remote totalizer to the 3020 with a 2-wire cable. Use your own cable. If the installation is not in conduit, use Stahlin compression fittings to secure the cable to the enclosure. Teledyne Isco recommends sheathed cable to protect the wires and to seal properly through the Stahlin fittings. Minimum wire size is #18 AWG. Maximum distance between the 3020 and the remote totalizer is 1,000 feet (304.8 meters). Connect one wire of the cable to the **+ REMOTE TOTALIZER** terminal in the flow transmitter on TS2. Connect the other wire to the **– REMOTE TOTALIZER** terminal in the flow transmitter. At the totalizer, connect the **+** wire to **terminal 1** on the terminal strip and connect the **–** wire to **terminal 2** on the terminal strip inside the enclosure.

4.4 Extension Cables for the Sensor

The submerged probe level sensor used with 3020 has a 25 foot (7.6 m) or 50 foot (15.2 m) cable attached, depending upon the transducer measuring range. This cable terminates in a 5-pin male M/S connector which plugs into a mating M/S connector at the 3020. **The cable cannot be cut or spliced.** If the cable length is insufficient, extension cables are available from Teledyne Isco in lengths of 25 and 50 feet. These cables come with appropriate mating M/S connectors for the submerged probe and the 3020. For distances greater than 75 feet (22.8 m), Teledyne Isco recommends using the Quick-Disconnect Box.

4.5 Quick-Disconnect Box

The Quick-Disconnect Box is a surface-mounted plastic enclosure similar to that used for the High-Low Alarm Relay Box described at the beginning of this section. Mount this box the same way. Introduce the cables into the box with either conduit or Stahlin cord-grip fittings as code permits in your area. Strip the cables and attach them to the terminal strip inside the box. Connect the cables as shown in the drawing that accompanies the extension cable. Do not install the Quick-Disconnect Box where it may be subject to submersion or abuse. If you do not use any of the holes in the enclosure, make sure you replace the plugs.

4.6 Model 2410 Circular Chart Recorder

The 2410 is a circular chart recorder manufactured for Teledyne Isco. Its general application is to record varying level or flow rate information on a circular chart paper record over a period of time. The time period is either 24 hours or seven days, depending on which version of the 2410 you select. You must connect the 2410 to commercial 120 VAC power to drive its chart motor. This is described in detail in the manual supplied with each unit. The pen recording the level or flow rate on the chart is driven by the 4-20 mA output signal from the 3020. Contact the factory for additional information about the 2410.

4.6.1 Wiring the 2410 Recorder

Select a 2-wire cable for interconnection. The conductors should be #18 AWG and the wires should be color-coded. Maximum length is 1,000 feet. The recorder manufacturer suggests the use of shielded cable and this may be necessary in some instances, such as when the wire run is long, or where high electrical background noise is a problem. Where you make the installation with conduit, **do not** run the signal wires in the same conduit with AC power wiring.

Connect the cable to the **20 MA OUTPUT** terminals of the 3020. Note which color conductor is on which terminal. For example, if the wires are black and white, connect the black wire to the **+** terminal of the 20 MA OUTPUT and the white wire to the **–** terminal of the 20 MA OUTPUT. Next, locate **TB2** in the lower right corner of the 2410 cabinet. Connect the **+** wire (black in this example) to **terminal 1** of **TB2** and the **–** wire (white in this example) to **terminal 2** of **TB2**. Refer to the manual supplied with the 2410 for further information.

Section 5 Maintenance and Troubleshooting

This section of the 3020 Instruction Manual provides instructions on maintenance necessary to keep the flow transmitter in top operating condition. There are sections on cleaning the flow meter case and maintaining the submerged probe level sensor and its desiccator, accessing mechanical and electrical components, fuse replacement, and the repair of CMOS circuitry. Also included are a troubleshooting section, a replacement parts list, and an accessory parts list.

Teledyne Isco recommends becoming completely familiar with the routine maintenance procedures presented here. While the 3020 is ruggedly built to withstand severe field conditions, it will function best and remain most reliable if these simple procedures are learned and followed.

5.1 Care of the Flow Transmitter Case

Under normal operating conditions, the case should require little or no maintenance. In very dirty installations, the window may get clouded over time. Clean it with a soapy rag, or spray it with an aerosol of mild detergent, and then wipe it dry with a clean, soft cloth. Do not use abrasives or any kind of solvent on the window, or the plastic may become scratched, clouded, or cracked. Make sure the lid is tightly latched. Compressed air may be used to blow away dust and debris from the case.

5.1.1 Case Seal

Periodically inspect the case seal and clean it if necessary. The ridge around the edge of the back half of the flow transmitter cabinet forms a seal with the groove in the cabinet door. This seal should be free of dirt, sand, etc. If it is dirty, clean it carefully with a damp cloth. The rubber gasket in the lid should also be clean; if not, it may be cleaned with a small brush and a damp cloth. If you do any of these cleaning procedures while the case is open, be careful not to allow any dirt or debris to fall inside the flow transmitter case. If the flow transmitter is installed outdoors and the seals are not properly maintained, they may leak, causing damage and eventual failure of the components inside.

5.1.2 Preventing Moisture Damage

To prevent damage to internal components, keep the lid tightly latched at all times, except when it is necessary to access the front panel to change the program. Do not operate the flow transmitter routinely with the case open. Doing so will expose the internal components to dirt and moisture. This is particularly true when the flow transmitter is installed outdoors or in wet locations. **Do not operate the flow transmitter with the protective cover over the wiring removed.** This creates a serious shock hazard.

5.2 Regenerating the Desiccant Cartridge

The 3020 includes a desiccant cartridge as part of the installation. This is a plastic tube filled with particles and attached to the flow transmitter (or Quick-Disconnect Box) with a clamp and a silicone rubber tube. The purpose of the desiccant cartridge is to prevent any moisture from entering the reference port vent tube for the submerged probe. On flow transmitters equipped with the pig-tailed M/S connector, the desiccant cartridge is mounted on the bottom of the flow transmitter case. Installations which use the Quick-Disconnect box will have the desiccant cartridge mounted on the Quick-Disconnect box, rather than at the flow transmitter. Either way, the desiccant cartridge requires inspection and periodic servicing.

5.2.1 Determining Condition of Desiccant

As long as the color of the particles inside the cartridge is blue or yellow, the desiccant is good and need not be regenerated. The cartridge will first begin to turn pink or green at one end of the cartridge as water is absorbed. As time passes, the pink or green color will spread through the rest of the desiccant until eventually, the entire cartridge will become pink or green. Before the entire cartridge has changed color, the desiccant should be regenerated.

5.2.2 Identify Desiccant

Teledyne Isco uses two types of silica gel:

- One looks like small beads or pellets that are blue-black when dry, pale pink to transparent when saturated.
- The other looks like coarse sand, yellow when dry, dark green when saturated.

Regenerate desiccant by heating at 212° - 350° (100° - 175°C).

⚠ CAUTION

Teledyne Isco has received reports of irritating fumes coming from the desiccant during regeneration. We have been unable to duplicate this, but suggest using caution anyway. Identify the desiccant you have. Use a vented oven in a well-ventilated room. Do not heat the desiccant to higher temperatures or for a longer time than necessary. Do not remain in the room while the regeneration process is going on.

5.2.3 Regeneration Procedure

To regenerate the cartridge, first snap it out of the brackets holding it to the case and detach the silicone tubing from the end of the cartridge. Then pull one of the end caps off the cartridge and pour the spent desiccant into a small metal pan or other heat-resistant container. Refill the cartridge with the extra desiccant provided and replace the end caps. The filters in the end caps keep pieces of the desiccant from falling out of the cartridge. Clean the filters periodically using ordinary dish soap and water, then allow to dry. Use the preceding descriptions to identify which desiccant you have. Then regenerate it by placing the particles in a shallow layer in the bottom of the heat-resistant container and heating them at the proper temperature for several hours, or until the blue or yellow color returns.

⚠ CAUTION

Do not attempt to regenerate the desiccator by placing the entire cartridge in an oven. The cartridge is plastic and will melt. Do not use a microwave oven. Do not allow moisture to enter the reference tube for the submerged probe.

Why Regenerate? It is very important to regenerate the desiccant, even though the flow transmitter will continue to operate for some time with a saturated desiccant cartridge. The problem is that soon water vapor will get inside the reference port vent tube. If enough condenses, it will form water drops that can easily block the narrow reference tube.

If water drops form inside the tube, the reference port will no longer be at atmospheric pressure, and level readings will become erroneous. Since you cannot see the water, you have no way of knowing it is there. Once the drops form, they are very difficult to remove. You could try compressed air if the water is inside an extension cable, since that has open connectors on both ends. However, you cannot blow water out of the probe cable, since it is only open on one end. **Over time, moisture in the probe reference line can cause permanent internal damage.** You can avoid this serious problem completely with a little maintenance. Also consider that the desiccant cartridge serves as a filter to keep out solids, such as dirt or small insects, which can also block the line.

5.3 Care of the Submerged Probe and Cables

The submerged probe and its cable require little periodic maintenance unless there is a great deal of debris in your flow stream. Certain materials that swell when wet, such as sawdust, can clog the ports of the probe blocking the hydrostatic pressure of the stream from reaching the transducer. The submerged probe pressure transducer is in a stainless steel housing filled with silicone oil.

The transducer is directly behind a thin stainless steel diaphragm that faces the nose section of the probe. If you remove the nose section from the submerged probe to clean it, this diaphragm will be exposed. Read the following sections carefully before attempting to disassemble the probe.

⚠ CAUTION

If you disassemble the submerged probe for cleaning, do not touch the stainless steel diaphragm with your fingers or tools. The diaphragm is very thin (<0.003"), and easily bent.
The slightest deformation may result in damage to the transducer or the placing of a permanent offset on it. In either case the submerged probe will be ruined. Do not drop the assembly or subject it to any physical abuse.

5.3.1 Low Maintenance

The submerged probe contains no user-serviceable parts and normally requires no maintenance. The probe will continue to function even when covered with several inches of silt, sand, or other solid materials. It is generally not necessary to clean accumulated solid materials from the vicinity of the probe.

However, it may be beneficial to periodically clean the flow stream up- and downstream from the submerged probe to maintain the hydrostatic conditions on which the level-to-flow rate conversion is based. The probe has been designed to expose a small frontal area and a streamlined profile to the flow, and that reduces the possibility of accumulating deposits of solid materials.

If level readings become erratic or erroneous, return the probe to Teledyne Isco Technical Service for evaluation.

5.3.2 Cleaning the Submerged Probe Without Disassembly

Occasionally, organic materials may become jammed inside the submerged probe's housing. If this material swells as it becomes saturated with water, it will exert pressure on the stainless diaphragm placed over the transducer. In the unlikely event that all entrance ports in the submerged probe housing become blocked with material that does not permit the pressure above the probe to be transmitted to the pressure transducer, you may clean the probe with the following procedure:

1. Remove the submerged probe and its mounting apparatus from the flow stream.
2. Scrape any accumulated solids off the exterior of the submerged probe body with a brush.
3. Gently flush the inside cavity of the submerged probe with water. Do not use brushes or tools to try to remove matter lodged in the submerged probe's ports or cavity.
4. If the ports are clogged and do not clear with the running water, you may have to carefully disassemble the submerged probe.

5.3.3 Disassembling the Probe for Cleaning

If you cannot clean the submerged probe sufficiently by washing and brushing the exterior, or if you want to completely clean the unit prior to long-term storage, remove the probe from the flow stream and proceed as follows:

1. Clean the exterior of the submerged probe with a stiff brush and flowing water.
2. Remove the submerged probe nose section by unscrewing the two flat-head screws that hold the nose section in place.
3. Pull the nose section straight out of the probe body.
4. Flush the probe cavity with gently flowing water to wash out any accumulated solid materials.

Figure 5-1 Warning Disk Inside Probe

Again, any deformation of the stainless steel diaphragm will permanently disable the submerged probe. If you must remove the nose of the probe, do it very carefully. A small warning disk is located in front of the transducer. **Do not** remove the warning disk.

After cleaning, reinstall the nose section and tighten the screws. **The mounting hole must be aligned with the grounding point.**

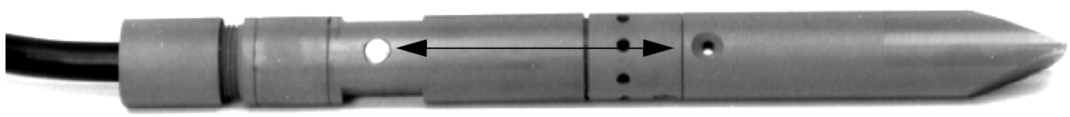


Figure 5-2 Alignment of Grounding Point

5.3.4 Cable Inspection

Periodically inspect the submerged probe cable for wear. Damaged cables can affect the operation of the probe, particularly if the reference port vent tube inside the cable is collapsed or blocked. Damaged cables cannot be spliced or repaired successfully and should be replaced.

If the submerged probe cable is damaged, you must replace the probe assembly, as the probe, cable, amplifier, and connector are a factory-sealed unit that cannot be repaired. Keep connectors clean and dry. In permanent installations, such as treatment plants, for example, install the cables so they are not at risk of damage resulting from other activity taking place in the area.

In temporary installations, do not leave cables lying around where they may be run over by heavy equipment. Do not leave extra cable lying in the flow stream where it can trap debris.

In permanent installations, cables repeatedly subjected to rough environments will fail and should be installed in conduit for protection. The conduit must be large enough to pass the M/S connectors, as you cannot remove or replace them.

⚠ CAUTION

Avoid putting heavy pressure on the submerged probe cable or making sharp bends in it when installing or servicing the probe. Excessive pressure may collapse the cable, crushing the reference vent tube. Sharp bends may cause the cable to kink, also blocking the vent.
When securing the cable with plastic cable ties, tighten them only enough to secure the cable; do not tighten them so much that the cable jacket is visibly deformed.

5.4 Mechanical and Electrical Components

The flow transmitter cabinet has two sections, upper and lower. The upper section contains the circuitry for the microprocessor, the keypad, the driver for the submerged probe level sensor, the totalizer, and the display. The board containing this circuitry (CPU) is enclosed in an aluminum housing for isolation and protection. Cables with connectors on both ends pass through the partition separating the two sections to the lower section which contains the terminal printed circuit board. See Figure 5-3 for a view of the aluminum cover and the cables. All wiring to the flow transmitter is connected to terminals on this board, which also contains the transformer, the beeper, sampler output relay, and fuse. This circuit board is covered with a protective shield to prevent accidental shock from touching the AC wiring below.

5.4.1 Accessing the Terminal PCB

First, remove the four Phillips screws holding the lower section face plate to the cabinet. This will expose the protective cover over the terminal PCB. Remove the four screws from the protective cover. Pull out the cover. The terminal PCB is now accessible.

⚠ WARNING

**Electrocution Hazard! You can be killed if you touch 120 VAC connections exposed on this board. Do not wire or attempt troubleshooting with power connected.
Disconnect power at the breaker panel or cutoff switch before changing the fuse, wiring, or removing the circuit boards.**

5.4.2 Accessing the Flow Transmitter PCB

First, remove the four screws holding the upper section face plate to the cabinet. Carefully lift off the plate. The main circuit board is inside the aluminum housing. See Figure 5-4. Remove the screws holding the aluminum housing. Lift off the aluminum housing. Note the two connectors with cables coming from the lower section of the case. Disconnect them at either end by pulling vertically from the board.

⚠ CAUTION

The 3020 circuit boards contain CMOS semiconductors, which are easily destroyed by the discharge of static electricity. Do not attempt troubleshooting or repair at the job site. Return the board to the factory for servicing or make repairs at an appropriately-equipped service area. See also Section 5.7.3.

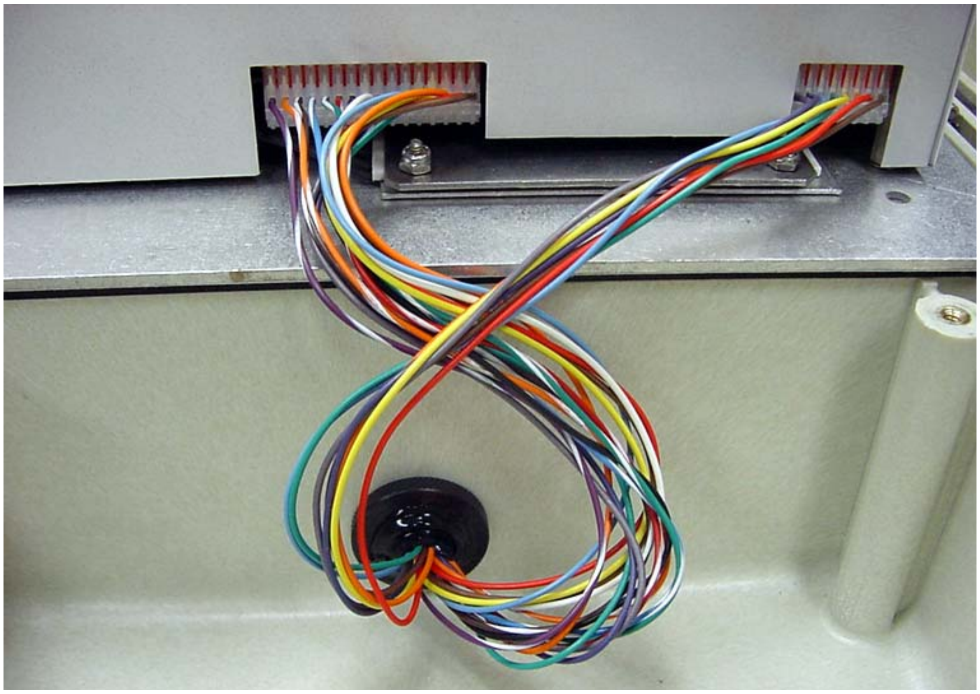


Figure 5-3 Aluminum Cover and Interconnect Cables

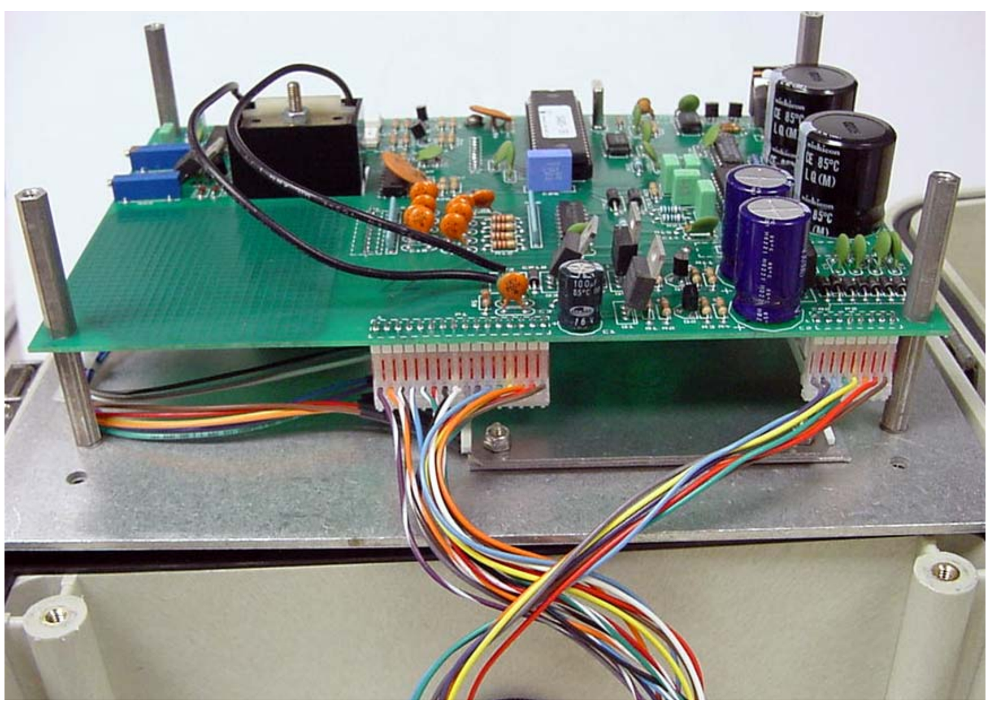


Figure 5-4 Circuit Board with Aluminum Cover Removed

5.4.3 Fuse Replacement

With the lower section of the cabinet open, the user can change the fuse. The fuse is located on the terminal PCB on the left side of the board next to the transformer. It is visible when the protective cover is off. See Figure 1-4. The fuse is labeled **F1**. The proper size for this fuse is **½ amp., Slow Blow**.

Always replace a blown fuse with one of the same rating. Using a larger fuse may cause serious damage to the unit and could even cause a fire hazard by burning up the transformer if there is a severe short on the secondary. **Turn off power before changing the fuse.**

If the new fuse blows immediately after power is restored, a serious problem is indicated. Either have the flow transmitter repaired by properly qualified personnel or return the flow transmitter to the factory for servicing.

5.5 Display Warnings

The 3020 LCD displays various error messages to warn the user of problems in the program, or difficulties inside the flow transmitter. Messages will generally assume the format of:

EE - X

(**X** represents a number or numbers from 1-80.)

The codes are indicative of software errors and are of no particular concern to the user. If they appear, exit the program by pressing CLEAR ENTRY twice and start the programming sequence over.

5.5.1 Software Reset

You can reset the flow transmitter's software by turning off power, holding down **4** and **CLEAR ENTRY** at the same time, and restoring power. This may require more than one person and it will be necessary to completely reprogram the unit afterwards. A repeated error message that will not clear or prevents you from programming indicates a serious internal problem. It may require service.

☑ Note

The software reset (4 + CLEAR ENTRY) replaces the user's program with factory default settings. Record all program settings prior to performing the reset.

5.6 Hints on Troubleshooting

The electronic circuitry of the 3020 is solid-state and its reliability is high. If the unit should fail to operate properly, the problem may be a mechanical failure. Check for a loose connector or a clogged reference line.

⚠ CAUTION

Do not attempt to service the 3020 Flow Transmitter unless skilled in the analysis and repair of digital circuits. You must also know how to work safely on AC-powered equipment, as a real safety hazard is present here. If the technical information presented in the following sections is not clear to you, do not attempt to make repairs, other than changing the fuse, or cleaning the submerged probe level sensor if it is dirty. Refer all other repairs to qualified service personnel or organizations.

5.7 If Serious Problems Occur

If you suspect an electronic problem, Teledyne Isco strongly recommends that you call the Teledyne Isco Customer Service Department - (800) 228-4373 or (402) 464-0231 outside the U.S.A. The Customer Service Department will advise you how to return the 3020 to the factory. The Teledyne Isco Technical Service Department has trained technicians and specially-designed equipment necessary for timely, efficient repair of the 3020. If you wish to attempt repairs, the Teledyne Isco Technical Service Department is available to provide advice and information on servicing.

When attempting to isolate problems within the unit, assume the CPU and memory are working properly until attempts to find problems in the rest of the circuitry have been exhausted. This is for two reasons: first, the likelihood of failure is far greater on transistor drive circuits (heavier currents pass through here) than on the CPU or memory. Second, it is doubtful whether the repair facility would have the time or equipment to do worthwhile troubleshooting (beyond changing components) on the CPU or memory.

5.7.1 Preliminary Troubleshooting Steps

Following are suggested areas to check before attempting to service the microprocessor CPU and associated circuitry.

- Check the fuse and the 120 VAC supply for the flow transmitter.
  Sometimes equipment appears to have failed completely when the real problem is only disconnection of the AC power source. Either a blown fuse, or someone accidentally flipping off the breaker can cause this. Also make sure the voltage selector switch on the terminal printed circuit board is in the correct position.
- Look for evidence of physical damage.
  You can usually identify readily burned or broken components, broken wires, overheated components, burned foil traces on the board, stuck or inoperative switches, loose or wrong connections, or evidence of water damage.
- Consider the possibility of a lightning strike.
  Inexplicably large numbers of bad semiconductors, burnt components, or parts of the board are indications that lightning has struck nearby. A close hit can destroy most of the components on the board, especially the

semiconductors. In such cases, you are better off to replace the board outright, rather than attempt to make repairs.

- Look for shorted or open diodes and transistors. Semiconductors, particularly power-handling ones, are prone to failure from short- circuiting, and you can usually identify this with an ordinary ohmmeter. Note however, that you cannot identify failed power MOS semiconductors this way.
- Check to see that voltage regulators are working properly.
  Properly working voltage regulators should operate within 5% of their rated value or better. A low 5-volt rail is an almost certain sign of trouble. Check to see there is no abnormal current draw in part or all of the circuitry. (Abnormal current draw will usually be indicated by the noticeable overheating of a voltage regulator, current-limiting resistor, or some other part of the circuit.)
- Make sure the crystal oscillator is running and at the proper frequency.

5.7.2 Precautions for Servicing AC-Powered Equipment

The 3020 is a low-voltage, DC-powered device, and hazardous voltages are not present on the CPU board. However, the unit converts power from 120 or 240 VAC to the DC used to run the flow transmitter. As a result, **hazardous voltages are present** on the 3 terminals of TS1 and some other places. Because of the shock hazard, Teledyne Isco suggests the following:

- Use a 1:1 isolation transformer.
  An isolation transformer separates the power needed for the flow transmitter from the commercial power supply, relieving the danger of electrocution from accidental grounding. Such transformers are available from electrical and electronic supply houses in various sizes. Regulated versions are even available. A 100 VA rating is sufficient for working on the 3020. Any knowledgeable technician can also create an isolation transformer by connecting two identical transformers (voltage and VA rating) back-to-back. You should still be very careful, however, because the isolation transformer only isolates you from the grounded AC system. **The voltage coming out of the isolation transformer is hazardous, easily carrying enough current to kill.**
- Use a GFCI-protected outlet.
  If you cannot find an isolation transformer, at least make sure the AC power source is protected by a GFCI (Ground Fault Circuit Interrupter) breaker or outlet. If there is accidental grounding, the GFCI will trip quickly, stopping the current flow.
- Avoid working on the terminal board while it is connected to AC.
  Make use of visual and low-voltage continuity and resistance checks as much as possible on this circuit board.

- If you must work on the terminal board with power applied, use extreme caution.
  Do not touch any part of the high voltage side of the circuit (TS1, fuse and transformer primary) with fingers or hands. Use insulated tools only. Remember that the voltage here is potentially fatal whether grounding is involved or not. Note that in general, the components on the terminal board (other than the fuse) are relatively unlikely to fail. It would be more worthwhile to concentrate troubleshooting on the CPU circuit board.
  Use of an isolation transformer will eliminate the possibility of shocks resulting from accidental grounding. Use of a GFCI will disconnect the power source quickly in case of an accidental ground. While wrist grounding is necessary for the safe servicing of CMOS components (see the following section), do not use a "hard" ground (less than 1,000 ohms), because that will cause any shock received to be severe or even fatal, due to the excellent connection between body and earth ground. Instead, use a grounding strap with at least one mega-ohm resistance, which is adequate for discharging static while at the same time safe for working with higher voltages.

5.7.3 Precautions for Servicing CMOS Circuitry

Most of the circuitry in the 3020 is made up of CMOS components. Because of the oxide gate structure of these devices, they are extremely susceptible to destruction caused by the discharge of static electricity through their inputs. Many of the driver transistors in the 3020 are power MOS devices; they are as susceptible to static damage as CMOS ICs. Because of this risk, you must take certain precautions when working on these circuits.

Hazard of Static Electricity – The voltage levels present from static buildup caused by walking over carpeted floors, movement of woolen or synthetic clothes over chair seats, workbenches, etc., are high enough to destroy CMOS circuitry when performing repair work. Ideally, you should ground all tools, soldering irons, etc., and you should do repair work on a grounded metal workbench, with grounding straps worn on your wrists. It is recognized that in most field repair situations, such precautions are impractical. However, you ought to avoid certain extreme hazards.

- Never perform any work in a room with a carpeted floor.
- Always roll up sleeves so that your arms are in contact with the working surface.
- Avoid using a work surface made of an extremely good insulator.
  Avoid plastic counter tops or glass as they are good insulators. A metal surface is best, but do not let components connected to the AC line touch a metal surface, particularly a grounded one. Wood or compressed wood by-product surfaces are marginal and we do not recommend them for use in winter or for severely dry

environments. Conductive grounding mats are available for workstations and are the best solution for discharging static and allowing safe repair of AC-powered equipment.

- The degree of hazard depends on the level of humidity. Be particularly careful if the work area is extremely dry, or if the work is being done in the winter, when forced heating and cold outdoor temperatures make relative humidity levels very low. Installing a humidifier in the work area is a good idea.
- Keep yourself grounded when handling disassembled equipment.
  If you have opened a unit for repair, make an effort always to touch the metal chassis before touching any of the circuit components. Note, however, the precautions about working on AC-powered equipment outlined in Section 5.7.2.
- Be especially careful handling the CMOS integrated circuits when they are separated from the rest of the circuitry.
  Simply being connected to the rest of the circuitry provides some protection. Most of the circuitry is well protected from damage caused by static discharge when the unit is powered up. However, never replace an IC when the unit is turned on.
- Always transport individual CMOS semiconductors and built-up printed circuit boards in conductive packaging. Foil is satisfactory; metallized plastic bags are also available and work well. Ordinary plastic bags and "pink poly" are not satisfactory unless the IC legs or leads are also pressed into a block of black conductive foam. If replacement components do not come in marked, protective packaging, do not use them. They may already be destroyed.
- Once assembled and soldered, printed circuit boards are easily damaged by improper repair procedures.
  Do not attempt to remove components, particularly ICs, from printed circuit boards unless you are skilled at this procedure. You can find a defective component and replace it, and the unit will still not work if too much heat or pressure break the foil traces or pulls the copper cores out of holes on the board. The simplest method for removing ICs is to cut off the legs at the chip body, remove the chip, and then desolder the legs from the board one at a time. Finally, clear the holes with a vacuum pump or solder wick.

5.7.4 Call for Assistance

If trouble symptoms persist and cannot be located, call the Customer Service Department, at **(800) 228-4373**. Outside the U.S.A., call **(402) 464-0231**.

5.8 Circuit Boards

The 3020 is a microprocessor based instrument that executes a program stored in memory. The circuitry (hardware) is discussed below. Because of the difficulty and specialized equipment necessary to check program software, its detailed description is beyond the scope of this manual. The 3020 contains several printed circuit boards. The keypad is mounted under an aluminum plate just behind the top front panel. It connects to the CPU board with a cable and connector. The CPU and display are inside the chassis in the top section of the flow transmitter. The display is attached to the CPU board.

5.8.1 Terminal Board

The terminal strip board is mounted in the bottom section of the flow transmitter cabinet under a protective cover. All field and power wiring brought into the flow transmitter is connected to this board. Connectors carry power and various signals to the CPU board which is mounted in the upper half of the flow transmitter cabinet in an aluminum housing. Switch **SW1** selects the input power voltage—120 or 240 volts.

⚠ WARNING

Hazard of electrocution! You can be killed if you touch the AC connections exposed on this board. Do not attempt troubleshooting with power connected. Otherwise, Teledyne Isco recommends only visual inspection or simple continuity checking with no power applied to the board.

AC power enters the board on TS1 and energizes the transformer T1 primary. F1, a ½-Amp, slow-blow fuse, protects the entire circuit. C1, C2, L1, and L2 provide transient suppression. Transistor Q1 drives the beeper. The relay provides flow pulses to the sampler. The remainder of the board essentially carries logic level signals from the main CPU board to the various terminals on TS2 and TS3.

5.8.2 CPU Board

U11 is the microprocessor that controls the rest of the board and performs level and flow calculations.

The submerged probe transmits pressure to the 3020 as a voltage that is proportional to pressure, which is also proportional to depth. U3 converts this voltage to a digital number, which is sent to the microprocessor. This number is used by the microprocessor to calculate the level and the flow rate.

The event mark and bottle count are input to U4 and from there go to U11, the microprocessor.

U6 is an EEPROM (Electrically Erasable Programmable Read Only Memory) used to store information so it will not be lost when the power is turned off.

U2 is used to de-multiplex keyboard information and decide which key has been pressed.

U14 and U10 are optocouplers used to optically isolate the 4 to 20 mA current loop from the rest of the electronics. U9 converts the serial data coming from U14 into parallel data for U8 which is a D to A converter. U7 amplifies the output of the D to A converter and shifts the level of the output so it is referenced from the negative side of the power supply. Q1 and one amplifier in U7 are used as a voltage controlled current source to control the current output.

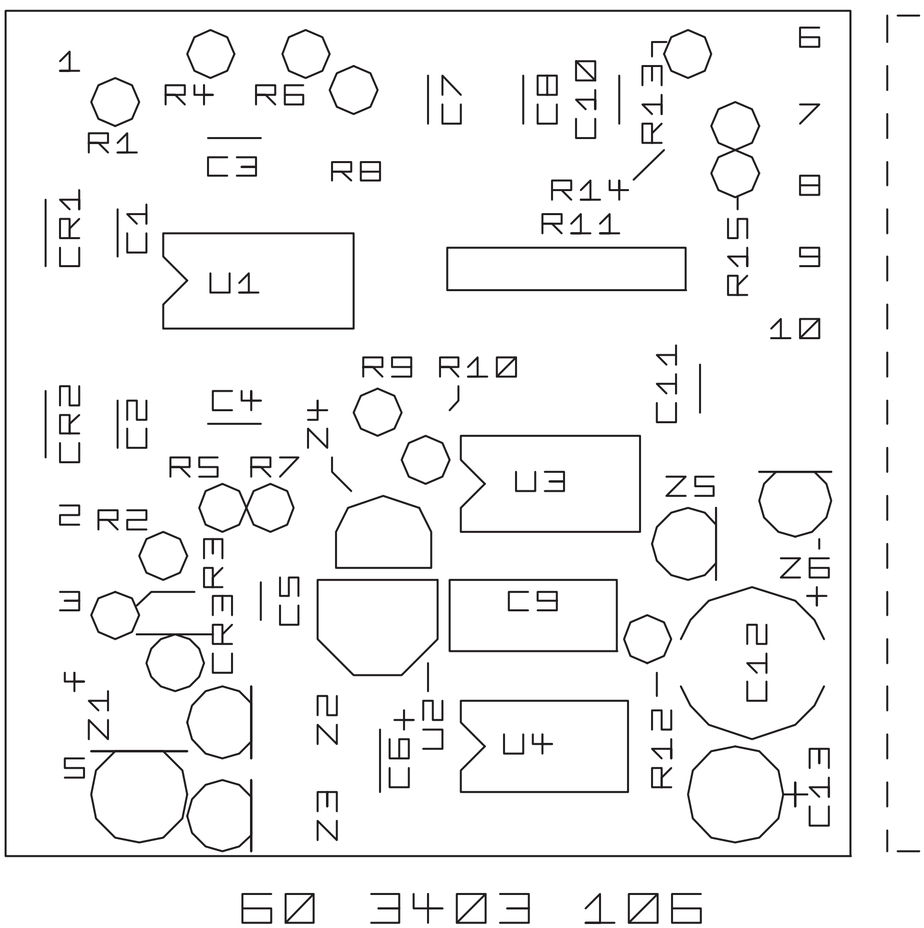


Figure 5-5 Component Layout of the CPU PCB

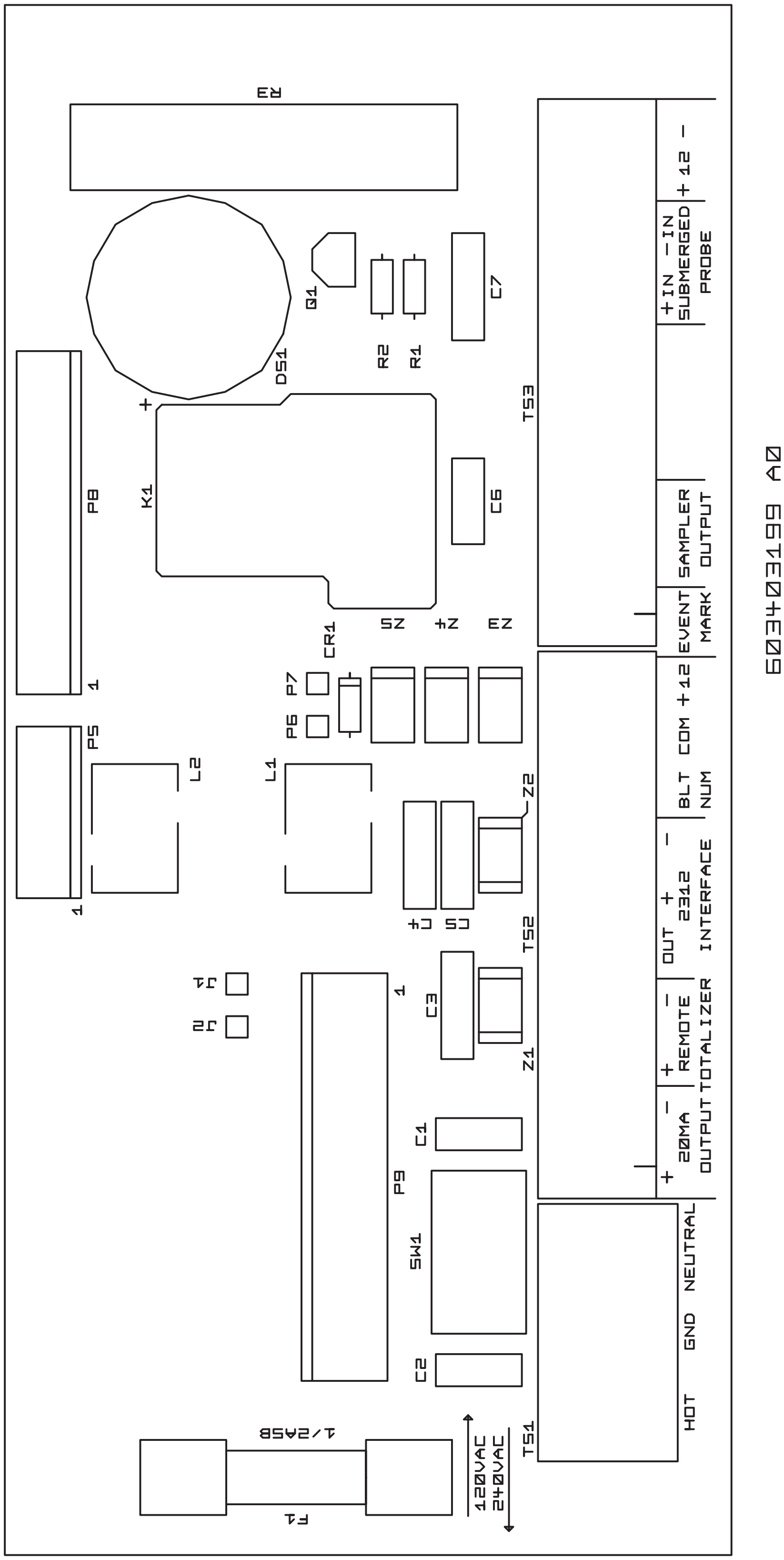


Figure 5-6 Component Layout of the Terminal Board

3020 Flow Transmitter

Appendix A Replacement Parts and Accessories

A.1 Replacement Parts List

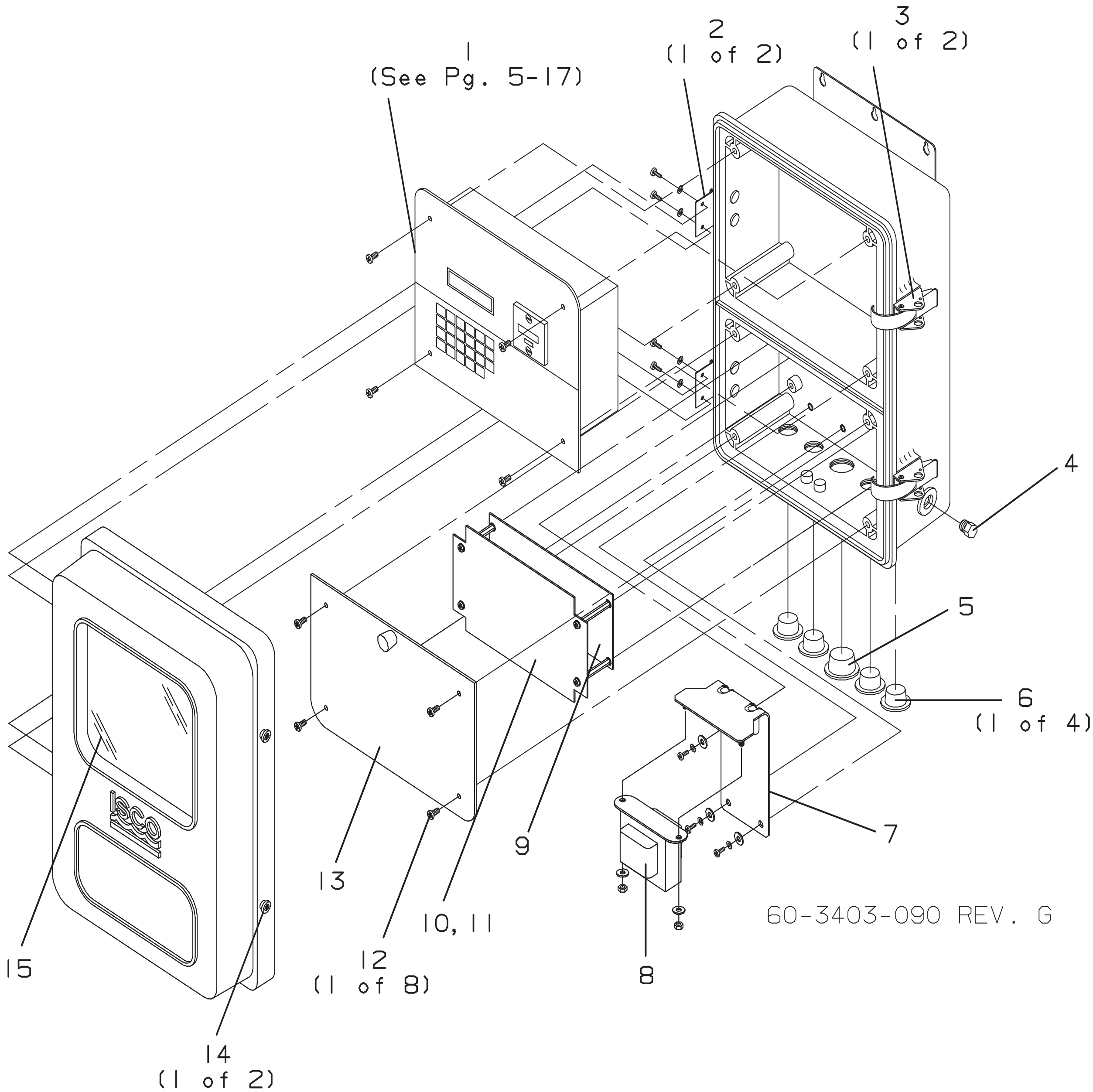
Replacement parts are called out in the following pages, followed by a list of accessories. Refer to the callout in the adjacent table to determine the part number for the item.

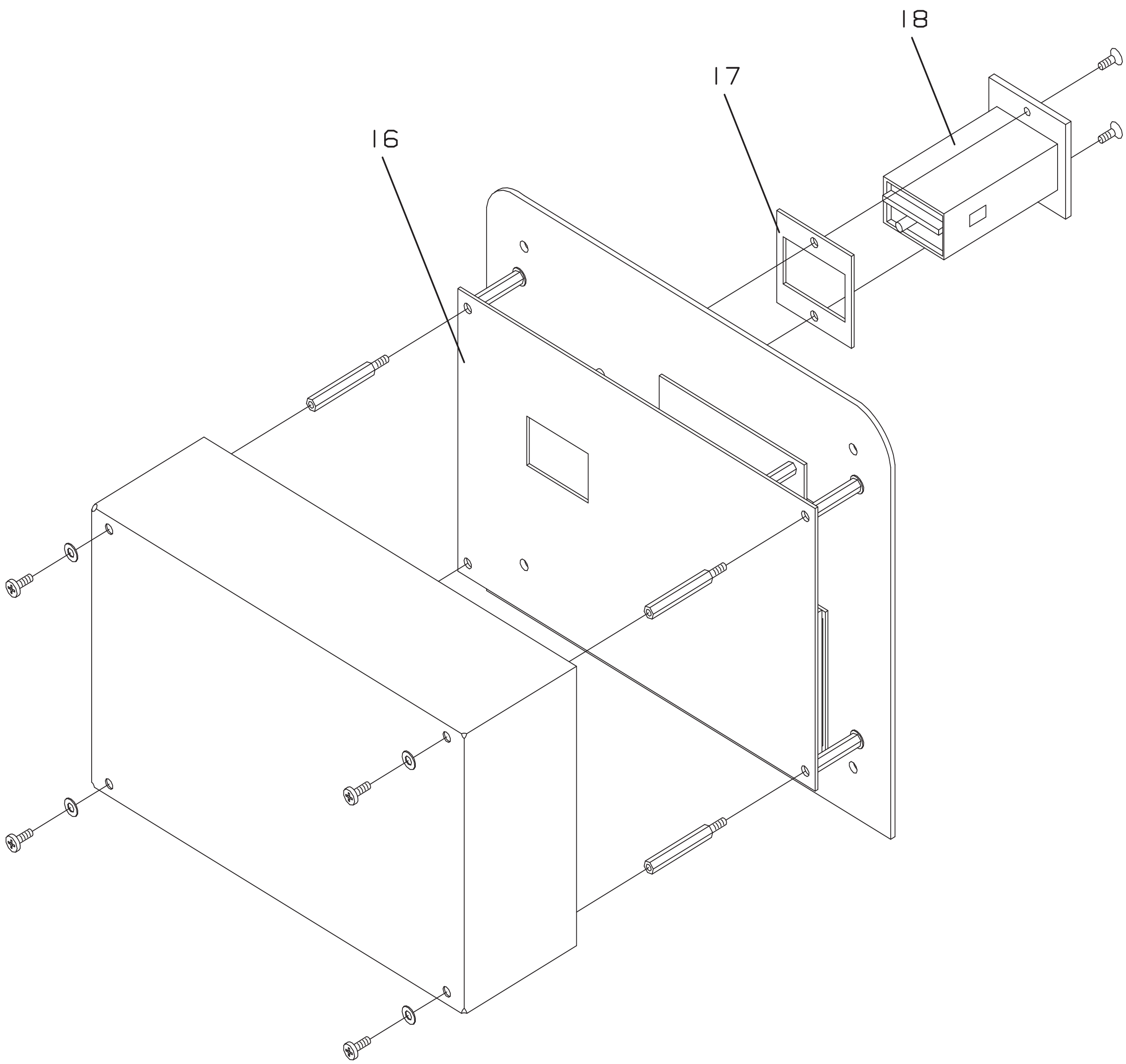
Replacement parts can be purchased by contacting Teledyne Isco's Customer Service Department.

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

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

E-mail: IscoInfo@teledyne.com


1
(See Pg. 5-17)
2
(1 of 2)
3
(1 of 2)
4
5
6
(1 of 4)
7
8
9
10, 11
12
(1 of 8)
13
14
(1 of 2)
15
60-3403-090 REV. G


16
17
18

603403090

REPLACEMENT PARTS LIST MODEL 3020

SHEET: 3 OF 3

TELEDYNE ISCO, INC.

REV: G | DATE: 011712

ITEM NO.	PART NUMBER	DESCRIPTION
1	603404043	CONTROL PANEL ASSEMBLY, SUBMERGED PROBE
2	603403040	CASE HINGE
3	109080000	DRAW LATCH,OVER CENTER
4	209016601	PLUG 1/8MIPT
5	109030907	TAPERED CAPLUG, 3/4
6	109030906	TAPERED CAPLUG, 1/2
7	603404073	TRANSFORMER MOUNTING BRACKET ASSEMBLY
8	603404074	POWER TRANSFORMER ASSEMBLY
9	603404076	CBA 3020 TERMINAL STRIP
10	603403072	WARNING SHIELD
11	603403075	LABEL, WARNING SHIELD
12	231019506	SCR SS SST PH P 8-32 x 3/8
13	603404063	LOWER COVER ASSEMBLY, METRIC
14	109080100	BUTTON KEEPER, STAINLESS STEEL
15	603213032	WINDOW
16	603404046	CPU WITH DISPLAY ASSEMBLY
17	603403035	TOTALIZER GASKET
18	603404010	IMPULSE COUNTER, 12VDC
19		
20*	611863073	WINDOW SUPPORT #1, IRIDITED
21*	411031130	FUSE 3AG, 250V, .5A, SLO-BLO
22*	603403034	UPPER PANEL GASKET
23*	603403036	LOWER PANEL GASKET
	*NOT SHOWN	

NOTE: 1. For current prices and quotations on parts, contact Isco Service Department.
2. This list is subject to change without notice.

A.2 Accessories and Spare Parts

When ordering an optional or accessory part, include the description and Teledyne Isco part number.

3020 for conduit installation (uses Quick-Disconnect Box) 68-3020-001

3020 for non-conduit installation 68-3020-002

Submerged Probe, 10’ Range (with 25-foot cable) 60-3224-002

25’ Extension Cable for the Submerged Probe 60-3224-004

50’ Extension Cable for the Submerged Probe 60-3224-005

Cable Connect Kit for the submerged probe level sensor for non-conduit installations .60-3404-048

Submerged Probe Quick Disconnect Box 60-3224-003

Submerged Probe Carrier Assembly *(Use with Isco Mounting Rings)* 60-3204-005

Reference port vent tubing (for use with
Quick-Disconnect Box where there is a possibility of submersion)

10 ft. 60-2703-111

25 ft. 60-2703-112

For non-conduit installations, a watertight cord grip is also required; see below.

Connect Cable, Series 3000 Flow transmitter to
Isco Sampler, 22 ft., non-conduit installations 60-1394-077

NOTE: Watertight cord grip fitting also required. p/n 207-0076-04

Flow transmitter to Sampler Y Connect Cable 60-3704-081

High Low Alarm Relay Box 60-3404-028

High Low Alarm Relay Box Instruction Manual 60-3403-071

Remote Totalizer (Eight digit, non-resettable) 60-2440-019

Connect Cable (Series 3000 Flow Transmitter to 2410 Circular Chart Recorder)

25 ft. 68-3020-009

50 ft. 68-3020-010

100 ft. 68-3020-011

250 ft. 68-3020-012

Watertight Cord Grip Fittings (Stahlin Fittings)

For 0.187" to 0.250" diameter cable. 209-0076-03

For 0.250" to 0.312" diameter cable. 209-0076-04

For 0.312" to 0.375" diameter cable. 209-0076-05

For 0.375" to 0.437" diameter cable. 209-0076-06

For 0.437" to 0.500" diameter cable. 209-0076-07

For 0.500" to 0.562" diameter cable. 209-0076-08

AC Power Cord (includes watertight cord grip fitting) 68-2410-001

Isco Open Channel Flow Measurement Handbook 60-3003-041

Submerged Probe Standard Nose Section 60-2503-086

Submerged Probe Slanted Nose Section 60-2503-097

Flume Probe Cap 60-2503-105

Submerged Probe Mounting Ring, 6" diameter pipe 68-2500-010

Submerged Probe Mounting Ring, 8" diameter pipe 68-2500-011

Submerged Probe Mounting Ring, 10" diameter pipe 68-2500-012
Submerged Probe Mounting Ring, 12" diameter pipe 68-2500-013
Submerged Probe Mounting Ring, 15" diameter pipe 68-2500-014
Four Foot Probe Extension. 60-2504-036
Submerged Probe Carrier Assembly *(Use with Isco Mounting Rings)* 60-3204-005

Mounting Rings

Probe Mounting Ring for 6" pipe 60-3200-007
Probe Mounting Ring for 8" pipe 60-3200-008
Probe Mounting Ring for 10" pipe 60-3200-009
Probe Mounting Ring for 12" pipe 60-3200-010
Probe Mounting Ring for 15" pipe 60-3200-011

Universal Mounting Ring (for Pipes 16" diameter and larger)

Base Section (with tabs for mounting up to five probes) 60-3004-171
Scissors Assembly. 60-3004-170
Extension 1 (9.0") 60-3004-172
Extension 2 (21.5") 60-3004-173
Extension 3 (31.5") 60-3004-174
Extension 4 (41.5") 60-3004-175

☑ ***Note***

Universal Ring Assemblies will require a base and scissors section for all sizes. Sizes from 21” to 80” will also require two or more extension sections.

Appendix B Programming Worksheets

The following is a worksheet for the user to select desired entries for each step of the 3020 program. Make several photo copies of this sheet. It is suggested that the user circle selected entries with a pencil; where numeric values are required, they may be written in. The Flow Transmitter may then be programmed by entering the values selected on the worksheet.

☑ Note

Programs will not require entries for every line shown below; choosing some entries will make other steps unnecessary. Study the explanations given for each program step in Section 2 before attempting to fill out the worksheet. Refer to the Simplified Flowchart Diagram, Figure 2-1, for an overview of the Programming sequence. The 3020 Flow Transmitter will reject invalid entries.

Step 1: Select Units (feet or meters)__________________

Step 2: Select Primary Device.

1. V-NOTCH WEIR
2. RECTANGULAR. WEIR WITH END CONTRACTIONS
3. RECTANGULAR WEIR WITHOUT END CONTRACTIONS
4. CIPOLLETTI WEIR
5. 1" PARSHALL FLUME
6. 2" PARSHALL FLUME
7. 3" PARSHALL FLUME
8. 6" PARSHALL FLUME
9. 9" PARSHALL FLUME
10. 12" PARSHALL FLUME
11. 18" PARSHALL FLUME
12. 24" PARSHALL FLUME
13. 36" PARSHALL FLUME
14. 6" PALMER-BOWLUS FLUME
15. 8" PALMER-BOWLUS FLUME
16. 10" PALMER-BOWLUS FLUME
17. 12" PALMER-BOWLUS FLUME
18. 15" PALMER-BOWLUS FLUME
19. 18" PALMER-BOWLUS FLUME

20. 24" PALMER-BOWLUS FLUME
21. 30" PALMER-BOWLUS FLUME
22. 48" PALMER-BOWLUS FLUME
23. LARGE 60° V TRAPEZOIDAL FLUME
24. 2" 45° WSC TRAPEZOIDAL FLUME
25. 12" 45° SRCRC TRAPEZOIDAL FLUME
26. 0.5' "H" FLUME
27. 0.75' "H" FLUME
28. 1' "H" FLUME
29. 1.5' "H" FLUME
30. 2' "H" FLUME
31. 3' "H" FLUME
32. 4.5' "H" FLUME
33. LEVEL ONLY
34. EQUATION (SEE STEPS 3-6)________________

Steps 3-6: Equation. NOTE: Steps 3-6 will only be used if #34 above EQUATION was selected in Step 1. Otherwise, go directly to Step 7. The values for the components of the general flow equation are entered in Steps 3-6.

$Q = K[(N1 \times H^{P1}) + (N2 \times H^{P2})]$

Step 3: N1 (-4,999 to +4,999) _______________

Step 4: P1 (0.1 to 3.0) _______________

Step 5: N2 (-4,999 to +4,999)_______________

Step 6: P2 (0.1 to 3.0) _______________

Step 7: Enter Maximum Head in Feet ____________

(range: 0.1 to 12.0)

Step 8: Enter Flow Rate at Maximum Head _________

(range: 0.001 to 9,999)

Step 9: Enter Totalizer Scaling ____________

(range: 0 to 9,999)

Program the following step only if the 3020 is connected to an automatic wastewater sampler. Press the SAMPLER OUTPUT key.

Step 10: Enter Sampler Scaling _____________

(range: 0 to 9,999)

Program Steps 10 to 14 only if the 3020 is connected to a 2312 Plotter. Press the PLOTTER OUTPUT key.

Step 11: Enter Units of Measure for Flow Rate on the Remote Plotter ______________

1. GPM 2. GPS 3. MGD 4. CFS 5. CMS 6. CMH

7. CMD 8. LPS 9. CFD 10. GPH 11. AFD 12. CFH

Step 12: Enter Zeroes to the right of the Flow Rate Display (range: 0 to 6)_____________

Step 13: Enter Units of Measure for Totalized Volume on Remote Plotter ______________

1. CF 2. GAL 3. CM 4. AF 5. L 6. MG

Step 14: Enter Zeroes to the Right of the Totalizer

(range: 0 to 9)______________

Step 15:Reset Plotter Totalizer to Zero

1. Yes 2. No_______________

Step 16: Display Operation. Press DISPLAY MODE.

1. Flow Rate 2. Level 3. Alternate Between Flow Rate and Level________________

Step 17: 4-20 mA Output Operation. Press the 4-20 ma OUTPUT key.

1. Transmit Flow Rate 2. Transmit Flow Rate With Event Mark 3. Transmit Level 4. Transmit Level With Event Mark ______________

Step 18: Current Level in Feet. Press ADJUST LEVEL.

(range -1.0 to 10)_____________

3020 Flow Transmitter

Appendix C General Safety Procedures

In field installations of 3020 Flow Transmitters 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 3020 Flow Meter has not been approved for use in hazardous locations as defined by the National Electrical Code.

⚠ CAUTION

Before any flow transmitter 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.

“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. Forced 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 Object.** 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.

“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.

“3. **Adverse Atmosphere.** [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.

“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.

"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.

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

"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.

"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.

"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.

"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 percent-age is sufficient for life.	—	5.0 15.0	At top, increasing to certain depth.	Natural gas, sludge gas, manufactured gas, sewer gas. Strata of sedimentary origin. In swamps or marshes.	1. Combustible gas indicator 2. Oxygen deficiency indicator.
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.

Appendix D Material Safety Data Sheets

D.1 Overview

This appendix provides Material Safety Data Sheets for the desiccant used by the 3020 Flow transmitter.

Teledyne Isco cannot guarantee the accuracy of the data. Specific questions regarding the use and handling of the products should be directed to the manufacturer listed on the MSDS.

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

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Section 5 - Health Hazard Data

PRIMARY ROUTES OF ENTRY	☐Inhalation ☐Ingestion ☐Skin Absorption ☐Not Hazardous	**CARCINOGEN LISTED IN**	☐NTP ☐OSHA ☐IARC Monograph ☐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.

3020 Flow Transmitter

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Teledyne Isco One Year Limited Factory Service Warranty*

This warranty exclusively covers Teledyne Isco instruments, providing a one-year limited warranty covering parts and labor.

Any instrument that fails during the warranty period due to faulty parts or workmanship will be repaired at the factory at no charge to the customer. Teledyne Isco's exclusive liability is limited to repair or replacement of defective instruments. Teledyne Isco is not liable for consequential damages.

Teledyne Isco will pay surface transportation charges both ways within the 48 contiguous United States if the instrument proves to be defective within 30 days of shipment. Throughout the remainder of the warranty period, the customer will pay to return the instrument to Teledyne Isco, and Teledyne isco will pay surface transportation to return the repaired instrument to the customer. Teledyne Isco will not pay air freight or customer's packing and crating charges. This warranty does not cover loss, damage, or defects resulting from transportation between the customer's facility and the repair facility.

The warranty for any instrument is the one in effect on date of shipment. The warranty period begins on the shipping date, unless Teledyne Isco agrees in writing to a different date.

Excluded from this warranty are normal wear; expendable items such as charts, ribbon, lamps, tubing, and glassware; fittings and wetted parts of valves; and damage due to corrosion, misuse, accident, or lack of proper maintenance. This warranty does not cover products not sold under the Teledyne Isco trademark or for which any other warranty is specifically stated.

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

This warranty is expressly in lieu of all other warranties and obligations and Teledyne Isco specifically disclaims any warranty of merchantability or fitness for a particular purpose.

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.**

Before returning any instrument for repair, please call, fax, or e-mail the Teledyne Isco Service Department for instructions. Many problems can often be diagnosed and corrected over the phone, or by e-mail, without returning the instrument to the factory.

Instruments needing factory repair should be packed carefully, and shipped to the attention of the service department. Small, non-fragile items can be sent by insured parcel post. **PLEASE BE SURE TO ENCLOSE A NOTE EXPLAINING THE PROBLEM.**

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) (866) 298-6174 (samplers & flow meters)
	Sales & General Information: (800) 228-4373 (USA & Canada)	
Fax:	(402) 465-3001	
Email:	IscoService@teledyne.com	

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TELEDYNE ISCO
A Teledyne Technologies Company