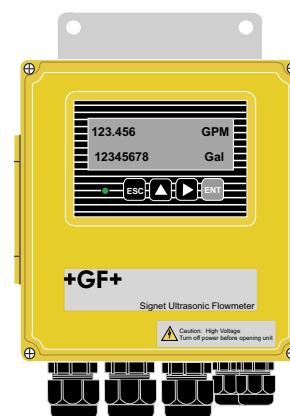


Signet 3350/3550 Ultrasonic Flowmeter

3-3350.090 Rev. A 11/05 English



1. Description

The Signet 3350/3550 Ultrasonic Flowmeter uses transit-time technology to deliver accurate flow rate and totalizer information with no direct fluid contact.

Originally used for temporary installations and periodic flow rate validation, today these ruggedized instruments are perfectly suited to applications where pipes cannot be penetrated, or where the fluid medium is hazardous or easily contaminated.

The clamp-on sensors are easy to install, without interrupting the process stream. Simply enter the pipe parameters and the application preferences; the 3550 will provide stable and accurate data that is tailored by you, for your unique requirements.

The Ultrasonic Flowmeter is programmable via the front panel keypad. Select display menu instructions in English, French, Spanish, German or Japanese on a 2-line, backlit LCD.

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Specifications

General

Flow rate range: 0.3 to 10 m/s (1 to 33 ft/s)
 Low flow cut off : 0 to 5 m/s configurable

Suitable pipe materials:

- Plastic (PVC, PVDF, CPVC, PP, PE, PEEK, etc.)
- Metals (carbon steel, SS, copper, aluminum, iron)

Pipe Size Range

- Plastic pipes:
 - 3550-100: DN25 to DN100 (1 in. to 4 in.)
 - 3550-200: DN50 to DN225 (2 in. to 9 in.)
- Metal pipes:
 - 3550-100: DN50 to DN100 (2 in. to 4 in.)
 - 3550-200: DN50 to DN225 (2 in. to 9 in.)

Application: Clean liquids, no aeration or particles

Accuracy

Pipe size	Over 2 m/s (6 ft/s)	Under 2 m/s (6 ft/s)
DN25 to DN40 (1 to 1½ in.)	±3% of rate	±0.06 m/s
DN50 to DN225 (2 to 9 in.)	±2% of rate	±0.04 m/s

Display: LCD w/back light 2x16 characters

- Sensor signal quality LED - Normal: green, Error: red
- User selectable language: English, French, German, Spanish, Japanese

Display resolution:

- Flow rate: 00.0000 min to 9999999 max
- Totalizer: 00000.00 min to 99999999 max

Totalizer Error condition:

Hold last good value or Continue Count

Error Time delay 0 to 100 s

Damping: 0 to 100s Averaging function for 4 to 20 mA output and Flow Rate display

Response time: 200 ms

Material

Flowmeter: ABS
 Sensors: PBT
 Sensor frame: 304 SS

Electrical

- 3-3350-1: 100-120 VAC ±10%, 50/60Hz, 15VA max
 - 3-3350-2: 200-240 VAC ±10%, 50/60Hz, 15VA max
- Signal cable: RF coaxial cable, 5 m std (Avail to 30 m)

Output Specifications

4 to 20 mA output

- Max. load resistance: 600Ω
- 4 to 20 mA Error condition (Burnout): User selectable
- Hold last good value
 - Over-scale (22.6 mA)
 - Under-scale (3.8 mA)
 - Zero (4 mA)

Bi-directional or Autoscale dual ranges

- User Selectable
- Hysteresis: 0 to 10% of flow rate range
- Flow range applicable to digital output

Output Specifications (continued)

Relay output (DO2)

- Capacity: 220V AC /30V DC, 1A (resistive load)
- Mechanical SPDT relay contact: (replaceable)
- Mechanical life expectancy: > 2 x 10⁷ operations
- Relay Pulse width: User selectable 50, 100 or 200 ms

Open collector output (DO1)

- Capacity: 30V DC, 0.1A
- Total pulse: Programmable, 1 pps to 1 pulse per day
- Open Collector Pulse width: User selectable 5, 10, 50, 100 or 200 ms

Digital output Logic

ACTIVE ON: Relay DO2 Normally OFF (de-energized)
 Open Collector DO1 normally open

ACTIVE OFF: Relay DO2 Normally ON (de-energized)
 Open Collector DO1 normally closed

Programmable functions

- Cutoff limit (common to DO1 and DO2)
- NOT USED
- TOTAL SWITCH Operation
 - +TOTAL PULSE: Proportional to +Flow rate
 - -TOTAL PULSE: Proportional to -Flow rate
- FLOW SPAN-2: Select a contact output at SPAN-2 measurement status (forward automatic 2 ranges, forward/reverse automatic 2 ranges).
- ALARM Operation
 - HARDWARE: Contact output at EEPROM error.
 - PROCESS: Contact output when signal is bad

FLOW SWITCH Operation

- UPPER SWITCH: HIGH Flow Alarm
- LOWER SWITCH: LOW Flow Alarm
- TOTAL SWITCH: Volumetric Pulse

Flow requirements

- Well-developed turbulent or laminar flow
- Maximum air in liquid volume: 0.2% @ 1 m/s (inversely proportional to velocity)

Weight

- Flowmeter: 0.8 kg
- Sensor: 3-3550-100: 0.3 kg
 3-3550-200: 0.4 kg

Environmental

NEMA4/IP65 enclosure for both flowmeter and flow sensor

Process temperature:

- With silicone rubber acoustic couplant -40°C to +180°C (-40°F to 356°F)
- With silicone-free grease acoustic couplant 0°C to 60°C (32°F to 140°F)

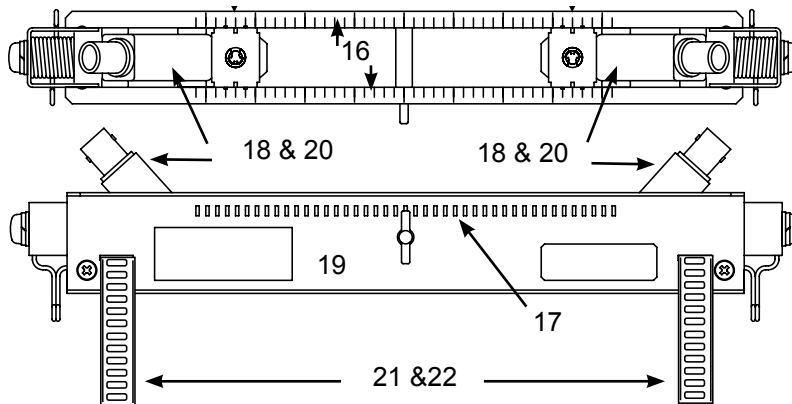
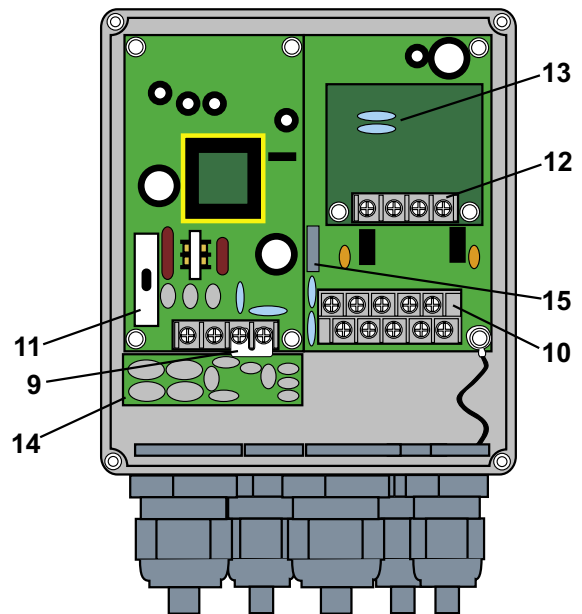
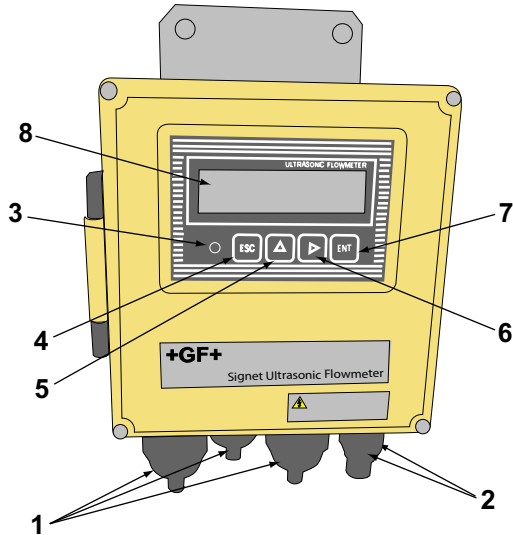
Ambient temperature:

- 3-3350-X: -20° to 50°C (-4° to 122°F)
- 3-3550-XXX: -20° to 60°C (-4° to 140°F)

Short-term thermal stability: 140°C, 30 min

Relative Humidity: 90% (non-condensing)

Features and Functions

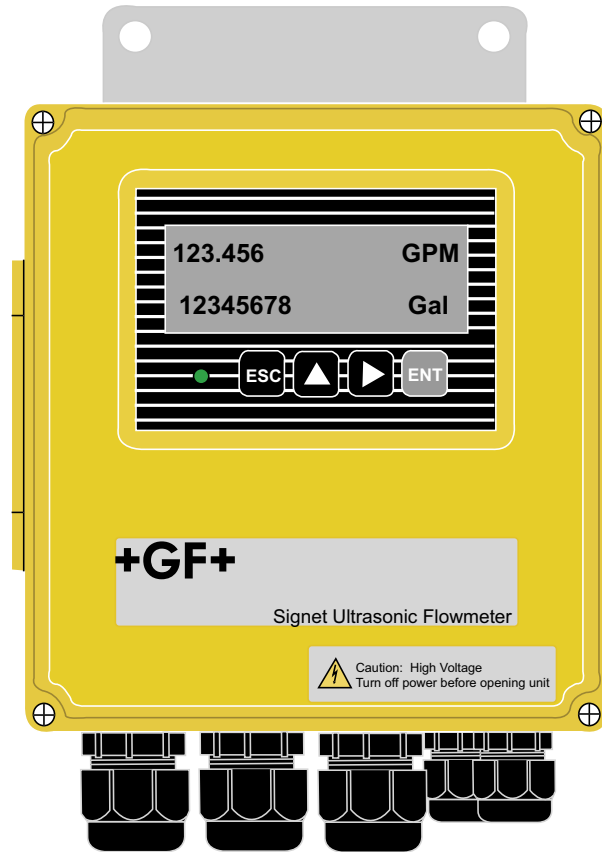


No.	Name	Description
1.	Cable ports, PG 13.5	For power cable, Output Cable
2.	Cable ports, PG 9	For signal cables only
3.	Flow signal LED	Green = Normal operation, Red = Error condition
4.	Escape key	Moves back one menu level or cancels changes not yet ENTERED
5.	UP key	Selects items, scrolls active numeric values and symbols
6.	Shift key	Advances blinking cursor, selects decimal position
7.	Enter key	ENTERS (saves to memory) new settings and selections
8.	Liquid Crystal Display	Displays flow rate and menu information
9.	Power terminals	Connect AC or DC power
10.	Input/Output Cables	Sensor coaxial cables, Relay output and 4-20 mA output cables
11.	Fuse and Fuse holder	250 V, 0.5 A for AC models, or 250 V, 1 A for DC models
12.	Communication board terminals	Wiring for optional Comm board for serial data output
13.	Communication board	RS-232 (3-3350.403) or RS-485 (3-3350.404) Optional
14.	Arrester board	Optional arc suppressors for relay outputs
15.	Relay	DO2 Dry Contact, 1 A 220 VAC or 30 VDC resistive load
16.	Scale	Used to measure proper spacing for TX-RX sensors
17.	Locking hole	Sensors lock in place at these openings
18.	Transmit and Receive Signal Cables	BLACK = Downstream, RED = Upstream
19.	Sensor Frame	Mounting apparatus for Sensor units
20.	Sensors	Ultrasonic TX-RX sensors
21.	Mounting straps for Frame	Stainless steel belts (3-3550.393)
22.	Spring tightener	Removes slack from steel mounting straps after mounting

Installation and Quick Start Guide

The installation and startup of this flowmeter is divided into seven steps. They are organized in the sequence they should be completed:

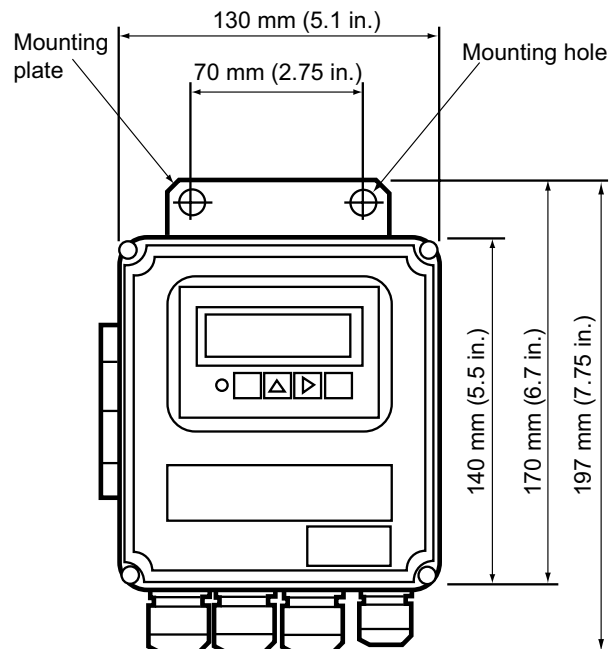
1. Select a mounting location and method for the 3350 electronics.
2. Select a location and mount the 3550 strap-on sensor assembly onto the pipe.
3. Connect the sensor cables and 24 VDC power to the electronics terminals.
4. Navigate to the MEASURE SETUP menu and enter the information for your pipe and fluid.
5. Position the two ultrasonic transducers at the spacing indicated by the PIPE PARAMETER and secure them in the frame.
6. Review the system troubleshooting information and the initial values of the output parameters in this manual to determine if it is safe to start the flowmeter.
7. Program the 3350 flowmeter electronics to reflect the remaining application requirements.



1. Select a mounting location and method for the 3350 electronics.

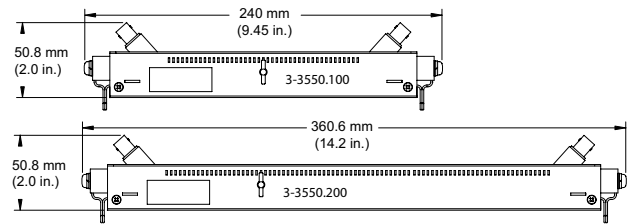
The electronics may be mounted on a wall or on a pipe stand.

- For wall mounting, use two M8 bolts. Drill holes based on the dimensions illustrated here.
- For pipe mounting, use the two U-bolts supplied with the unit.



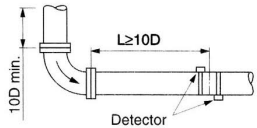
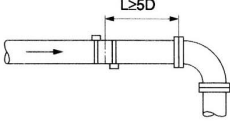
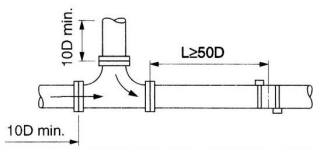
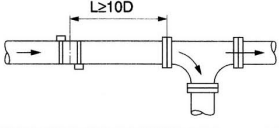
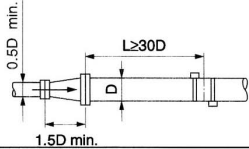
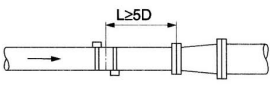
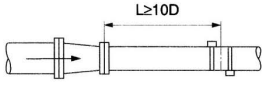
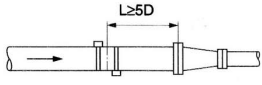
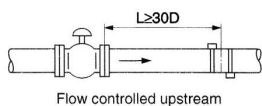
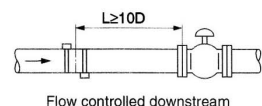
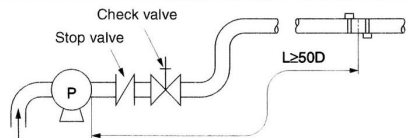
2A. Select a location for the 3550 strap-on sensor assembly.

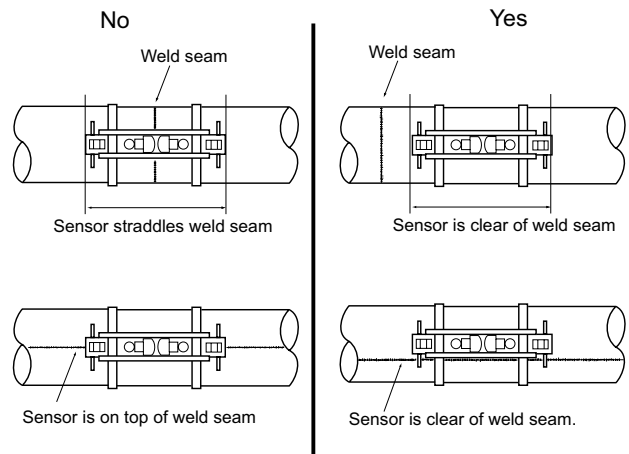
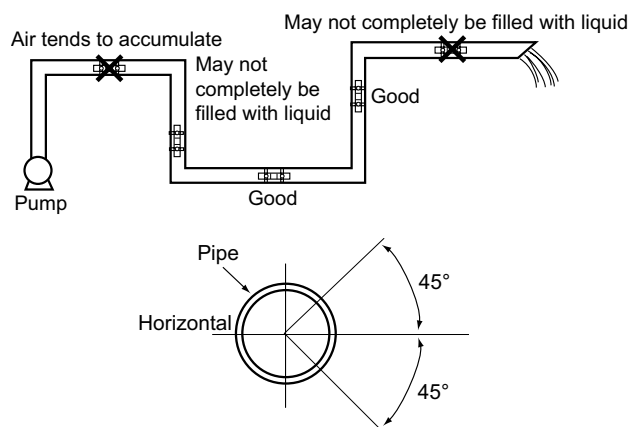
The length of upstream and downstream straight pipe of the ultrasonic detector should be long enough to ensure accurate measurements.



The sensor can be installed at any position around the pipe when attention is given to the following requirements:

- The pipe must be completely filled with fluid.
- On horizontal pipes, mount the sensors at $\pm 45^\circ$ from the horizontal plane to avoid air pockets and debris that may accumulate at the top and bottom of the pipe.
- The pipe surface must be free of pits and distortions. Use thinner, sandpaper, etc., to remove surface corrosive, rust, etc, and to remove any rust, pitch, or other materials from the pipe surface.
- Do not mount the sensors on a section of pipe that is visibly out-of-round, or straddling a flange or weld seam.

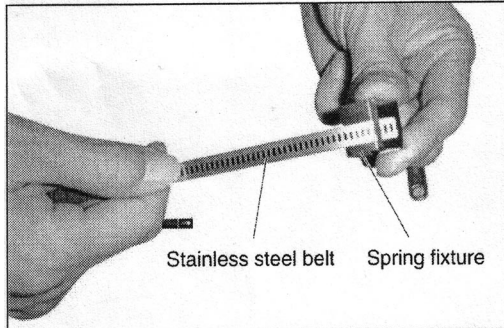
Name	Straight length of upstream piping	Straight length of downstream piping
90° bend		
Tee		
Diffuser		
Reducer		
Valve		
Pump		



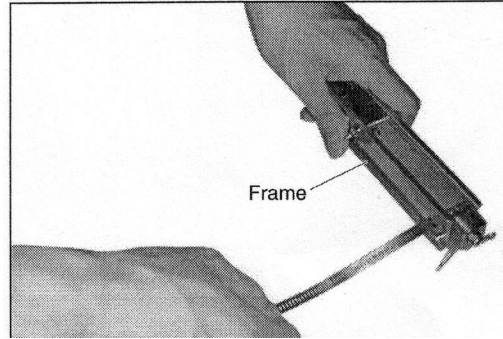
2b. Mount the 3550 strap-on sensor assembly onto the pipe

CAUTION
 Handle the steel mounting belts carefully to avoid injury.

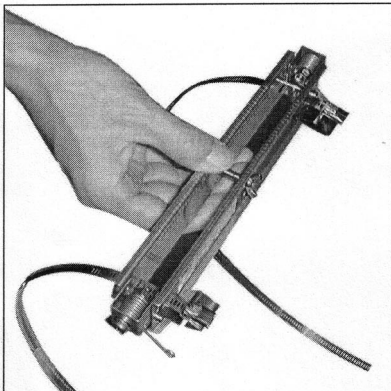
1. Slide the spring fixture onto the stainless steel belt.



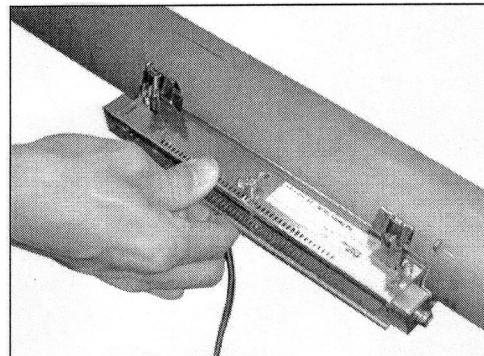
2. Pass the stainless steel belt through 2 belt holes on the frame.



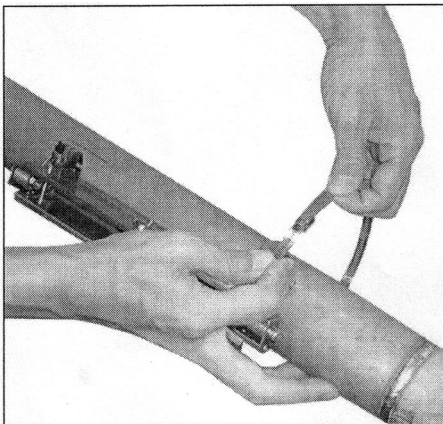
3. Place the frame on a pipe smooth, clean section subjected to a surface treatment.



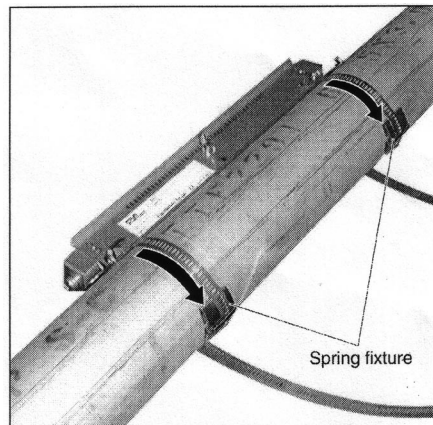
4. Temporarily tighten the first stainless steel belt on the pipe.



5. Adjust the frame so it is parallel with the pipe, put the spring fixture to the side of the frame and tighten the stainless steel belt so that the frame will tightly be fitted. Mounting on pipe whose diameter is DN150 (6 in.) or larger, connect 2 stainless steel belts.



6. After tightening both stainless steel belts, slide the spring fixture to the opposite to the frame.
Note: Frame must be relocated, use new stainless steel belts.



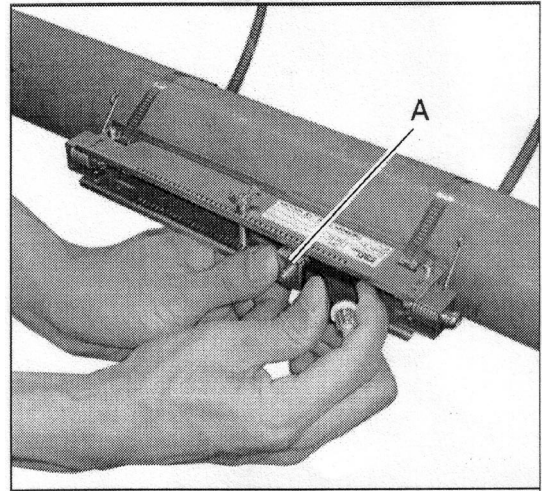
2b. Mount the 3550 strap-on sensor assembly onto the pipe (continued)

Before mounting the sensor unit into the frame, Apply silicone (or silicone-free grease) over the transmission surface of the sensor unit. Do not leave any bubbles.

When using silicon-free grease, do not exceed the fluid temperature range:

- Silicon rubber: 20 to 100°C
- Silicon-free grease: 0 to 60°C

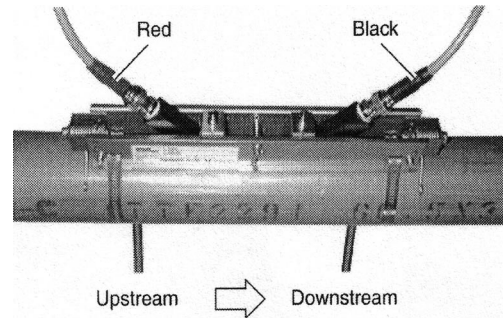
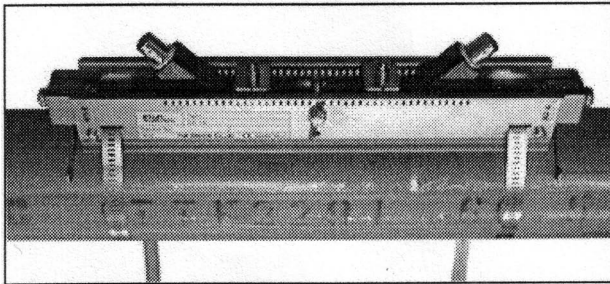
Silicon-free grease should be reapplied approximately once every 6 months. (Silicon rubber need not be reapplied.)



Insert the sensor unit into the frame. The UPSTREAM and DOWNSTREAM sensors must be spaced according to the PIPE PARAMETER results. Do not lock the sensors yet. They will need to be adjusted in step 5.

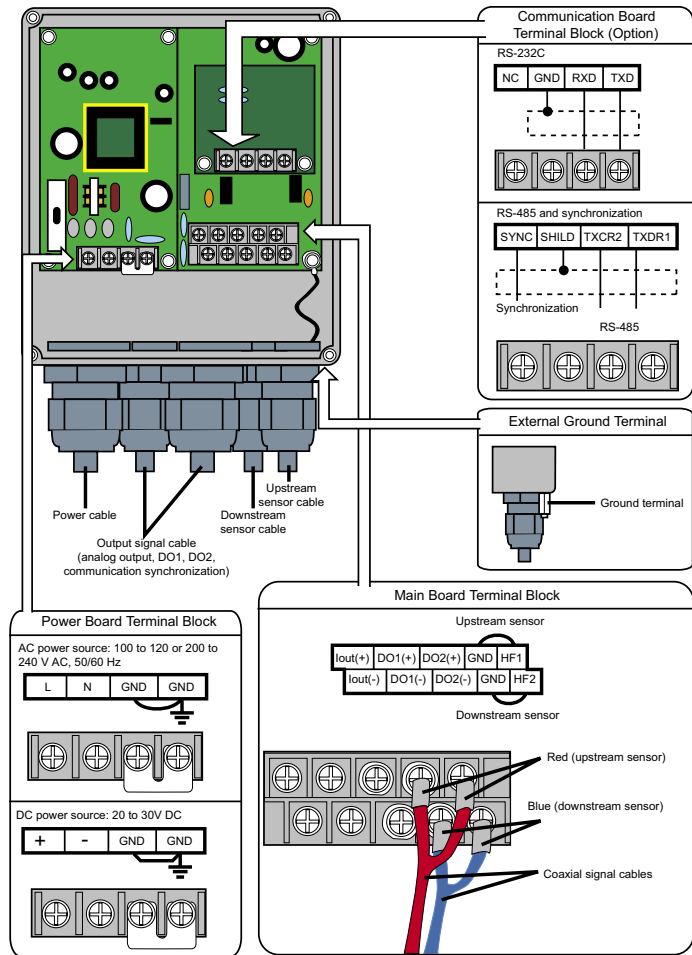
Connect the signal line with BNC connectors to the sensor units. Engage the red BNC connector upstream, and the black BNC connector downstream.

Mount both sensor units so as to be roughly symmetrical with respect to the frame.



3. Wiring

Connect the power source and the two sensor cables as shown here.



- Notes:
1. All screws are M3 on the terminal block. Use crimp-style terminals for M3 whose outer diameter is 5.8 mm (1/4 in.) or smaller.
 2. Connect the power board ground terminal block or the external ground terminal to earth ground.
 3. Use only cables supplied with sensors.

4. PIPE PARAMETERS

Display language

Before proceeding to the next step, the 3350 can be set to display the menus in several languages. The procedure to change from the ENGLISH selection is provided here.

The languages available are listed in the order in which they appear in the menu.

- English
- Japanese
- German
- French
- Spanish

Press:

- x 4
-
- x 7
-
-
-

Display shows:

- “MAINTENANCE MODE”.
- “CURRENT CALIBRATION”.
- “LANGUAGE”.
- 2nd line begins blinking.
- Scroll to the language required.
- New selection is stored.

Use and keys to resume measurement mode.

4. PIPE PARAMETER (continued)

The PIPE PARAMETER section of the Measure Setup menu calculates the correct spacing between the two Ultrasonic electrodes. This must be done before the installation can be completed. The following pages will guide the user through each step.

If the parameter protection is set at "PROTECTION ON", change it to "PROTECTION OFF".
The ID NO. must be entered if it is active.

Press:

Display shows:



3x.

1st line: "MEASURE SETUP"



1st line: "SYSTEM UNIT"



3x.

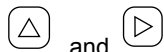
1st line: "PIPE PARAMETER"



1st line: "OUTER DIAMETER". 2nd line: "60.00 mm"



Cursor blinks on 2nd line.



and

Input the outer diameter. (Pipe data is located in section 3.2.)



"COMPLETE" is indicated for about 1 second on 2nd line.



1st line: "PIPE MATERIAL". 2nd line: "PVC" (As currently selected)



Cursor blinks on 2nd line.



Select the pipe material from menus. If the pipe material is not listed, select "PIPE SV" and

input the sound velocity of the pipe material at the end of its, See piping data in section 3.2.



"COMPLETE" is indicated for about 1 second on 2nd line.



1st line: "WALL THICKNESS". 2nd line: "4.50mm" * (or as currently selected)



Cursor blinks on 2nd line.



and

Input the wall thickness of a measurement pipe. See piping data in section 3.2.



"COMPLETE" is indicated for about 1 second on 2nd line.

4. PIPE PARAMETER (continued)

Press:



and



and



2x.

Display shows:

1st line: "LINING MATERIAL". 2nd line: "NO LINING"

Cursor blinks on 2nd line.

Select the lining material. If the material is not listed, select "Lining S.V." and input the sound velocity of the lining material. Sound Velocity data is located in section 6.6.

"COMPLETE" is indicated for about 1 second on 2nd line.

1st line: "LINING THICKNESS". 2nd line: "2.00 mm". (Not present if "No Lining" is selected)

Cursor blinks on 2nd line.

Input the lining thickness.

"COMPLETE" is indicated for about 1 second on 2nd line.

1st line: "KIND OF FLUID". 2nd line: "WATER".

Cursor blinks on 2nd line.

Select "WATER" or "SEA WATER". If the fluid is not listed, input the sound velocity of fluid.

Sound Velocity (acoustic velocity) data is located at the back of this manual.

"COMPLETE" is indicated about 1 second on 2nd line.

1st line: "KINEMATIC VISCO". 2nd line: "1.0038E-6m2/s". Kinematic viscosity of water or Sea

Water is factory set. If fluid to be measured is other than water, input the kinematic viscosity referring to piping data at the back of this manual.

Cursor blinks on 2nd line.

Input the kinematic viscosity.

"COMPLETE" is indicated about 1 second on 2nd line.

First line: "SENSOR MOUNTING" Second line: "V"
(Do not change this setting. The "Z" option is not available for this system)

1st line: "SENSOR TYPE". 2nd line: "3-3350-100".

Cursor blinks on 2nd line.

Select "3-3350-100" or "3-3350-200".

"**COMPLETE**" is indicated about 1 second on 2nd line.

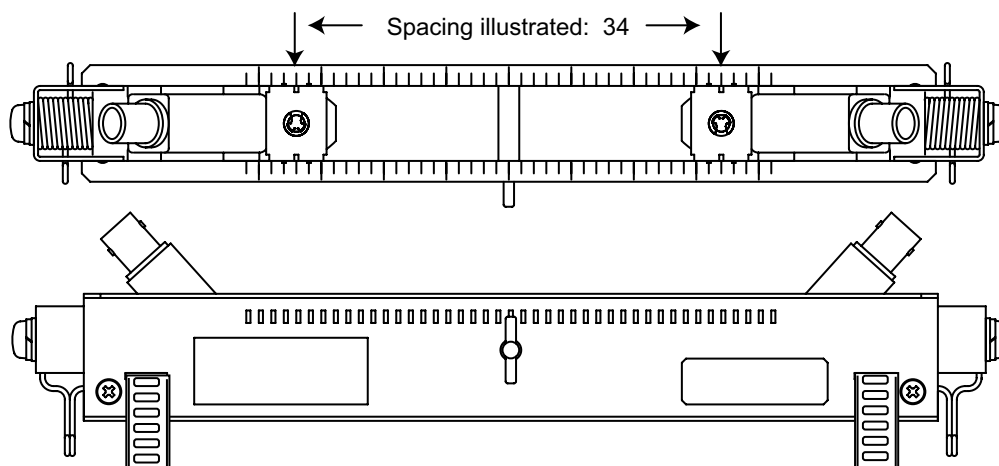
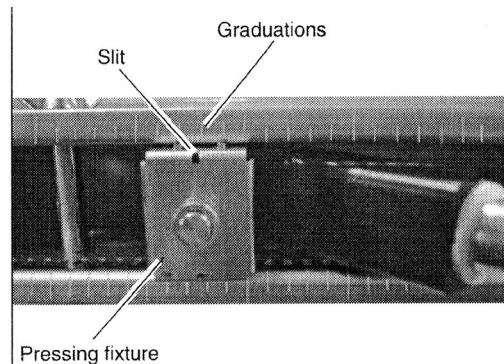
1st line: "PIPE PARAMETER". 2nd line: "S= 16 (48mm)"
Use this value to secure the two sensors at the correct spacing.

1st line: "MEASURE SETUP"

Measurement mode is resumed.

5. Position the two ultrasonic sensors at the spacing indicated by the PIPE PARAMETER and secure them in the frame.

Closeup of the center mark on the sensor and the spacing scale on the frame.



6. System Troubleshooting

If everything has been completed according to the instructions, the system is ready to begin working. All of the remaining settings and menus enable the output functions to be tailored to suit a specific application. Review the next two pages and identify the functions that must be modified for the application. About 10 seconds after connecting the signal line, the red LED on the flow transmitter should turn green, indicating the received signal is normal.

If the LED remains red, the Flowmeter is not receiving a good signal from the 3350 sensor.

The problem is most probably caused by the sensor installation.

Check these conditions:

Sensor spacing: Are the sensors the correct distance apart?

Sensor orientation: Are both sensors facing outward from each end of the frame?

Lock mechanism: Are both lock mechanisms securely latched into the frame?

Lubricant: Have the two sensors been coated liberally with silicone grease or a similar filler?

Parameter settings: Is the information in the PARAMETER SETTINGS menu correct?

Full pipe: Is the pipe filled with fluid?

Factory settings

The tables below list each setting in the 3350 Magmeter menus, all of the available options, and the factory settings that will be found in a new instrument.

No.	Setting Item	Setting Range	Initial Value	Settable Value	
1	Parameter protection	2 menus	PROTECTION ON	PROTECTION ON, PROTECTION OFF	
2	ID No.	0000 TO 9999	0000		
3	Measurement conditions	Unit system	2 menus	Metric	Metric (metric system)
4		Flow rate unit	12 menus (Metric system)	L/s	l/s, L/min L/h ML/d m ³ /s m ³ /min m ³ /h Mm ³ /d BBL/s BBL/min BBL/h MBBL/d
			12 menus (Inch system)		gal/s gal/min gal/h Mgal/d ft ³ /s ft ³ /min ft ³ /h Mft ³ /d BBL/s BBL/min BBL/h MBBL/d
5		Total unit	8 menus (Metric system)	mL	mL L m ³ km ³ Mm ³ mBBL BBL kBBL
			10 menus (Inch system)		gal kgal ft ³ kft ³ Mft ³ mBBL BBL kBBL ACRE-in ACRE-ft
6		Pipe outer diameter	10.00 to 300mm	60.00mm	[mm, in]
7		Pipe material	10 menus Sound velocity: 1000 to 3700 m/s	PVC	PVC, PVDF, PEEK, PP, CARBON STEEL, STAINLESS STEEL, COPPER, other (sound velocity: __[m/s, ft/s])
8		Wall thickness	0.1 to 50.00mm	4.50mm	[mm,in]
9		Lining material	7 menus Sound velocity: 1000 to 3700m/s	No lining	No lining, tar epoxy, mortar, rubber, Teflon, Pyrexglass, other (sound veloc- ity: __[m/s, ft/s])
10		Lining thickness	0.01 to 50.00		[mm, in]
11		Fluid type	3 menus Sound velocity: 500 to 2500m/s	Water	Water, sea water, other (Sound velocity: [m/s, ft/s])
12		Kinematic viscosity	0.0001 to 999.9999 x 10- 6m ² /s	1.0038 x 10-6m ² /s	[x10-6m ² /s, ft ² /s]
13		Sensor mounting method	2 menus	V	V,Z
14		Sensor type	2 menus	3-3350-100	3-3350-100, 3-3350-200

15	Output conditions	Zero adjustment	2 menus	Clear (adjusted)	Set zero, clear (factory set at clear)
16		Damping	0 to 100sec	5 sec	sec
17		Low flow rate cut off	0 to 5 m/s in terms of flow velocity	0.001 L/s	Units are based on FLOW RATE UNIT.
18		Display 1st line contents	7 menus	Flow velocity (m/s)	Flow velocity, flow rate (ACTUAL), flow rate (%), forward total, reverse total, forward total pulse, reverse total pulse
19		Display 1st line decimal point position		00000.000	□□□□□□□□ Mark the decimal position
20		Display 2nd line contents	7 menus	Flow rate (L/s)	Flow velocity, flow rate (ACTUAL), flow rate (%), forward total, reverse total, forward total pulse, reverse total pulse
21		Display 2nd line decimal point position		00000.000	□□□□□□□□ Mark the decimal position

No.	Setting Item		Settable Range	Initial Value	Settable Value
22	Analog Output	Flow span-1	0.3 to 10m/s in terms of flow velocity	10.0000L/s	Units are based on FLOW RATE UNIT.
23		Flow span-2	0.3 to 10m/s in terms of flow velocity	0.0000L/s	Units are based on FLOW RATE UNIT.
24		Hysteresis	0 to 10%	5.00%	%
25		Burnout	4 menus	Hold	Hold, upper limit, lower limit, zero
26		Burnout timer	0 to 100sec	10sec	sec
27	Total output	Total action	3 menus	Start	Start, stop, reset
28		Pulse value	0.00001 to 999999	1mL	Units are based on TOTAL UNITS
29		Total pulse width	5 menus	5msec	5,10,50, 100, 200msec
30		Burnout	2 menus	Hold	Hold, count
31		Burnout timer	0 to 100sec	10sec	sec
32	Output conditions	DO1 output type	5 output contents menus 3 alarm menus Flow switch range 0 to 10 m/s. Total switch range: 0.00001 to 99999999	NOT USED	NOT USED, Flow direction, Alarm [all, hard, process], Flow switches, Upper limit, Lower limit, Total switch. (Units are based on FLOW RATE UNITS and TOTAL UNITS selections.)
33		DO1 output action	2 menus		ON, OFF
34		DO2 output type	5 output contents menus 3 alarm menus Flow switch range 0 to 10 m/s. Total switch range: 0.00001 to 99999999	NOT USED	NOT USED, Flow direction, Alarm [all, hard, process], Flow switches, Upper limit, Lower limit, Total switch (Units are based on FLOW RATE UNITS and TOTAL UNITS selections.)
35		DO output action	2 menus		ON, OFF
36		Span calibration	0 to ±200%	100.0%	%

Parameter Protection

Parameter Protection serves to protect the flow meter settings from unauthorized changes.

- The 3350 uses an Identification number (ID No.) to enable authorized changes.
- The ID number is factory set at 0000 and the Parameter Protection is turned ON.
- To change the ID number, the parameter protection must first be turned OFF:

Press:

Display shows:



First line: "PAR. PROTECTION" Second line: "PROTECTION ON"



2nd line of display begins blinking.



"PROTECTION OFF".




"INPUT ID NO.".



"0000" with first zero blinking.



Use UP and RIGHT buttons to set the ID No. into the display

Note: If ID No. is "0000" (factory set), press  key to set the parameter protection to OFF.



First line: "PAR. PROTECTION" Second line: "PROTECTION OFF"

* If "INPUT ERROR!" appears, the ID No. is incorrect. The display returns to the previous step.

Identification (ID) number

Press:

Display shows:



4x "MAINTENANCE MODE".



"CURRENT CALIBRATION".





8x "REGISTER ID NO."



2x 2nd line blinks





Press  key and  key to compose a new ID number.



"COMPLETE" is indicated about 1 second on 2nd line.



Using  key and  key to resume the measurement mode.

Note: To enable the new ID number, set the parameter protection to "PROTECTION ON".

Measure setup mode

METRIC or ENGLISH

- Metric system (factory set)
Select to use the 3350 in a metric measurement system (meters and liters)
- Inch system
Select to use the 3350 in an English measurement system (inches and gallons)

Press

Display shows



3x

"MEASURE SETUP".



"SYSTEM UNIT".



Cursor begins blinking



"METRIC".



"COMPLETE" is indicated about 1 second on 2nd line.

Use key and key to resume measurement mode.

Set the flow rate unit

Depending on the measurement selection above, the flow rate can be set to measure in a variety of engineering units. Select one

- Metric system

L/s (factory set)	L/min	L/h	ML/d
m3/s	m3/min	m3/h	Mm3/d
BBL/s	BBL/min	BBL/h	MBBL/d
- Inch system

gal/s	gal/min	gal/h	Mgal/d	ft3/s
ft3/min	ft3/h	Mft3/d	BBL/s	BBL/min
BBL/h	MBBL/d			

Press:

Display shows:



3x

"MEASURE SETUP".



"SYSTEM UNIT".



"FLOW UNIT".



"FLOW UNIT" blinks



6x

"m3/h".



Stores the new setting into memory

Use key and key to resume measurement mode.

Set the total unit

Select the unit of total volume.

- Metric system

mL (factory set)	L
m3	km3
Mm3	
mBBL	BBL
	kBBL
- Inch system

gal	kgal
ft3	kft3
Mft3	mBBL
BBL	kBBL
	ACRE-in
	ACRE-ft

Press:

Display shows:



1st line: [TOTAL UNIT]

2nd line: [mL]



2nd line blinks.



Repeatedly to select total unit.



Stores the new setting into memory

Use key and key to resume measurement mode.

Adjust Zero point

The ZERO ADJUST allows the instrument to be set to ignore any electrical background noise in the application. There are two options:

- "SET ZERO" records the actual input as equal to zero.
- "CLEAR" sets the zero point to absolute "0".

To set the instrument to zero, completely close the valves upstream and downstream the flow meter so the sensors are detecting still water in a FULL PIPE.

If there is no valve or if the fluid flow cannot be stopped, select "CLEAR" instead of "ZERO ADJUST". Any electrical noise in the system will not be factored out of the measurement when "CLEAR" is used.

Press:		Display shows:
	△ x2	"OUTPUT SETUP".
	ENT	"ZERO ADJUST" 2nd line shows "SET ZERO"
	ENT	"SET ZERO" blinks. If "CLEAR" is blinking press △ to go to "SET ZERO".
	ENT	The static signal being sensed in the pipe will be set to represent zero flow.
Use ESC key and △ key to resume measurement mode.		

Set the Damping

The DAMPING function attenuates any instability in the flow measurement that may be present due to piping limitations or flow profile disturbances. Higher damping times result in smoother output.

A time constant is set (response time of about 63%).

Damping range: 0 to 100 sec in 1 sec increments.

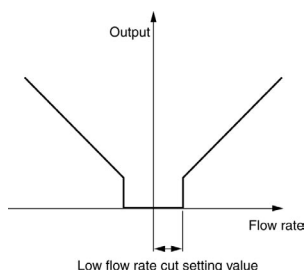
Note: If Damping is set to 0 sec, the response time is:
 System cycle: 0.2 sec
 Dead time: less than 0.2 sec
 Time constant: 0.1 sec

Press:		Display shows:
	△ x2	"OUTPUT SETUP".
	ENT	"ZERO ADJUST".
	△	"DAMPING".
	ENT	Cursor blinks
	△	Press to set value from 0 to 100 seconds
	ENT	Stores the new setting into memory
Use ESC key and △ key to resume measurement mode.		

Set the Low Flow Rate Cutoff

The flow rate display, the analog output (4-20 mA) and the totalizer can be disabled when the flow rate falls below this setting. Use this function to prevent output response to invalid input such as flow signals generated by vibration, convection or electrical noise.

Set range: equivalent to 0 to 5 m/s in the selected flow rate units. Factory set at 0.001 L/s



Press:		Display shows:
	△ x2	"OUTPUT SETUP".
	ENT	"ZERO ADJUST".
	△ x2	"CUTOFF".
	ENT	Cursor blinks
	△	Press to set flow rate cutoff
	ENT	Stores the new setting into memory
Use ESC key and △ key to resume measurement mode.		

Configuring the Display

The 3350 display has two lines with 16 characters on each line. Each line can be set to display a different value:

- **VELOCITY**
Display the linear velocity of the flow. Units are m/s for METRIC systems or ft/s for ENGLISH systems.
- The decimal point position is fixed.
- **FLOW RATE**
Display the flow rate in the volumetric units selected (GPM, L/m, BBL/DAY, etc.
- **FLOW RATE (%)**
Display the flow rate as a percentage of the flow range setting.
- **±TOTAL (ACTUAL)**
Display the totalizer value derived from the actual flow rate. Select the total resulting from forward flow or from reverse flow.
- **±TOTAL (PULSE)**
Display the totalizer value that is derived from the pulse output (DO1 or DO2)

Press:



2x



3x



Use key and key to set new value.



Use key and key to resume measurement mode.

Display shows:

“OUTPUT SETUP”.

“ZERO ADJUST”.

“DISPLAY” “1ST ROW”
Press again to select “2ND ROW”.

“1ST ROW” and “FLOW RATE”
FLOW RATE is blinking

“1ST ROW DIGIT” and “****. **”

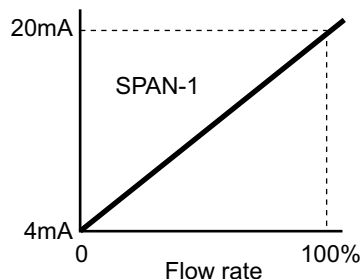
Scroll to select decimal position.

“1ST ROW DIGIT” and “COMPLETE”
briefly, then

“1ST ROW DIGIT” and new display value
New display value is blinking.

Set the 4-20 mA Range (FLOW SPAN-1)

- The analog output (4-20 mA) corresponds to the range setting.
- If “INPUT ERROR” appears, the setting is beyond the operating range of the instrument.
- After changing the RANGE, adjust zero point.
- If “PIPING PARAMETERS” or “FLOW UNIT” are changed, FLOW SPAN must be reset.



Press:



2x



Use key and key to set maximum flow rate.



Stores the new setting into memory

Press to set FLOW-SPAN-2

or

Use key and key to resume measurement mode.

Display shows:

“OUTPUT SETUP”.

“ZERO ADJUST”.

“RANGE”.

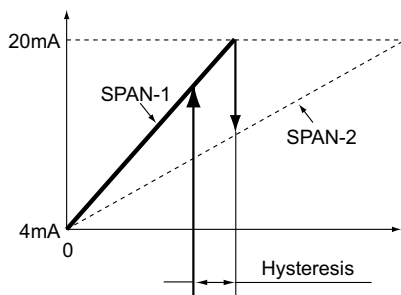
Cursor blinks

Press again to select “FLOW SPAN-1”.

Cursor blinks

Set Dual 4-20 mA Ranges (FLOW SPAN-2)

- Use FLOW SPAN-2 to set the 4-20 mA output to automatically switch scales as the flow rate varies.
- If it is not used, set the range of FLOW SPAN-2 to 0.
- The HYSTERESIS can be set from 0 and 10% of the smaller range.
- When the source of DO1 or DO2 is set to “FLOW SPAN-2”, a contact outputs “SPAN-2” action. Select [ACTIVE ON] or ACTIVE OFF separately.
- Always reset the ZERO ADJUST after changing the range value.
- The dual ranges can be set to measure reverse flow. Use the “-” sign in the first position when setting the reverse flow range.



Press:



Display shows:

“FLOW SPAN-2”.



Cursor blinks

Use key and key to set maximum flow rate.



Stores the new setting into memory



“HYSTERESIS”.



Cursor blinks

Use key and key to set hysteresis.



Stores the new setting into memory



“BURNOUT”



Current selection blinks



Scroll to new setting.



Stores the new setting into memory



“BURNOUT TIMER” and “10 s”



Cursor blinks

Use key and key to set new time delay.



Stores the new setting into memory.

Use key and key to resume measurement mode.

Set BURNOUT mode for the 4-20 mA output

BURNOUT is the error mode for the 4-20 mA output.

Specify how the 4-20 mA output will react during loss of signal, etc. due to hardware error, empty pipe or ingress of bubbles.

The options are:

HOLD (factory set):	Retain the last good value
OVER SCALE:	Outputs 23.2 mA.
UNDER SCALE:	Outputs 0.8 mA.
ZERO:	Outputs 4 mA.
BURNOUT TIMER	0 to 100 seconds
	(factory set at 10 sec).

(time delay from error detection to response)

Set Pulse Output and Totalizer functions

Set the pulse value, pulse width and preset value.
































Then, reset the total value to a preset value (factory set at 0), and start a total.

BURNOUT(TOTAL)

Determines the behaviour of the totalizer when an error occurs due to an empty pipe interior or bubbles mixed in fluid (common to total indication and total pulse output).

HOLD: Stops the total (as factory set).

COUNT: Continues the total according to a flow rate marked immediately before the error occurrence. BURNOUT TIMER
Sets the time from error occurrence to error processing. | Settable range: 0 to 100 sec (factory set at 10 sec). The
total continues until the burnout timer is actuated.

Press:	Display shows:	Press:	Display shows:
 2x	OUTPUT SETUP		TOTAL PRESET and 0 mL
	ZERO ADJUST		Cursor blinks.
 4x	"RANGE" and "FLOW RATE"	Use  key and  key to set the value where the totalizer will start after a reset	
	"FLOW RATE" blinks		Stores the new value into memory
	"TOTAL" blinks		BURNOUT (TOTAL) and HOLD
	"TOTAL MODE" and "START"		HOLD blinks.
	"PULSE VALUE" and 1mL" (or current selection)		Scroll to select BURNOUT action.
	Cursor blinks		Stores the new setting into memory
Use  key and  key to set the volume represented by each pulse.			"BURNOUT TIMER" and "10 s"
	Stores the PULSE VALUE into memory		Cursor blinks
 selection)	PULSE WIDTH and 5.0 ms (or current selection)	Use  key and  key to set new time delay.	
	Cursor blinks on 2nd line.		Stores the new setting into memory.
	Press to scroll to select pulse width value	Use  key and  key to resume measurement mode.	
	Stores the new value into memory		

Start, Stop and Reset the Totalizer

- The total is started, stopped or reset manually, from this menu.

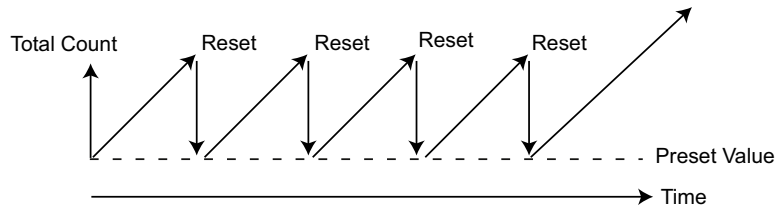
START: Total output starts

STOP: Total output stops

RESET: Reset the total memory to the preset value.

This setting simultaneously resets both forward total memory and reverse total memory.

After performing a RESET the total function will remain STOPPED until "START" is executed.



Press:



2x

Display shows:

OUTPUT SETUP



ZERO ADJUST



4x

"RANGE" and "FLOW RATE"



"FLOW RATE" blinks



"TOTAL" blinks



"TOTAL MODE" and "START"



"START" blinks



Scroll to select RESET or STOP.



START, STOP or RESET is implemented.

The TOTAL memory will be reset to the PRESET value

After resetting, the total operation automatically stops.

To resume a total, execute "START":



"STOP" blinks



Scroll to select START.



START is implemented.

Use key and key to resume measurement mode.

Set Relay Outputs (DO1 and DO2)

DO1 is an open collector switch output rated at 30 V DC, 100 mA maximum load

DO2 is a dry contact relay rated at 220 V AC/30 V DC, 1 A maximum load.

The following options are common to DO1 and DO2:

NOT USED Disables the contact output.

+TOTAL PULSE

DO1 or DO2 will output a pulse when the volume set by PULSE VALUE is measured in the forward total pulses.

-TOTAL PULSE

DO1 or DO2 will output a pulse when the volume set by PULSE VALUE is measured in by the reverse total pulses.

FLOW SPAN-2

Select a contact output at SPAN-2 measurement status (forward automatic 2 ranges, forward/reverse automatic 2 ranges).

ALARM

- **HARDWARE:** DO1 or DO2 will output a pulse when a EEPROM error is detected.
- **PROCESS:** DO1 or DO2 will output a pulse when the sensor signal is not received or is unstable.

FLOW SWITCH

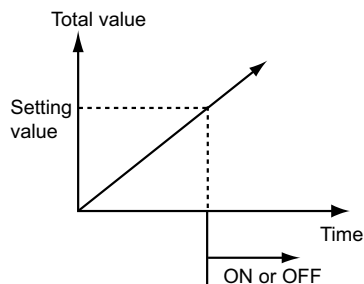
- **UPPER SWITCH:** DO1 or DO2 will output a pulse when the flow rate is above the setpoint.
- **LOWER SWITCH:** DO1 or DO2 will output a pulse when the flow rate is below the setpoint.

TOTAL SWITCH

DO1 or DO2 will output a pulse when the total value exceeds the setpoint.

CONTACT ACTION

- **ACTIVE ON:** Norm. OFF (DO1) or norm. open (DO2).
- **ACTIVE OFF:** Norm ON (DO1) or norm closed (DO2).



Press:



2x

Display shows:

OUTPUT SETUP



ZERO ADJUST



5x

“DO1 OUT” and “NOT USED”

6x

“DO2 OUT” and “NOT USED”



“NOT USED” blinks



Scroll to the new setting



New setting is stored in memory

If “ALARM” is selected, next display selects HARDWARE FAULT, PROCESS FAULT or ALL.

Select one and press .

If FLOW SWITCH is selected, next display selects UPPER SWITCH or LOWER SWITCH.

Select one and press .

Use and to set the flow rate setpoint for the

FLOW SWITCH. When completed, press .



STATUS OUT and CONTACT ACTION CONTACT ACTION is blinking.



CONTACT ACTION and ACTIVE ON ACTIVE ON is blinking.

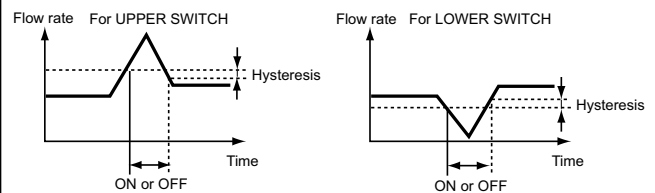


Scroll to change setting to ACTIVE OFF.



“DO1 OUT” (or DO2) and new selection.

Use key and key to resume measurement mode.



Adjust the 4-20 mA Span

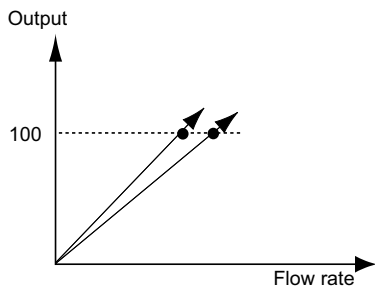
The output values can be offset to allow for the compensation if the 3350 does not match other external reference measurements. Use this function to make small adjustments to match the 4-20 mA output to a PLC or Chart Recorder.

Example: A flow rate measurement performed by a monitoring agency has determined that the flow rate as measured by the 3350 is 5% too low.

To make a 5% adjustment to the flow rate display, the 4-20 mA output and the TOTAL PULSE output, set the CALIBRATION SPAN to +105%.

- If the output values are 5% low, set the CALIBRATION SPAN to 95%.
- Use the “-” sign to change the result from FORWARD to REVERSE flow.
- CALIBRATION SPAN range: ±200%
- ALL OUTPUT values are affected by this setting!
- This functions calculates new values by this formula:

$$\text{Output} = \frac{\text{Measured value} \times [\text{CALIBRATION SPAN}\%]}{100}$$



Press:



2x



7x



Use key and key to set SPAN percentage.



New setting is stored in memory

Use key and key to resume measurement mode.

Display shows:

“OUTPUT SETUP”.

“ZERO ADJUST”.

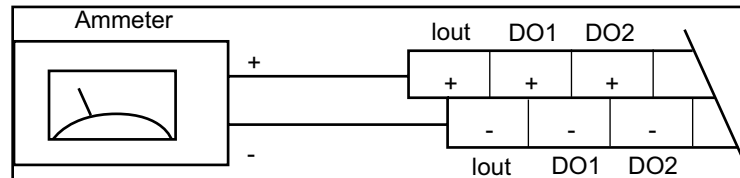
“CALIBRATION SPAN”.

Cursor blinks.

Adjust the 4-20 mA Calibration

Use this function to make small adjustments to the 4 mA and 20 mA output values respectively.

- The calibration is performed so as to obtain 4 mA and 20 mA when the analog signal (4-20 mA DC) output is 0% and 100%, respectively.
- Connect an ammeter to lout terminals as shown.



Test Current Output with External equipment

This function is similar to the CURRENT CALIBRATION, but it allows any current output value to be set instead of just 4 and 20 mA. Use it to check and adjust the input of receiver equipment that is connected to the 4-20 mA output signal from the 3350.

Output range limits: 0.8 mA minimum to 23.2 mA maximum.

Press:	Display shows:
x4	"MAINTENANCE MODE".
	"CURRENT CALIBRATION".
2x	CALIBRATION and 4 mA blinking
Press (UP) or (Down) key	to obtain 4 mA on the ammeter.
	New setting is stored in memory
	CALIBRATION and 20mA
	CALIBRATION and 20mA blinking
Press (UP) or (Down) key	to obtain 20 mA on the ammeter.
	New setting is stored in memory
Use key and key	to resume measurement mode.

Press:	Display shows:
x4	"MAINTENANCE MODE".
	"CURRENT CALIBRATION".
	"CURRENT OUTPUT SETTING".
	"OUTPUT SETTING" and current value.
	Current value blinking
Press (UP) or (Down) key	to set any value from 0.8 mA to 23.2 mA.
	New set value is being generated.
	New setting is stored in memory
	Constant current output is terminated and measurement value resumes.
Use key and key	to resume measurement mode.

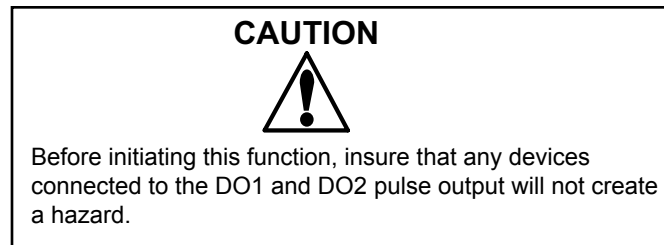
Test the DO1 output in TOTAL PULSE mode











- The output of DO1 can be checked by designating pulse rate from 1 to 100 pulses per second.
- The pulse width setting is integral to the pulse rate allowable. Set the rate taking the pulse width into account.

Example: If the pulse width is set at 50 ms, the TOTAL PULSE output cannot exceed 10 pulses/s
To calculate:

$$1000 \div (\text{pulse width in ms} \times 2) = \text{max pulse rate}$$

- DO1 (transistor open collector) and DO2 (relay contact) operate simultaneously.
- DO2 (relay contact) always operates at the rate of 1 pulses per second.



Press:	Display shows:
	"MAINTENANCE MODE".
	"CURRENT CALIBRATION".
 2x	"TOTAL PULSE" and "10 PULSE/s" (or current setting)
	Cursor begins blinking
Press  and 	to set the required pulse output for DO1. (From 1 to 100 pulses/second)
	DO1 output begins at set pulse rate. DO2 output begins at 1 pulse/second.
	DO1 and DO2 PULSE OUTPUTS stop
Use  and 	to resume the measurement mode.

Set Serial Communication parameters

If the optional serial communication module is installed, use this function to set these parameters:

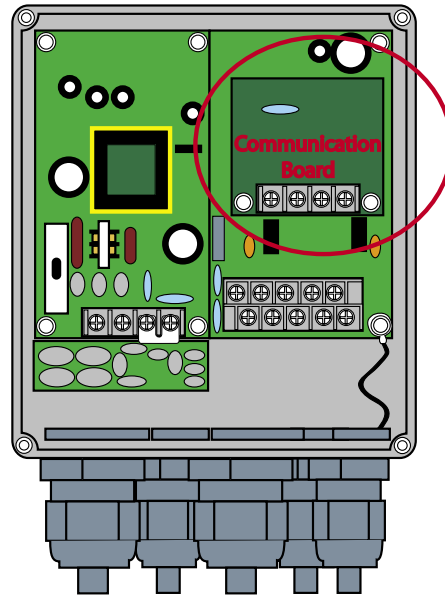
Transmission type: RS-232C (factory set)
RS-485

Transmission rate (baud rate):
2400 BPS
4800 BPS
9600 BPS (factory set)
19200 BPS

Parity: NON (factory set), ODD, EVEN

Stop bits: 1 BIT (factory set), 2 BITS.

Slave No.: 0 (factory set) to 63.



Press:



Display shows:

"MAINTENANCE MODE".



"CURRENT CALIBRATION".



5x

"COMMUNICATION"



2x

COM. MODE and RS-232C (factory set)
RS-232C is blinking



COM. MODE and RS-485



RS-485 is saved to memory



COM. BAUD RATE and 9600 BPS



9600 BPS begins blinking



Scroll to required baud rate



New setting is saved to memory.



COM. PARITY and NON



NON begins blinking.



Scroll to required setting.



New setting is saved to memory.



COM. STOP BIT and 1 BIT



1 BIT begins blinking



Scroll to 2BITS



New setting is saved to memory.



COM.SLAVE NO. and 00 (factory set)



Cursor begins blinking

Use and to set from 00 to 63



New setting is saved to memory.



to resume the measurement mode.

Check the software version

- Use this function to identify the version of the operating software in this instrument.

Press:

Display shows:



MAINTENANCE MODE



CURRENT CALIBRATION



9x

VER.NO. and SIG03A
(Or current software revision number)



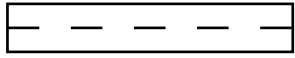


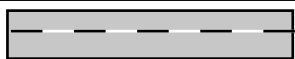

and



to resume the measurement mode.

TROUBLESHOOTING AND MAINTENANCE

If indication is abnormal

Symptom	Cause
 <p>No Display</p>	Power is not turned on. Source voltage is too low. Fuse is blown LCD is defective. DC power polarity is inverted.
 <p>1st line is indicated black</p>	Source voltage is too low. DC power polarity is inverted. LCD is defective.
 <p>Indication is undefined</p>	Hardware error.
 <p>Indication is dim</p>	Ambient temperature is too low (below -20°C). LCD is defective. <p style="text-align: right;">Raise the temperature. Replace the LCD unit.</p>
 <p>Entirely black</p>	Ambient temperature is too high (50°C or higher). Lower the temperature.
LED is always RED	Sensor output is abnormal. Possible causes: Pipe is not full. Sensors are exposed to bubbles. Sensor cable connection is not secure Sensor mounting is incorrect (check electrode spacing, orientation and position.) Inadequate seal between face of electrodes and pipe surface. Pipe condition is interfering with ultrasonic signal (scaling, lining, etc.)

If keying is abnormal

Symptom	Cause
No response to key press.	Hardware error.
Certain key is not responded. Action is not as defined.	

If measurement value is abnormal

Symptom	Cause	Remedy
Minus (-) symbol indicated on measurement value.	Connection between main unit and sensor units (upstream, downstream) are inverted.	Connect correctly.
	So is actual flow.	
Measurement value fluctuates excessively while flow rate is constant.	Straight part of pipe is not enough.	Select where 10D upstream and 5D downstream can be secured.
	Pump, valve or others which disturb the flow are located nearby.	Separate them at least 30D.
	Pulsation exists actually.	Set the damping to longer response time.

Symptom	Cause	Remedy
Measurement value does not change while flow rate does (LED lit red).	Ultrasonic wave is not propagated into piping, whereby reading is held. 1. Installation is poor.	
	<ul style="list-style-type: none"> • Pipe specifications are wrong. • Sensor is mounted on welding. → • Sensor mounting dimensions are wrong. • Silicone filler is not applied properly when mounting the sensor. • Sensor cable connection is poor. 	Upon checking, remove the sensor, apply silicone filler, and slightly offposition the sensor.
	Sensor mounting is poor <ul style="list-style-type: none"> • Mounting dimensions. • There is a gap between sensor and piping. → 	<ul style="list-style-type: none"> • Mounting the sensor in parallel with pipe, allowing correct sensor unit spacing. • Mount the sensor properly so that it is kept in close contact with the pipe.
	2. Pipe or fluid is problematic	
	<ul style="list-style-type: none"> • Not completely filled. → 	Locate a place which is completely filled on the same piping line, and shift the sensor there. <ul style="list-style-type: none"> • Mount the sensor at lowermost position on piping line.
	<ul style="list-style-type: none"> • Ingress of bubbles 	
	Bubbles are introduced if reading is normal when flow is stopped. If mounted immediately downstream a valve, cavitation causes the same phenomenon as when bubbles are introduced. →	Eliminate ingress of bubbles. <ul style="list-style-type: none"> • Raise the pumping well level. • Check the pump shaft seal. • Retighten the negative pressure piping flange. • Avoid a flow as cascade to pumping well.
	<ul style="list-style-type: none"> • Excessively TURBID 	
	More TURBID than inflow sewage water or return sludge. <ul style="list-style-type: none"> • Scales are on inside wall of old pipe. → • Lining is thick. • Lining is peeled. There is a gap between lining and pipe. → <ul style="list-style-type: none"> • Sensor is mounted on uneven pipe or tapered pipe. 3. Influence by external noise. <ul style="list-style-type: none"> • There is radio broadcasting station nearby. • There is heavy traffic (automobiles, trains, etc.) near the measurement site. → 4. Hardware error. →	<ul style="list-style-type: none"> • Move the sensor to smaller pipe diameter on the same line. • Move the sensor to another place or pipe. Mount the sensor on straight pipe. <ul style="list-style-type: none"> • Reduce the length of main unit sensor cable to a minimum. • Connect the main unit and pipe to ground. See "Section 1.6.6. Remedying a hardware fault."

Symptom	Cause	Remedy
Flow rate will not go to zero when flow is stopped.	Water is moving in pipe.	Normal
	Zero adjustment is not correct.	Reset zero adjustment when water is completely still.
	Sensors are located at an air pocket, or pipe is empty (LED lit red).	Normal
Flow rate is incorrect.	Pipe parameters are different from the actual values.	Input correct dimensions in PIPE PARAMETERS. Inside diameter error of 1% produces about 3% measurement error. Treat scale buildup inside pipe as lining.
	Scales exist on wall of old pipe.	
	Straight part of pipe is not enough (10D upstream and 5D downstream cannot be obtained).	Find a better place for mounting the sensor (more straight pipe upstream of disturbance).
		There must be no disturbance within 30D upstream. Pump, valve, joint pipe, etc. are not allowed.
		Mount the sensor at different angles with respect to pipe cross section until an average is obtained.
	Pipe is not filled with water or is has accumulated sediment causing volumetric error.	Reading rises as cross-sectional area reduces. Move to vertical pipe.

Symptom	Cause	Remedy
Current output is incorrect.	Range setting is incorrect.	Set the range correctly.
Current output is not 4 mA when flow rate is 0.	Analog output is not calibrated.	Calibrate the analog output.
Current output is 0 mA.	4-20 mA loop wiring is open.	Check 4-20 mA loop wiring.
Output is over 20 mA.	"OVERFLOW" is indicated on LCD.	Flow rate is over range. Adjust Output Range settings.
Output is below 4 mA.	"UNDERFLOW" is indicated on LCD.	Backflow Set the upstream and downstream properly.
Measurement value varies but analog output is constant.	Output load is above 600Ω.	Reduce the output load to less than 600Ω.
Analog output does not match the measurement value.	Analog output is not calibrated.	Calibrate the analog output.
Output remains unchanged even after analog output calibration.	Hardware error.	Contact technical support.

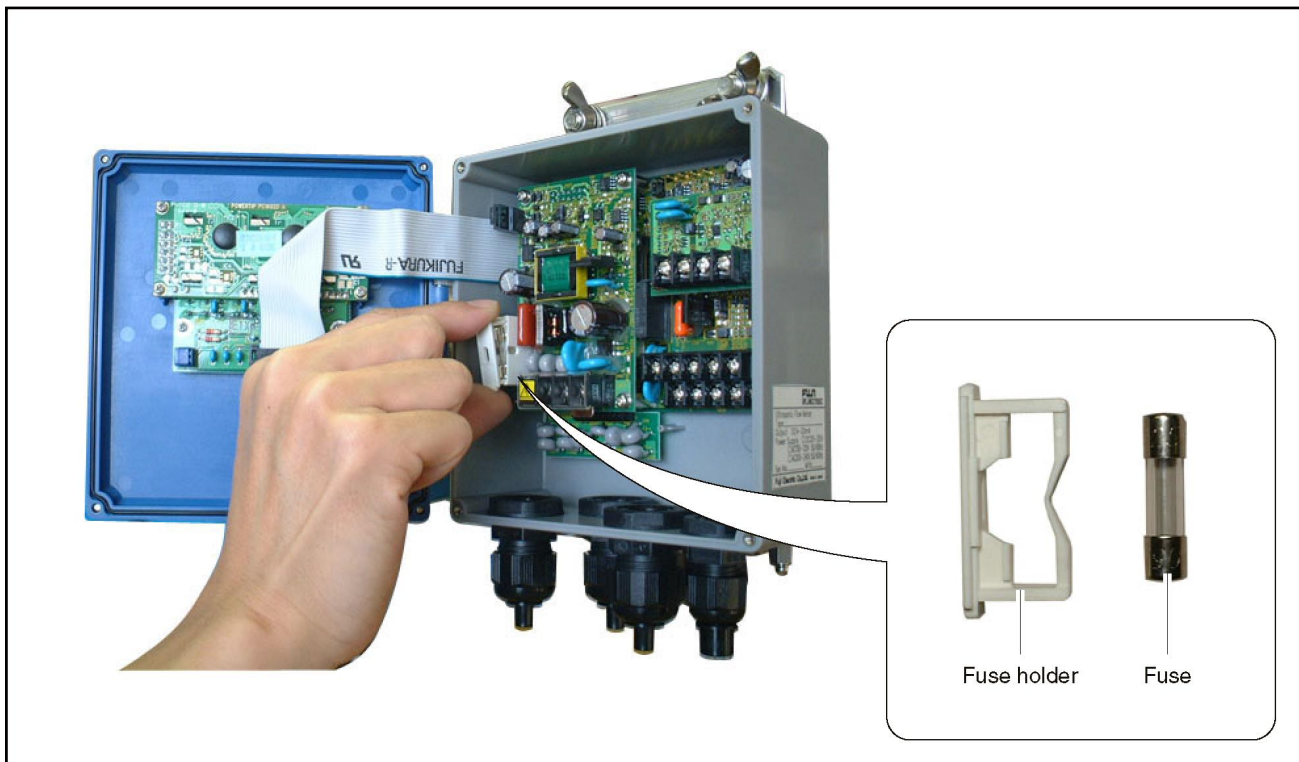
How to replace the fuse

WARNING!



- Turn off power before replacing the fuse.
- Fuse specifications
- AC power source (100 or 200 V): 5.2 mm (diameter) x 20 mm (long), 250 V, 0.5 A.
- DC powered source: 5.2 mm (diameter) c 20 mm (long), 250 V, 1 A.

1. Loosen 4 screws from the flow transmitter front, and open the cover.
2. Detach the fuse holder from the power supply board, and replace the fuse. Then, return the fuse holder in place
3. Close the cover, and tighten 4 screws.



CAUTION



Close cover before restoring power.

Replacing the relay

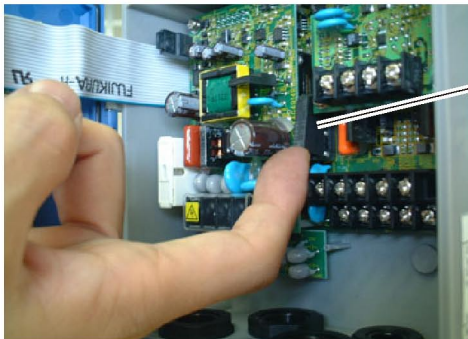
DO2 is a relay contact with a life span of 20,000 operations (rate load). Replace it before the end of its life by estimating the number of contact operations.

To replace the fuse:

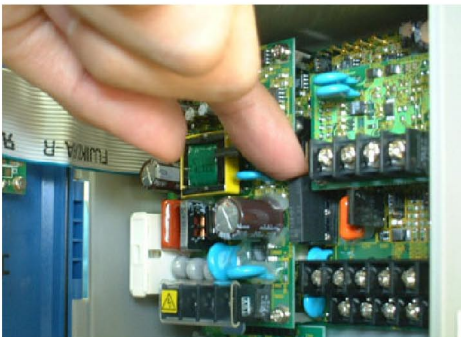
1. Turn off power and open the cover.
2. Pull the relay from the socket as illustrated below.
3. Insert a new relay into the socket. Seat the relay firmly to engage the relay locking claws.
4. Close the cover and turn on power.
5. Set the maintenance mode to "STATUS OUTPUT", and check the relay ON and OFF actions.



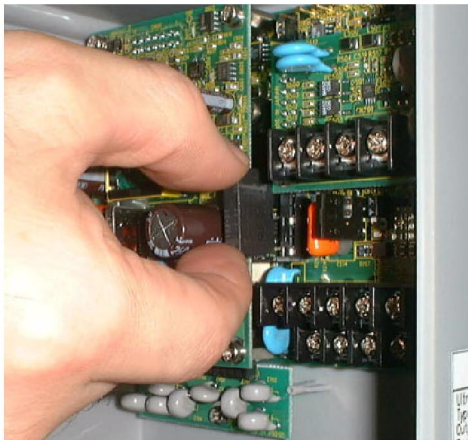
- High voltage is present inside the cover. Turn on power only after closing the cover.



Loosen the relay module by pushing from the bottom and the top.



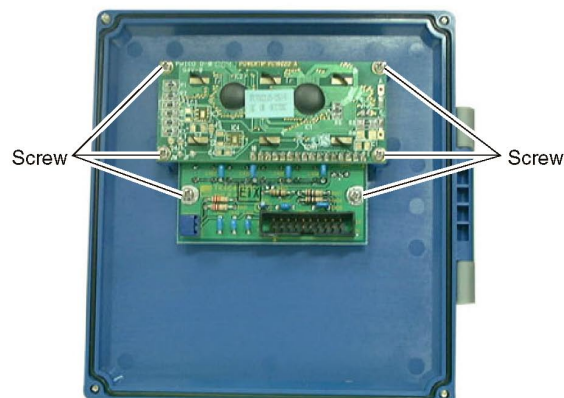
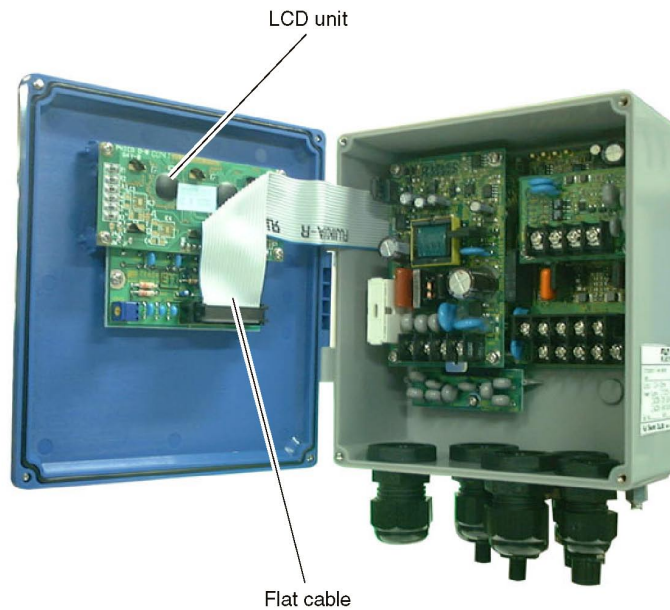
Pull the loose module out of the socket.



Replacing the LCD

Over the life of the LCD the contrast will deteriorate gradually. Maximum life expectancy of the LCD is 7 years. Replace the LCD after 5 years of normal use for troublefree performance.

1. Turn off power and open the cover.
2. Disconnect the flat cable connector.
3. Loosen 6 screws from the LCD assembly.
4. Mount a new LCD assembly.
Be careful to insert the keypad and LED so they are aligned with the cover openings and are not pinched or stressed by the cover.
5. Reconnect the flat cable connector.
6. Close the cover and turn on power.
7. Make sure the LCD is working, and that keys respond properly.



Piping data: Acoustic Velocity in Solids

Material	ft/sec	m/sec
Arcrylic	8954	2730
Aluminum	10102	3080
Aluminum (rolled)	9971	3040
Aluminum (2024)	10365	3160
Asbestos Cement	7216	2200
Brass (Naval)	6724	2050
Carbon Steel	10516	3206
Cast Iron	10594	3230
Copper	7413	2260
Copper (annealed)	7626	2325
Copper-Nickel (70-30)	7446	2270
Copper-Nickel (90-10)	6757	2060
Ductile Iron	9840	3000
FRP	8216	2505
Glass. Crown	9315	2840
Glass, Pyrex	10758	3280
Glass, Quartz	11546	3520
Gold	3936	1200
Inconel	9906	3020
Iron	10611	3235
Iron Ductile	9840	3000
Lead	7118	2170
Lucite	4133	1260
Mild steel	10611	3235

Material	ft/sec	m/sec
Monel	8922	2720
Mortar	8200	2500
Nickel	9709	2960
Nylon	7872	2400
Nylon, 6-6	3510	1070
Polyethylene (LD)	6363	1940
Polyethylene (HD)	7577	2310
PVC, CPVC	7872	2400
Steel, 1% carbon	10562	3220
Steel, galvanized-standard	10590	3223
Steel, harden 1% carbon	10332	3150
Stainless Steel-302	10234	3120
Stainless Steel-304	10516	3206
Stainless Steel-316	10414	3175
Stainless Steel-347	10168	3100
Stainless Steel-410	9807	2990
Stainless Steel-430	11021	3360
Tar epoxy	6560	2000
Tin, rolled	5478	1670
Titanium	10250	3125
Tungsten, annealed	9479	2890
Tungsten, drawn	8659	2890
Tungsten, carbide	13054	3980
Zinc, rolled	8003	2440

Acoustic Velocity of Water (Listed at varying temperatures)

Temp. (C)	Acoustic Velocity (m/s)	Temp. (C)	Acoustic Velocity (m/s)
0	1402.74	26	1499.64
2	1412.57	28	1504.68
4	1421.96	30	1509.44
6	1430.92	32	1513.91
8	1439.46	34	1518.12
10	1447.59	36	1522.06
12	1455.34	38	1525.74
14	1462.70	40	1529.18
16	1469.70	42	1532.37
18	1476.35	44	1535.33
20	1482.66	46	1538.06
22	1488.63	48	1540.57
24	1494.29	50	1542.84

Temp. (C)	Acoustic Velocity (m/s)	Temp. (C)	Acoustic Velocity (m/s)
52	1544.95	78	1555.18
54	1546.83	80	1554.81
56	1548.51	82	1554.30
58	1550.00	84	1553.63
60	1551.30	86	1552.82
62	1552.42	88	1551.88
64	1553.35	90	1550.79
66	1554.11	92	1549.58
68	1554.70	94	1548.23
70	1555.12	96	1546.75
72	1555.37	98	1545.14
74	1555.47	100	1543.41
76	1555.40		

Acoustic Velocity in Fluids

Substance	Form Index	Temp. (°C)	Sound Speed (m/s)	Kinematic Viscosity (m ² s x 10 ⁻⁶)
Acetic acid	CH ₃ COOH	20	1159	
Acetic anhydride	(CH ₃ CO) ₂ O	20	1180	0.789
Acetic acid, anhydride	(CH ₃ CO) ₂ O	20	1180	0.769
Acetonitrile	C ₂ H ₃ N	25	1290	0.441
Acetylacetone	C ₆ H ₁₀ O ₂	25	1399	
Acetylene dichloride	C ₂ H ₂ Cl ₂	25	1015	0.400
Acetylene tetrachloride	C ₂ H ₂ Br ₄	25	1027	
Acetylene tetrachloride	C ₂ H ₂ Cl ₄	25	1147	1.156 (15°C)
Ethyl alcohol	C ₂ H ₆ O	25	1207	1.396
Alkazene-13	C ₁₅ H ₂₄	25	1317	
Alkazene-25	C ₁₀ H ₁₂ Cl ₂	25	1307	
2-amino-ethanol	C ₂ H ₇ NO	25	1724	
2-aminotolidine	C ₇ H ₂ N	25	1618	4.394 (20°C)
4-aminotolidine	C ₇ H ₉ N	25	1480	1.863 (50°C)
Ammonia	NH ₃	-33	1729	0.292
1-amyl alcohol	C ₅ H ₁₂ O	25	1204	4.374
Aminbenzene	C ₆ H ₅ No ₂	25	1639	3.63
Aniline	C ₆ H ₅ NO ₂	20	1659	1.762
Azine	C ₆ H ₅ N	25	1415	0.992
Benzene	C ₆ H ₆	25	1306	0.711
Benzol	C ₆ H ₆	25	1306	0.711
Bromine	Br ₂	25	889	0.323
Bromobenzene	C ₆ H ₅ Br	25	1170	0.693
1-bromo-butane	C ₄ H ₉ Br	20	1019	0.49 (15°C)
Bromoethane	C ₂ H ₅ Br	20	900	0.275
Bromoform	CHBr ₃	20	918	0.654
n-butane	C ₄ H ₁₀	-5	1085	
2-butanol	C ₄ H ₁₀ O	25	1240	3.239
sec-butylalcohol	C ₄ H ₁₀ O	25	1240	3.239
n-butyl bromide	C ₄ H ₉ Br	20	1019	0.49 (15°C)
n-butyl chloride	C ₄ H ₉ Cl	25	1140	0.529
tert butyl chloride	C ₄ H ₉ Cl	25	984	0.646
Butyl oleate	C ₂₂ H ₄₂ O ₂	25	1404	0.529
2,3 butylene glycol	C ₄ H ₁₀ O ₂	25	1484	
Carbinol	CH ₄ O	25	1076	0.695
Carbitol	C ₆ H ₁₄ O ₃	25	1458	
Carbon dioxide	CO ₂	-37	839	0.137
Carbon disulphide	CS ₂	20	1158	0.290
Carbon tetrachloride	CCl ₄	20	938	0.608
Cetane	C ₁₈ H ₃₄	20	1338	4.32
Chlorobenezene	C ₆ H ₉ Cl	20	1289	0.722 (25°C)

Acoustic Velocity in Fluids

Substance	Form Index	Temp. (°C)	Sound Speed (m/s)	Kinematic Viscosity (m ² s x 10 ⁻⁶)
1-Chlorobutane	C ₄ H ₉ Cl	25	1140	0.529
Chloroform	CHCl ₃	20	931	0.383
1-chloropropane	C ₃ H ₇ Cl	25	1058	0.378
Cinnamaldehyde	C ₉ H ₈ O	25	1554	
Cinnamic aidehyde	C ₉ H ₈ O	25	1554	
Colamine	C ₂ H ₇ NO	25	1724	
o-cresol	C ₇ H ₈ O	20	1541	4.29 (40°C)
m-cresol	C ₇ H ₈ O	20	1500	5.979 (40°C)
Cyanomethane	C ₂ H ₂ N	25	1290	0.441
Cyclohexane	C ₆ H ₁₂	20	1284	1.31 (17°C)
Cyclohexanol	C ₆ H ₁₂ O	25	1454	0.071 (17°C)
Cyclohexanone		25	1423	
Decane	C ₁₀ H ₂₂	25	1252	1.26 (20°C)
1-decane	C ₁₀ H ₂₀	25	1235	
n-decylene	C ₁₀ H ₂₀	25	1235	
Diacetyl	C ₄ H ₆ O ₂	25	1236	
Daimylamine	C ₁₀ H ₂₃ N	25	1256	
1. 2-dibromotane	C ₂ H ₄ Br ₂	25	995	0.79 (20oC)
trans-1, 2-diproeheme	C ₂ H ₂ Br ₂	25	935	
Dibutyl phthalate	C ₆ H ₂₂ O ₄	25	1408	
Dichloro-t-butyl alcohol	C ₄ H ₈ Cl ₂ O	25	1304	
2,3-dichlorodixane	C ₂ H ₈ Cl ₂ O ₂	25	1391	
dichlorodflourmeheme (Freon 12)	CCl ₂ F ₂ CCl ₂	25	774.1	
1,2-dichloroethene	C ₂ H ₂ Cl ₂	25	1061	
trans 1, 2-dichlethane	C ₂ H ₂ Cl ₂	25	1010	
Dichlorofluoro- methane (Freon21)	CHCl ₂ F	0	891	
1-2-dichlorohexafluoro- cyclobutane	CC ₄ Cl ₂ F ₆	25	669	
1-3-dichloroisobutane	C ₄ H ₆ Cl ₂	25	1220	
Dichloro methane	CH ₂ Cl ₂	25	1070	0.31
1, 1-dichloro 1,2 2, 2-tetra fluoroethane	CClF ₂ - CClF ₂	25	665.3	
Diethyl ether	C ₄ H ₁₀ O	25	985	0.311
Diethylene glycol	C ₄ H ₁₀ O ₃	25	1586	
Diethylene glycol, monoethyl ether	C ₆ H ₁₄ O ₃	25	1458	
Diethylenimide oxide	C ₄ H ₉ NO	25	1442	

Acoustic Velocity in Fluids

Substance	Form Index	Temp. (°C)	Sound Speed (m/s)	Kinematic Viscosity (m ² s x 10 ⁻⁶)
1,2-bis (difluoramino) butane	C ₄ H ₈ (NF ₂) ₂	25	1000	
1,2-bis (difluouramino)- 2-methylpropane	C ₄ H ₉ (NF ₂) _s	25	900	
1,2-bis (difluoramino) propane	C ₃ H ₆ (NF ₂) ₂	25	960	
2,2-bis (difluoramino) propane	C ₃ H ₆ (NF ₂) ₂	25	890	
2,2-dihydroxy- dilethyrther	C ₄ H ₁₀ O ₂	25	1586	
Dihdroxyethane	C ₂ H ₆ O ₂	25	1658	
1,3-dimethyl- benzene	C ₈ H ₁₀	20	1343	0.749 (15°C)
1,2-dimethyl- benzene	C ₈ H ₁₀	25	1331.5	0.903 (20°C)
1,4-dimethyl- benzene	C ₈ H ₁₀	20	1334	0.662
2,2-dimethyl- butane	C ₆ H ₁₄	25	1079	
Dimethyl ketone	C ₃ H ₆ O	25	1174	0.399
Dimethyl pentane (47)	C ₇ H ₁₆	25	1063	
Dimethyl phthalate	C ₈ H ₁₀ O ₄	25	1463	
Dilodo-methane	CH ₂ I ₂	25	980	
Dioxane	C ₄ H ₈ O ₂	25	1376	
Dodecane (23)	C ₁₂ H ₂₆	25	1279	1.80
1, 2-ethanediol	C ₂ H ₆ O ₂	25	1658	
Ethanenitrile	C ₂ H ₃ N	25	1290	0.441
Ethanoic anhydride (22)	(CH ₃ CO) ₂ O	25	1180	0.769
Ethanol	C ₂ H ₆ O	25	1207	1.39
Ethanol amide	C ₂ H ₇ NO	25	1724	
Ethoxyethane	C ₄ H ₁₀ O	25	985	0.311
Ethyl acetate	C ₄ H ₈ O ₂	20	1164	0.499
Ethyl alcohol	C ₂ H ₆ O	25	1207	1.396
Ethyl benzene	C ₈ H ₁₀	20	1338	0.797 (17°C)
Ethyl Bromide	C ₂ H ₅ Br	20	900	0.2.75
Ethyl iodide	C ₂ H ₅ I	20	876	0.29
Ether	C ₄ H ₁₀ O	20	1006	0.336
Ethyl ether	C ₄ H ₁₀ O	25	985	0.311
Ethylene bromide	C ₂ H ₄ Br ₂	25	995	0.79
Ethylene chloride	C ₂ H ₄ Cl ₂	25	1193	0.61

Acoustic Velocity in Fluids

Substance	Form Index	Temp. (°C)	Sound Speed (m/s)	Kinematic Viscosity (m ² s x 10 ⁻⁶)
Ethylene glycol	C ₂ H ₆ O ₂	20	1666	21.112
50% glycol 50% H ₂ O		25	1578	
d-fenochone	C ₁₀ H ₁₆ O	25	1320	0.22
d-2-fenochone	C ₁₀ H ₁₆ O	25	1320	0.22
Fluoro-benzene (46)	C ₆ H ₅ F	25	1189	0.584
Formaldehyde, methylester	C ₂ H ₄ O ₂	25	1127	
Formamide	CH ₃ NO	25	1622	2.91
Formic acid, amide	CH ₃ NO	25	1622	2.91
Freon 12		25	774.2	
Furfural	C ₅ H ₄ O ₂	25	1444	
Furfuryl alcohol	C ₅ H ₆ O ₂	25	1450	
Fural	C ₅ H ₄ O ₂	25	1444	
2-furaldehyde	C ₅ H ₄ O ₂	25	1444	
2-furancarboxaide- hyde	C ₅ H ₄ O ₂	25	1444	
2-furyl-methanol	C ₅ H ₆ O ₂	25	1450	
Gallium	Ga	30	2870	
Glicerin	C ₃ H ₆ O ₃	20	1923	1188.5
Glycerol	C ₃ H ₅ O ₂	25	1904	757.1
Glycol	C ₂ H ₆ O ₂	25	1658	
Heptane	C ₇ H ₁₆	25	1131	0.598(20°C)
n-heptane	C ₇ H ₁₆	25	1180	
Hexachloro- cyclopentadiene	C ₅ Cl ₆	25	1150	
Hexadecane	C ₁₆ H ₃₄	25	1338	4.32(20°C)
Hexalin	C ₃ H ₁₀	20	1338	0.797 (17°C)
Hexane	C ₂ H ₅ Br	20	900	0.2.75
n-hexane	C ₂ H ₅ I	20	876	0.29
2, 5-hexanedione	C ₄ H ₁₀ O	20	1006	0.336
n-hexanol	C ₄ H ₁₀ O	25	985	0.311
Hexahydrobenzene	C ₂ H ₄ Br ₂	25	995	0.79
Hexahydrophenol	C ₂ H ₄ Cl ₂	25	1193	0.61
Hecamethylene	C ₅ H ₁₂	25	1248	1.31
2-hydroxy-toluene	C ₇ H ₈ O	20	1541	4.29 (40°C)
3-hydroxy-toluene	C ₇ H ₈ O	20	1500	5.979 (40°C)
Iodo-benzene	C ₆ H ₅ I	20	1114	0.954
Iodo-ethane	C ₂ H ₅ I	20	876	0.29
Iodod-methane	CH ₃ I	25	978	0.211
Isobutyl acetate	C ₆ H ₁₂ O	27	1180	

Acoustic Velocity in Fluids

Substance	Form Index	Temp. (°C)	Sound Speed (m/s)	Kinematic Viscosity (m ² s x 10 ⁻⁶)
Isobutanol	C ₂ H ₆ O ₂	25	1212	
Iso-butane		25	1219.8	0.34
Isopentane	C ₅ H ₁₂	25	980	0.34
Isopropanol (46)	C ₃ H ₈ O	20	1170	2.718
Isopropyl alcohol	C ₃ H ₈ O	20	1170	2.718
Kerosene		25	1324	
Ketohexamethylene	C ₆ H ₁₀ O	25	1423	
Mercury	Hg	20	1451	0.114
Mesityloxiide	C ₆ H ₁₆ O	25	1310	
Methanol	CH ₄ O	25	1076	0.695
Methyl acetate	C ₃ H ₆ O ₂	20	1181	0.411
o-methylaniline	C ₇ H ₉ N	25	1618	4.394 (20°C)
4-methylaniline	C ₇ H ₉ N	25	1480	1.863 (50°C)
Methyl alcohol	CH ₄ O	25	1076	0.695
Methyl benzene	C ₇ H ₈	20	1328	0.644
2-methyl-butane	C ₅ H ₁₂	25	980	0.34
Methyl carbinol	C ₂ H ₆ O	25	1207	1.396
Methyl-chloroform	C ₂ H ₃ Cl ₃	25	985	0.902 (20°C)
Methyl-cyanide	C ₂ H ₃ N	25	1290	0.441
3-methyl cyclohexanol	C ₇ H ₁₄ O	25	1400	
Methylene chloride	CH ₂ Cl ₂	25	1070	0.31
Methylene iodide	CH ₂ I ₂	25	980	
Methyl formate	C ₂ H ₄ O ₂	25	1127	
Methyl iodide	CH ₃ I	25	978	0.211
a-methyl napthalene	C ₁₁ H ₁₀	25	1510	
2-mehtylphenol	C ₇ H ₈ O	20	1541	4.29 (40°C)
3-methylphenol	C ₇ H ₈ O	20	1500	5.979 (40°C)
n-hexanol	C ₄ H ₁₀ O	25	985	0.311
Milk, homogenized		25	1548	
Morpholine	C ₄ H ₉ NO	25	1442	
Naphtha		25	1225	
Nitrobenzene	C ₆ H ₅ NO ₂	20	1473	1.665
Nitromethane	CH ₃ NO ₂	25	1300	0.549
Nonane	C ₉ H ₂₀	25	1207	0.99 (20°C)
1-nonene	C ₉ H ₁₈	25	1207	
Octane	C ₈ H ₁₈	25	1172	0.73
n-octane	C ₈ H ₁₈	20	1192	0.737 (25°C)
1-octane	C ₈ H ₁₈	25	1175.5	

Acoustic Velocity in Fluids

Substance	Form Index	Temp. (°C)	Sound Speed (m/s)	Kinematic Viscosity (m ² s x 10 ⁻⁶)
Oil of camphor Sassafrassy		25	1390	
Oil, car (SAE 20a.30)		25	870	190
Oil, castor	C ₁₁ H ₁₀ O ₁₀	25	1477	0.670
Oil, diesel		25	1250	
Oil, fuel AA gravity		25	1485	
Oil (Lubricating X200)		25	1530	
Oil (olive)		25	1431	100
Oil (peanut)		25	1458	
Oil (sperm)		25	1440	
Oil, 6		22	1509	
2, 2-oxydiethanol	C ₄ H ₁₀ O ₃	25	1586	
Pentachloroethane	C ₂ HCl ₅	25	1082	
Pentalin	C ₂ HCl ₅	25	1082	
Pentane	C ₅ H ₁₂	25	1020	0.363
n-pentane	C ₅ H ₁₂	20	1032	0.366
Perchlorocyclo- pentadiene	C ₅ H ₆	25	1150	
Perchloroethylene	C ₂ Cl ₄	25	1036	
Perchloro-1-hepten	C ₇ F ₁₄	25	583	
Perfluoro-n-hexane	C ₆ F ₁₄	25	508	
Phene	C ₆ H ₆	25	1306	0.711
b-phenyl acrolein	C ₉ H ₈ O	25	1554	
Phenyl amine	C ₆ H ₅ NO ₂	25	1639	3.63
Phenyl bromide	C ₆ H ₅ Br	20	1170	0.693
Phenyl chloride	C ₆ H ₅ Cl	25	1273	0.722
Phenyl iodide	C ₆ H ₅ I	20	1114	0.954(15°C)
Phenyl methane	C ₇ H ₈	20	1328	0.644
3-Phenyl propenal	C ₉ H ₈ O	25	1554	
Phthaldione	C ₈ H ₄ O ₃	125	1125	
Pimelic ketone	C ₆ H ₁₀ O	25	1423	
Plexiglas, lucite acrylic		25	2651	
Refrigerant 11	CCl ₃ F	0	828.3	
Propane	C ₃ H ₈ O ₃	-45	1003	
1, 2, 3-propanetriol	C ₃ H ₈ O ₃	25	1904	0.757 x 10 ⁻³
1-propanol	C ₃ H ₈ O	20	1222	
2-propanol	C ₃ H ₈ O	20	1170	2.718
2-propanone	C ₃ H ₈ O	25	1174	0.399
Propene	C ₃ H ₆	-13	963	
n-propyl acetate	C ₅ H ₁₀ O ₂	2	1280	

Acoustic Velocity in Fluids

Substance	Form Index	Temp. (°C)	Sound Speed (m/s)	Kinematic Viscosity (m ² s x 10 ⁻⁶)
1, 1, 2-trichloro- 1, 2, 2-trifluoro- ethane	C ₆ H ₁₅ N	0	783.7	
Triethylamine	C ₆ H ₁₅ N	25	1123	
Triethylene glycol	C ₆ H ₁₄ O ₄	25	1608	
1, 1, 1-trifluoro- 2-chloro-2-bromo- ethane	C ₂ HClBrF ₃	25	693	
1, 2, 2-trifluorotrichlo- ethane (Freon 113)	CCl ₂ F-CClF ₂	0	783.7	
d-1, 3,3- trimethylnorcamphor	C ₁₀ H ₁₆ O	25	1320	
Trinitrotoluene	C ₇ H ₅ (NO ₂) ₃	81	1610	
Turpentine		25	1255	1.4
Unisis 800		25	1346	
Water, distilled	H ₂ O	20	1482	1.00
Water, heavy	D ₂ O	20	1388	1.129
Water, sea		20	1520	1.00
Wood alcohol	CH ₄ O	25	1076	0.695
m-xylene	C ₈ H ₁₀	20	1343	0.749 (15°C)
o-xylene	C ₈ H ₁₀	25	1331.5	0.903 (200C)
p-xylene	C ₈ H ₁₀	20	1334	0.662
Xylene hexafluoride	C ₈ H ₄ F ₆	25	879	0.613

Pipe Dimensions: PVC

Nominal Diameter	PVC IPS CLASS					Schedule PVC	
	100 SDR-41	125 SDR-32.5	160 SDR-26	200 SDR-21	315 SDR-13.5	Sch. 40	Sch. 80
1"	O.D.	1.315	1.315	1.315	1.315	1.315	1.315
	Wall	0.052	0.060	0.063	0.097	0.133	0.179
	I.D.	1.211	1.195	1.189	1.121	1.049	0.957
1-1/2"	O.D.	1.900	1.900	1.900	1.900	1.900	1.900
	Wall	0.060	0.073	0.090	0.141	0.145	0.200
	I.D.	1.780	1.754	1.720	1.618	1.610	1.500
2"	O.D.	2.375	2.375	2.375	2.375	2.375	2.375
	Wall	0.073	0.091	0.113	0.176	0.154	0.218
	I.D.	2.229	2.193	2.149	2.023	2.067	1.939
2-1/2"	O.D.	2.875	2.875	2.875	2.875	2.875	2.875
	Wall	0.066	0.110	0.137	0.213	0.203	0.276
	I.D.	2.699	2.655	2.601	2.449	2.469	2.323
3"	O.D.	3.500	3.500	3.500	3.500	3.500	3.500
	Wall	0.085	0.108	0.135	0.187	0.216	0.300
	I.D.	3.330	3.284	3.230	3.166	2.962	2.900
4"	O.D.	4.500	4.500	4.500	4.500	4.500	4.500
	Wall	0.110	0.138	0.173	0.214	0.333	0.337
	I.D.	4.280	4.224	4.154	4.072	3.384	4.026
5"	O.D.	5.563	5.563	5.563	5.563	5.563	5.563
	Wall	0.136	0.171	0.214	0.265	0.258	0.375
	I.D.	5.291	5.221	5.135	5.033	5.047	4.813
6"	O.D.	6.625	6.625	6.625	6.625	6.625	6.625
	Wall	0.162	0.205	0.255	0.316	0.280	0.432
	I.D.	6.301	6.215	6.115	5.993	6.065	5.781
8"	O.D.	8.625	8.625	8.625	8.625	8.625	8.625
	Wall	0.210	0.265	0.332	0.411	0.322	0.500
	I.D.	8.205	8.095	7.961	7.803	7.981	7.625

Nominal Diameter		PVC PIP CLASS					
		100 Foot Head	63 SDR-64	80 SDR-51	100 SDR-41	125 SDR-32.5	160 SDR-26
4"	O.D.			4.130	4.130	4.130	4.130
	Wall			0.081	0.101	0.127	0.159
	I.D.			3.968	3.928	3.676	3.812
5"	O.D.						
	Wall						
	I.D.						
6"	O.D.	6.140		6.140	6.140	6.140	6.140
	Wall	0.120		0.120	0.150	0.189	0.236
	I.D.	5.900		5.900	5.840	5.762	5.666
8"	O.D.	8.160		8.160	8.160	8.160	8.160
	Wall	0.087		0.160	0.199	0.251	0.314
	I.D.	7.986		7.840	7.762	7.658	7.532

Pipe Dimensions: PVC

Nominal Diameter	PVC IPS CLASS					Schedule PVC	
	100 SDR-41	125 SDR-32.5	160 SDR-26	200 SDR-21	315 SDR-13.5	Sch. 40	Sch. 80
1"	O.D.		1.315	1.315	1.315	1.315	1.315
	Wall		0.052	0.060	0.063	0.097	0.133
	I.D.		1.211	1.195	1.189	1.121	1.049
1-1/2"	O.D.		1.900	1.900	1.900	1.900	1.900
	Wall		0.060	0.073	0.090	0.141	0.145
	I.D.		1.780	1.754	1.720	1.618	1.500
2"	O.D.		2.375	2.375	2.375	2.375	2.375
	Wall		0.073	0.091	0.113	0.176	0.154
	I.D.		2.229	2.193	2.149	2.023	2.067
2-1/2"	O.D.		2.875	2.875	2.875	2.875	2.875
	Wall		0.066	0.110	0.137	0.213	0.203
	I.D.		2.699	2.655	2.601	2.449	2.469
3"	O.D.	3.500	3.500	3.500	3.500	3.500	3.500
	Wall	0.085	0.108	0.135	0.187	0.259	0.216
	I.D.	3.330	3.284	3.230	3.166	2.962	3.068
4"	O.D.	4.500	4.500	4.500	4.500	4.500	4.500
	Wall	0.110	0.138	0.173	0.214	0.333	0.237
	I.D.	4.280	4.224	4.154	4.072	3.384	4.026
5"	O.D.	5.563	5.563	5.563	5.563		5.563
	Wall	0.136	0.171	0.214	0.265		0.258
	I.D.	5.291	5.221	5.135	5.033		5.047
6"	O.D.	6.625	6.625	6.625	6.625		6.625
	Wall	0.162	0.205	0.255	0.316		0.280
	I.D.	6.301	6.215	6.115	5.993		6.065
8"	O.D.	8.625	8.625	8.625	8.625		8.625
	Wall	0.210	0.265	0.332	0.411		0.322
	I.D.	8.205	8.095	7.961	7.803		7.981

Nominal Diameter	PVC Cast Iron O.D.								PVC Sewer DR-35
	100 psi DR-41	125 psi DR-32.5	100 psi DR-25	165 psi DR-25	200 psi DR-21	150 psi DR-18	235 psi DR-18	200 psi DR-14	
4"	O.D.		4.800			4.800			4.125
	Wall		0.192			0.267			0.125
	I.D.		4.416			4.266			3.875
5"	O.D.								
	Wall								
	I.D.								
6"	O.D.		6.900			6.900		6.900	6.275
	Wall		0.276			0.383		0.493	0.180
	I.D.		6.348			6.134		5.914	5.915
8"	O.D.		9.050			9.050		9.050	8.400
	Wall		0.362			0.503		0.646	0.240
	I.D.		8.326			8.044		7.758	7.920

Pipe Dimensions: Steel

Nominal Diameter	Carbon Steel									Standard Weight	Extra Strong	Double Extra Strong	
	Schedule												
	10	20	40	60	80	100	120	140	160				
1"	O.D.			1.315		1.315				1.315	1.315	1.315	1.315
	Wall			0.133		0.179				0.250	0.133	0.179	0.358
	I.D.			1.049		0.957				0.815	1.049	0.957	0.559
1-1/2"	O.D.			1.900		1.900				1.900	1.900	1.900	1.900
	Wall			0.145		0.200				0.281	0.145	0.200	0.400
	I.D.			1.610		1.500				1.338	1.610	1.500	1.100
2"	O.D.			2.375		2.375				2.375	2.375	2.375	2.375
	Wall			0.154		0.218				0.343	0.154	0.218	0.436
	I.D.			2.067		1.939				1.689	2.067	1.939	1.503
2-1/2"	O.D.			2.875		2.875				2.875	2.875	2.875	2.875
	Wall			0.203		0.276				0.375	0.203	0.276	0.552
	I.D.			2.469		2.323				2.125	2.469	2.323	1.771
3"	O.D.			3.500		3.500				3.500	3.500	3.500	3.500
	Wall			0.216		0.300				0.438	0.216	0.300	0.600
	I.D.			3.068		2.900				2.624	3.068	2.900	2.300
3-1/2"	O.D.			4.000		4.000				4.000	4.000	4.000	4.000
	Wall			0.266		0.318				0.318	0.636	0.318	0.083
	I.D.			3.548		3.364				3.548	3.364	3.364	2.728
6"	O.D.			6.625		6.625		6.625		6.625	6.625	6.625	6.625
	Wall			0.280		0.432		0.562		0.718	0.280	0.432	0.897
	I.D.			6.065		5.761		5.501		5.189	6.065	5.761	4.897
8"	O.D.		8.625	8.625	8.625	8.625	8.625	8.625	8.625	8.625	8.625	8.625	8.625
	Wall		0.250	0.322	0.406	0.500	0.593	0.718	0.812	0.906	0.322	0.500	0.875
	I.D.		8.125	7.981	7.813	7.625	7.439	7.189	7.001	6.813	7.981	7.625	6.875

Nominal Diameter	Stainless Steel				
	Schedule				
	5	10	40	80	
1"	O.D.	1.315	1.315	1.315	1.315
	Wall	0.065	0.109	0.133	0.179
	I.D.	1.185	1.097	1.049	0.957
1-1/2"	O.D.	1.900	1.900	1.900	1.900
	Wall	0.065	0.109	0.145	0.200
	I.D.	1.770	1.682	1.610	1.500
2"	O.D.	2.375	2.375	2.375	2.375
	Wall	0.065	0.109	0.154	0.218
	I.D.	2.245	2.157	2.067	1.939
2-1/2"	O.D.	2.875	2.875	2.875	2.875
	Wall	0.083	0.120	0.203	0.276
	I.D.	2.709	2.635	2.469	2.323

Nominal Diameter	Stainless Steel				
	Schedule				
	5	10	40	80	
3"	O.D.	3.500	3.500	3.500	3.500
	Wall	0.083	0.120	0.216	0.300
	I.D.	3.334	3.260	3.068	2.900
3-1/2"	O.D.	4.000	4.000	4.000	4.000
	Wall	0.120	0.120	0.226	0.318
	I.D.	3.834	3.760	3.548	3.364
6"	O.D.	6.625	6.625	6.625	6.625
	Wall	0.109	0.134	0.280	0.432
	I.D.	6.407	6.357	6.065	5.761
8"	O.D.	8.625	8.625	8.625	8.625
	Wall	0.109	0.148	0.322	0.500
	I.D.	8.407	8.329	7.981	7.625

Pipe Dimensions: Welded Steel, Aluminum, and Copper

Nominal Diameter	Aluminum	Copper Tubing			Copper & Brass Pipe	Welded Steel				
		Type				16 Gage	14 Gage	12 Gage	10 Gage	
		K	L	M						
1"	O.D.		1.125	1.125	1.125	1.315				
	Wall		0.065	0.050	0.035	0.127				
	I.D.		0.995	1.025	1.055	1.062				
1-1/2"	O.D.		1.625	1.625	1.625	1.900				
	Wall		0.072	0.060	0.027	0.150				
	I.D.		1.481	1.505	1.571	1.600				
2"	O.D.		2.125	2.125	2.125	2.375				
	Wall		0.083	0.070	0.058	0.157				
	I.D.		1.959	1.985	2.009	2.062				
2-1/2"	O.D.	2.500	2.625	2.625	2.625	2.875				
	Wall	0.050	0.095	0.080	0.065	0.188				
	I.D.	2.400	2.435	2.495	2.500	2.500				
3"	O.D.	3.000	3.125	3.125	3.125	3.500				
	Wall	0.050	0.109	0.090	0.072	0.219				
	I.D.	2.900	2.907	2.945	2.981	3.062				
3-1/2"	O.D.		3.625	3.625	3.625	4.000				
	Wall		0.120	0.100	0.083	0.250				
	I.D.		3.385	3.425	3.459	3.500				
	O.D.	4.000	4.125	4.125	4.125	4.500	4.000	4.000	4.000	4.000

Nominal Diameter	Aluminum	Copper Tubing			Copper & Brass Pipe	Welded Steel					
		Type				16 Gage	14 Gage	12 Gage	10 Gage	7 Gage	
		K	L	M							
4"	Wall	0.063	0.134	0.110	0.095	0.250	0.060	0.075	0.0105	0.135	
	I.D.	3.874	3.857	3.905	3.935	4.000	3.880	3.851	3.791	3.731	
5"	O.D.	5.000	5.125	5.125	5.125	5.563	5.000	5.000	5.000	5.000	5.000
	Wall	0.063	0.160	0.125	0.109	0.250	0.060	0.075	0.105	0.135	0.179
	I.D.	4.874	4.805	4.875	4.907	5.063	4.880	4.851	4.791	4.731	4.641
6"	O.D.	6.000	6.125	6.125	6.125	6.625	6.000	6.000	6.000	6.000	6.000
	Wall	0.063	0.192	0.140	0.122	0.250	0.060	0.075	0.105	0.135	0.179
	I.D.	5.874	5.741	5.845	5.881	6.125	5.880	5.851	5.791	5.731	5.641
8"	O.D.	8.000	8.125	8.125	8.125	8.625	8.000	8.000	8.000	8.000	8.000
	Wall	0.094	0.271	0.200	0.170	0.313	0.060	0.075	0.105	0.135	0.179
	I.D.	7.812	7.583	7.725	7.785	8.000	7.880	7.851	7.791	7.731	7.641

Pipe Dimensions: Galvanized Steel Tubing and Pipe

Nominal Diameter		Sch 5	Sch 10	Sch 40
1 in.	O.D.	1.3150	1.3150	1.3150
	Wall	0.0650	0.0830	0.1090
	I.D.	1.1850	1.1490	1.0970
1½ in.	O.D.	1.9000	1.9000	1.9000
	Wall	0.0650	0.1090	0.1450
	I.D.	1.7700	1.6820	1.6100
2 in.	O.D.	2.3750	2.3750	2.3750
	Wall	0.0650	0.1090	0.1540
	I.D.	2.2450	2.1570	2.0670
2½ in.	O.D.	2.8750	2.8750	2.8750
	Wall	0.0830	0.1200	0.2030
	I.D.	2.7090	2.6350	2.4690
3 in.	O.D.	3.5000	3.5000	3.5000
	Wall	0.0830	0.1200	0.2160
	I.D.	3.3340	3.2600	3.0680

Nominal Diameter		Sch 5	Sch 10	Sch 40
4 in.	O.D.	4.5000	4.5000	4.5000
	Wall	0.0830	0.1200	0.2370
	I.D.	4.3340	4.2600	4.0260
5 in.	O.D.	5.5630	5.5630	5.5630
	Wall	0.1090	0.1340	0.2580
	I.D.	5.3450	5.2950	5.0470
6 in.	O.D.	6.6250	6.6250	6.6250
	Wall	0.1090	0.1340	0.2800
	I.D.	6.4070	6.3570	6.0650

Nominal Diameter		Sch 5	Sch 10	Sch 20	Sch 30	Sch 40
8 in.	O.D.	8.6250	8.6250	8.6250	8.6250	8.6250
	Wall	0.1090	0.1480	0.2500	0.2770	0.3220
	I.D.	8.4070	8.3290	8.1250	8.0710	7.9810

Pipe Dimensions: Galvanized Steel Tubing and Pipe

Nominal Diameter		Std	Sch 60	Sch 80	E.H.
1.000	O.D.			1.3150	
	Wall			0.1790	
	I.D.			0.9570	
1.500 (1-1/2")	O.D.			1.9000	
	Wall			0.2000	
	I.D.			1.5000	
2.000	O.D.			2.3750	
	Wall			0.2180	
	I.D.			1.9390	
2.500 (2-1/2")	O.D.			2.8750	
	Wall			0.2760	
	I.D.			2.3230	
3.000	O.D.			3.5000	
	Wall			0.3000	
	I.D.			2.9000	
4.000	O.D.		4.5000	4.5000	
	Wall		0.2810	0.3370	
	I.D.		3.9380	3.8260	
5.000	O.D.			5.5630	
	Wall			0.3750	
	I.D.			4.8130	
6.000	O.D.			6.6250	
	Wall			0.4320	
	I.D.			5.7610	
7.000	O.D.	7.6250			7.6250
	Wall	0.3010			0.5000
	I.D.	7.0230			6.6250
8.000	O.D.		8.6250	8.6250	
	Wall		0.4060	0.5000	
	I.D.		7.8130	7.6250	
9.000	O.D.	9.6250			9.6250
	Wall	0.3420			0.5000
	I.D.	8.9410			8.6250

Nominal Diameter		Sch 120	Sch 140	Sch 160	Double E.H.
1.000	O.D.			1.3150	1.3150
	Wall			0.2500	0.4000
	I.D.			0.8150	0.5150
1.500 (1-1/2")	O.D.			1.9000	1.9000
	Wall			0.2810	0.4000
	I.D.			1.3380	1.1000
2.000	O.D.			2.3750	2.3750
	Wall			0.3430	0.4360
	I.D.			1.6890	1.5030
2.500 (2-1/2")	O.D.			2.8750	2.8750
	Wall			0.3750	0.5520
	I.D.			2.1250	1.7710
3.000	O.D.			3.5000	3.5000
	Wall			0.4370	0.6000
	I.D.			2.6260	2.3000
4.000	O.D.	4.5000		4.5000	4.5000
	Wall	0.4370		0.5310	0.6740
	I.D.	3.6260		3.4380	3.1520
5.000	O.D.	5.5630		5.5630	5.5630
	Wall	0.5000		0.6250	0.7500
	I.D.	4.5630		4.3130	4.0630
6.000	O.D.	6.6250		6.6250	6.6250
	Wall	0.5620		0.7180	0.8640
	I.D.	5.5010		5.1890	4.8970
7.000	O.D.				7.6250
	Wall				0.8750
	I.D.				5.8750
8.000	O.D.	8.6250	8.6250	8.6250	8.6250
	Wall	0.7180	0.8120	0.9060	0.8750
	I.D.	7.1890	7.0010	6.8130	6.8750
9.000	O.D.				
	Wall				
	I.D.				

Pipe Dimensions: Iron

Nominal Diameter		DUCTILE IRON						
		CLASS						
		50	51	52	53	54	55	56
3"	O.D.		3.960	3.960	3.960	3.960	3.960	3.960
	Wall		0.250	0.280	0.310	0.340	0.370	0.400
	I.D.		3.460	3.400	3.340	3.280	3.220	3.160
4"	O.D.		4.800	4.800	4.800	4.800	4.800	4.800
	Wall		0.260	0.290	0.320	0.350	0.380	0.410
	I.D.		4.280	4.220	4.160	4.100	4.040	3.980
6"	O.D.	6.900	6.900	6.900	6.900	6.900	6.900	6.900
	Wall	0.250	0.280	0.310	0.340	0.370	0.400	0.430
	I.D.	6.400	6.340	6.280	6.220	6.160	6.100	6.040
8"	O.D.	9.050	9.050	9.050	9.050	9.050	9.050	9.050
	Wall	0.270	0.300	0.330	0.360	0.390	0.420	0.450
	I.D.	8.510	8.450	8.390	8.330	8.270	8.210	8.150

Nominal Diameter		CAST IRON							
		CLASS							
		A	B	C	D	E	F	G	H
3"	O.D.	3.960	3.960	3.960	3.960				
	Wall	0.390	0.420	0.450	0.480				
	I.D.	3.020	3.120	3.060	3.000				
4"	O.D.	4.800	5.000	5.000	5.000				
	Wall	0.420	0.450	0.480	0.520				
	I.D.	3.960	4.100	4.040	3.960				
6"	O.D.	6.900	7.100	7.100	7.100	7.220	7.220	7.380	7.380
	Wall	0.440	0.480	0.510	0.550	0.580	0.610	0.650	0.690
	I.D.	6.020	6.140	6.080	6.000	6.060	6.000	6.080	6.000
8"	O.D.	9.050	9.050	9.300	9.300	9.420	9.420	9.600	9.600
	Wall	0.460	0.510	0.560	0.600	0.660	0.660	0.750	0.800
	I.D.	8.130	8.030	8.180	8.100	8.100	8.100	8.100	8.000

Ordering Information

Mfr. Part No.	Code	Description
Transmitters		
3-3350-1	159 001 081	Transmitter 110 VAC, 4 to 20 mA output, wall mount
3-3350-2	159 001 082	Transmitter 220 VAC, 4 to 20 mA output, wall mount
Sensors		
3-3550-100	159 001 083	DN 25 - DN 100 (1 in. to 4 in.) Ultrasonic clamp-on sensor
3-3550-200	159 001 084	DN 50 - DN 225 (2 in. to 9 in.) Ultrasonic clamp-on sensor

Accessories and Replacement Parts

Mfr. Part No.	Code	Description
Signal Cables		
3-3550.393	159 001 099	Stainless steel belt pair for sensor frame
3-3550.390	159 001 085	Pipe clamp kit
3800-1000	159 001 086	Tube of silicone grease
3800-1001	159 001 363	Silicone-free grease
3800-1002	159 001 364	RTV compound
3-3550.395	159 001 087	Sensor heads, matched pair, 1 in. to 4 in.
3-3550.396	159 001 095	Sensor heads, matched pair, 2 in. to 9 in.
3-3550.075	159 001 090	Cable, 5m pair (standard)
3-3550.076	159 001 091	Cable, 10m pair
3-3550.077	159 001 092	Cable, 15m pair
3-3550.078	159 001 093	Cable, 20m pair
3-3550.079	159 001 094	Cable, 30m pair

- Transmitters are supplied with pipe clamp kit.
- Sensors are supplied with two mounting belts, 5m cable pair and tube of silicone grease.



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