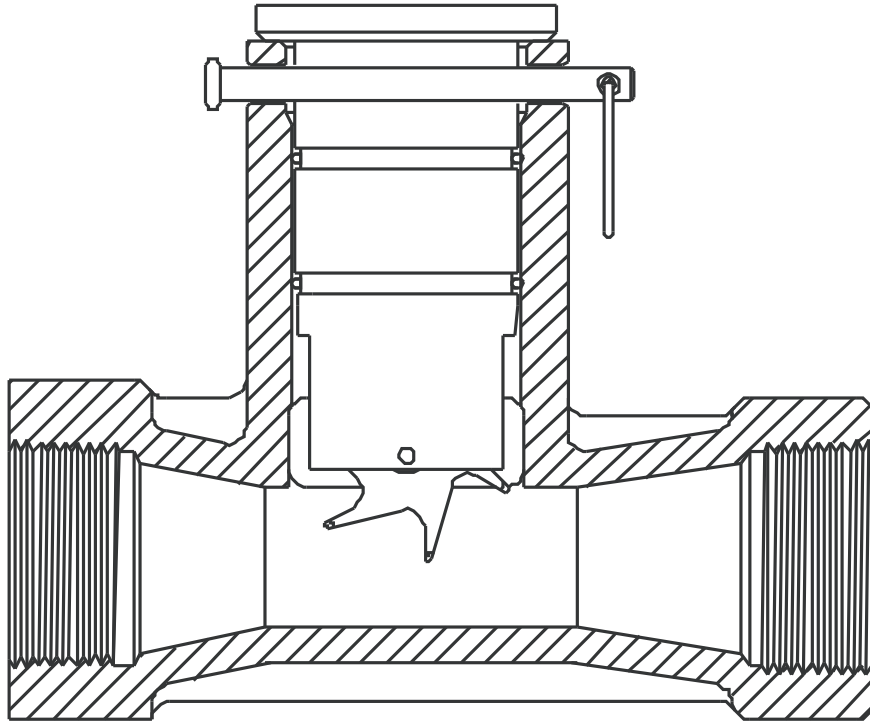




Badger Meter

Impeller Flow Sensors

250 and 228 Metal Tee



IMPORTANT:

**This manual contains important information.
READ AND KEEP FOR REFERENCE.**

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INTRODUCTION

Used in conjunction with any Badger Meter impeller flow monitor or transmitter, Badger Meter non-magnetic flow sensors provide an accurate reading of the rate of liquid flow as well as total accumulated flow. A number of sensor models are offered, which cover applications for a wide range of pipe sizes and pressure/temperature specifications.

The flow sensors generate a frequency which is proportional to flow rate. An internal pre-amplifier allows the pulse signal to travel up to 2000 feet without further amplification. Power to operate the sensor is provided by the flow monitor. The impeller bearing assembly, shaft and O-rings are replaceable in the field.

Badger Meter flow sensors feature a closed, six-bladed impeller design, using a proprietary, non-magnetic sensing technology. The forward-swept impeller shape provides higher, more constant torque than four-bladed impeller designs, and is less prone to fouling by water-borne debris. The forward-curved shape, coupled with the absence of magnetic drag, provides improved operation and repeatability, even at lower flow rates. As the liquid flow turns the impeller, a low impedance signal is transmitted with a frequency proportional to the flow rate.

Sensors of similar type are interchangeable, so there is no need for recalibration after servicing or replacement.

ELECTRONIC TYPES

Badger Meter provides several basic sensor configurations using the same impeller element. This allows for a wide range of applications and pipe sizes. Sensors are normally supplied with 20 feet of 2-conductor 20 AWG shielded U.L. type PTLC 105°C cable. Optional sensors designated with the prefix "IR" feature two single conductor 18 AWG solid copper wire leads 48 inches in length with U.L. Style 116666 direct burial insulation. These IR models are used in below grade applications such as irrigation, municipal, and groundwater monitoring. All Series 200 sensor electrical components are self-contained. Pressure/temperature ratings for the various models are contained in the "[Specifications](#)" section of this manual. These models can be further described as follows:

Standard Sensor

Designed for indoor or protected area applications such as HVAC, pump control, and industrial process monitoring where the flow rates are between 0.5-30 feet/second and temperatures are below 221°F. Standard sensors are supplied with 20 feet of 2-conductor 20 AWG shielded U.L. type PTLC 105°C cable.

IR Sensor

Designed for below grade applications such as irrigation, municipal, and groundwater monitoring where the flow rates are between 0.5-30 feet/second and temperatures are below 180°F. IR sensors are supplied with two single conductor, 18 AWG solid copper wire leads 48 inches in length with U.L. Style 116666 direct burial insulation.

CSA Sensor

Designed for indoor or protected area applications where intrinsic safety is required and the flow rates are between 0.5-30 feet/second and temperatures are below 221°F. CSA sensors are supplied with 20 feet of 2-conductor 20 AWG shielded U.L. type PTLC 105°C cable. These sensors must be used with an approved safety barrier.

Models 228BR, 228CB, and 228SS

Sizes of 2 inch and 2-1/2 inch are available in this series.

Model 228BR

This model consists of a Model 220BR sleeve and hex mounting adapter assembly inserted in a 2 inch or 2-1/2 inch bronze tee and preset to a specific height. The 2 inch size includes copper solder adapters for mating to copper tubing.

Model 228CB

This model consists of a Model 220BR sleeve and hex mounting adapter assembly inserted in a 2 inch or 2-1/2 inch Class 150 cast iron tee and preset to a specific height.

Model 228SS

This model consists of a Model 220SS sleeve and hex mounting adapter assembly inserted in a 2 inch 316 stainless steel tee and preset to a specific height.

Model 250BR

These models combine a PPS electronics package inserted in a 1/2 inch, 3/4 inch, 1 inch, 1-1/4 inch, and 1-1/2 inch proprietary cast bronze pipe tee with threaded NPT connections.



MECHANICAL INSTALLATION

General

The accuracy of flow measurement for all flow measuring devices is highly dependent on proper location of the sensor in the piping system. Irregular flow velocity profiles caused by valves, fittings, pipe bends, etc. can lead to inaccurate overall flow rate indications even though local flow velocity measurement may be accurate. A sensor located in the pipe where it can be affected by air bubbles, floating debris, or sediment may not achieve full accuracy and could be damaged. Badger Meter flow sensors are designed to operate reliably under adverse conditions, but the following recommendations should be followed to ensure maximum system accuracy:

1. Choose a location along the pipe where 10 pipe diameters upstream and 5 pipe diameters downstream of the sensor provide no flow disturbance. Pipe bends, valves, other fittings, pipe enlargements and reductions should not be present in this length of pipe.
2. The preferred location for the sensor around the circumference of a horizontal pipe is on top. If trapped air or debris will interfere, the sensor should be located further around the pipe from the top but not more than 45 degrees from top dead center. The sensor should never be located at the bottom of the pipe, as sediment may collect there. Locations off top dead center cause the impeller friction to increase, which may affect performance at low flow rates. Any circumferential location is correct for installation in vertical pipes. Rising flow preferred to reduce effects of any trapped air.

Mechanical Installation for 228BR, 228CB and 228SS

These tee-type sensors have a factory set insertion depth and alignment.

WARNING

Do not disturb the position of the thread hex adapter or the lower two nuts on the threaded rods of the hex adapter. This could lead to inaccurate calibration and faulty reading of the flow rate.

Remove the sleeve assembly by removing the top 7/16 inch nuts only. Pull the sleeve assembly straight out of the mounting adaptor.

To install the sensor tee

1. There must be free, unrestricted pipe for at least 10 diameters upstream and 5 diameters downstream of the tee.

Note: If soldering of threaded adapters is to be done near the assembly, remove the sensor sleeve to prevent heat damage to the O-rings and plastic parts.

2. Apply pipe compound over the first 3 or 4 threads of the mating pipe.
3. Thread the pipe into the sensor tee until hand tight.
4. Tighten the pipe, using a wrench, an additional 1-1/2 turns.

To install sensor in tee

1. Apply a small amount of silicone grease to O-rings on sensor sleeve assembly and chamfer on inside lip of tee. Clean off any grease which could be deposited on the impeller.
2. Align flow arrow on sensor with direction of flow.
3. Carefully press sleeve straight into hex mounting adaptor.
4. Install 7/16 lock nuts on threaded rod, tighten, do not move bottom nuts as they set sensor depth.
5. Before pressurizing pipe, verify that:
 - All threaded connections are tight.
 - The flow direction arrow on sensor is aligned with flow direction.
 - The 7/16 nuts are re-installed on the threaded rods above the metal collar.

Mechanical Installation for 250BR

Install with flow label pointing in the direction of flow (downstream).

To install the sensor tee

1. Note intended direction of flow as indicated by arrows on the cast bronze tee. There must be free, unrestricted pipe for at least 10 diameters upstream and 5 diameters downstream of the tee.
2. Apply pipe compound over the first 3 or 4 threads of the mating pipe.
3. Thread the pipe into the sensor tee until hand tight.
4. Tighten the pipe, using a wrench, an additional 1 1/2 turns.

To install sensor in tee

1. Apply a small amount of silicone grease to O-rings on sensor insert and chamfer on inside lip of tee. Clean off any grease which could be deposited on the impeller.
2. Align flow arrow on sensor with direction of flow.
3. Carefully press sensor straight into tee.

CAUTION

Impeller may strike the sides of venturi cavity in tee if misaligned, causing damage to impeller or shaft.

4. Install clevis pin through the tee, sensor and conduit cap, and install split ring.
5. Before pressurizing pipe, verify that:
 - All threaded connections are tight.
 - The flow direction arrows on the tee and sensor are aligned with the flow direction.
 - The clevis pin and cotter ring are installed.

ELECTRICAL INSTALLATION - STANDARD SENSORS

1. The metal collar on the top of the Series 220 sensors or an optional conduit cap on the Series 250 sensors will accept 1/2 inch threaded conduit fittings.
2. Route the cable from the sensor to a Badger Meter flow monitor/transmitter. The cable may be extended up to 2000 feet, using 2-conductor shielded 20 AWG or larger stranded copper wire. Be sure to leave enough flexibility in the cable or conduit to allow for future service of sensor, if necessary.
3. When connecting to a Badger Meter flow monitor/transmitter, locate the section of terminal strip on the monitor labeled "SENSOR INPUT" or "SENSOR". Connect the red wire to "IN", "SIGNAL(+)" or "SIGNAL" terminal and the black wire to "GND", "SIGNAL(-)", or "COM" terminal and the shield drain wire (if applicable) to "SLD".
4. When interfacing with other equipment, consult manufacture for input designations. The signal wave forms and power requirements are as shown in the "" section. Refer to Technical Bulletin DTB-058 at www.badgermeter.com.

Electrical Installation - IR Sensors

The sensor leads are supplied with watertight caps over the ends. See Application Note DAB-031 and Technical Bulletin DTB-043 at www.badgermeter.com.

5. DO NOT remove the plastic caps from the sensor leads until ready to splice.
6. Use a twisted pair cable suitable for direct burial to connect the sensor to the transmitter, monitor or controller. Multi-pair telecommunication cable or direct burial cables may be used.
7. Make a water tight splice. Two part epoxy type waterproof kits are recommended. Be sure the epoxy seals the ends of the cable jacket.
8. Make sure the epoxy is hardened before inverting the splice or dropping it in standing water.
9. DO NOT make an underground splice unless absolutely necessary.
10. Route the cable from the sensor to a Badger Meter flow monitor/transmitter. The cable may be extended up to 2000 feet, using 2-conductor shielded 20 AWG or larger stranded copper wire with appropriate ratings. Be sure to leave enough flexibility in the cable or conduit to allow for future service of sensor, if necessary.
11. When connecting to a Badger Meter flow monitor/transmitter, locate the section of terminal strip on the monitor labeled "SENSOR INPUT" or "SENSOR". Connect the red wire to "IN", "SIGNAL(+)" or "SIGNAL" terminal and the black wire to "GND", "SIGNAL(-)", or "COM" terminal and the shield drain wire (if applicable) to "SLD".
12. When interfacing with other equipment, the signal wave forms and power requirements are as shown in the Specifications section. Refer to Technical Bulletin DTB-058 at www.badgermeter.com.

Electrical Installation - High Temperature Sensors

1. Route a cable from the sensor to a Badger Meter flow monitor/transmitter. The cable may be run up to 2000 feet, using 2-conductor shielded 20 AWG or larger stranded copper wire. Be sure to leave enough flexibility in the cable or conduit to allow for future service of sensor, if necessary.
2. Connect to cable inside sensor electronic housing and connect with standard wire nuts.
3. When connecting to a Badger Meter flow monitor or transmitter, locate the section of terminal strip on the monitor labeled "SENSOR INPUT" or "SENSOR". Connect the red wire to "IN", "SIGNAL(+)" or "SIGNAL" terminal and the black wire to "GND", "SIGNAL(-)", or "COM" terminal and the shield drain wire (if applicable) to "SLD".
4. When interfacing with other equipment, the signal wave forms and power requirements are as shown in the specifications section.

Electrical Installation

The Series 200 Sensor is approved, as an entity, as Intrinsically Safe when installed in conformance with Badger Meter installation drawings 06-480-002 as specified on the blue label identifying an intrinsically safe sensor.

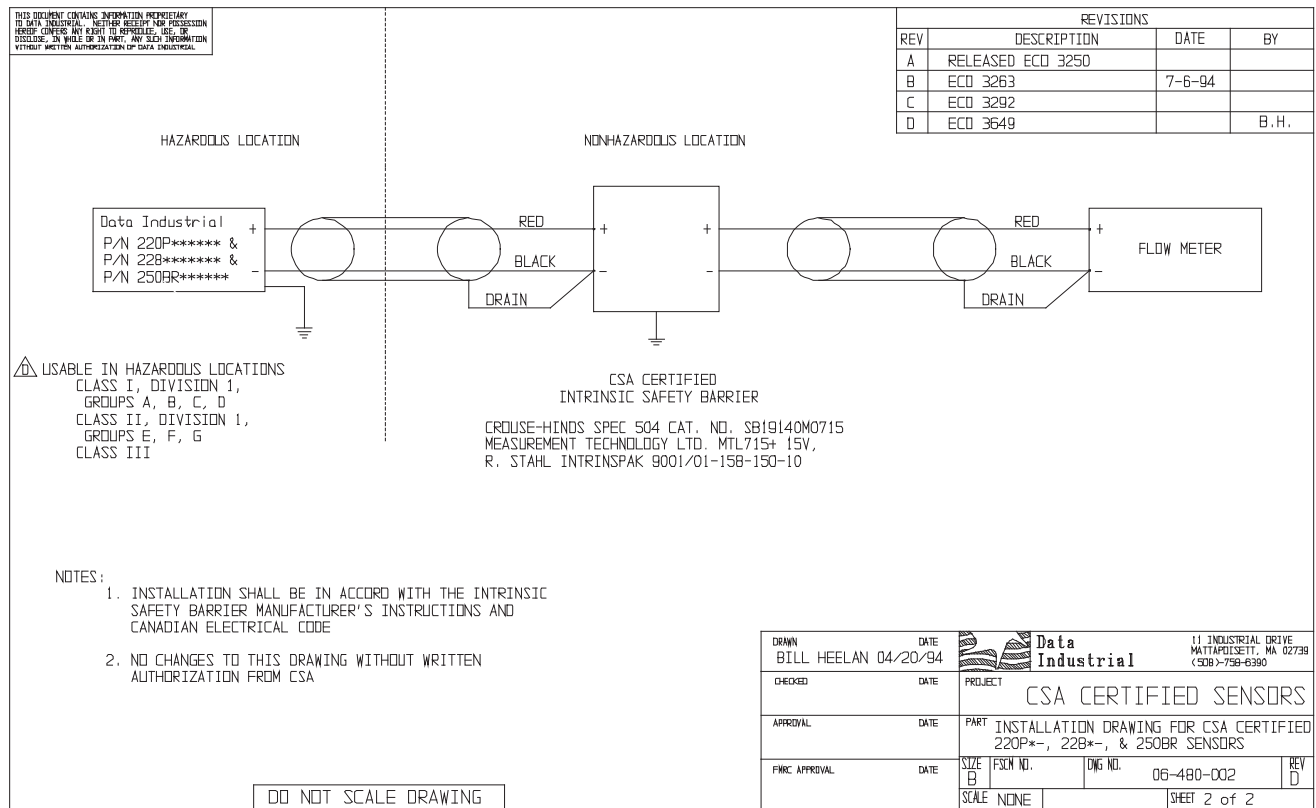
Entity approval implies that only the sensor is approved as intrinsically safe. Unless power supplies, equipment, and instruments connected to the sensor are each rated either explosion-proof or intrinsically safe, these devices cannot be installed in a hazardous area. The referenced installation drawing shows such apparatus located in a non-hazardous location. Proper interfacing between the hazardous and non-hazardous areas must be provided. It is of absolute importance that this interface be constructed and that all wiring be performed by qualified contractors. To ensure the Intrinsic Safety of the installation, the connection of the intrinsically safe sensor to instruments and or power supplies must take place using an approved intrinsically safe barrier located in a non-hazardous area. These barriers, listed below, are readily available from various suppliers.

Manufacturer:

Crouse-Hinds Spec 504
Measurement Technology Ltd.
R Stahl Intrinsicpak

Barrier:

Cat No. SB19140M0715
MTL 715+ 15 V
9001/01-158-150-10



CALIBRATION

Badger Meter sensors use unique K and Offset numbers for calibration. These numbers are derived from calibration runs using NIST traceable instruments. Using both a K and an Offset number provides higher accuracy than using a K (pulse/gal) factor alone. K and Offset numbers for each tee configuration are listed in the following tables.

Calibration Tables

The table below provides calibration and operation data for Data Industrial Metal Tee Sensors 0.5 inch to 2.5 inch.

- Column 1 Tee Model Number
- Column 2 Apparent I.D. - For use with the Series 900 and the Series 1000
- Columns 3 and 4 The K value and Offset values to use in our frequency equation

$$\text{Freq} = \frac{\text{Gpm}}{\text{K}} - \text{offset}$$

This equation describes the frequency of the output signal of all Badger Meter flow sensors. By substituting the appropriate K and Offset values from the table, the sensor's output frequency can be calculated for each pipe size. This information is required when calibrating an output board or when using the raw sensor data as direct output to interface with a device that is not a Badger Meter product.

- Column 5 This column indicates the suggested flow range of each tee sensor. Badger Meter sensors will operate both above and below the indicated flow rates. However, good design practice dictates the use of this range for best performance.

Sensors should be sized for flow rather than pipe size. To prevent disturbances to the flow profile always connect the sensor tee to pipe nipples measuring at least 10 pipe diameters in length on the up stream (supply) side and at least 5 pipe diameters in length on the downstream (delivery) side before making the transition in pipe size.

**Calibration Table for
Series 228BR, 228CB, 250BR, 228SS**

Model	Apparent I.D. for Series 1000, 900	K Value	Offset	Suggested Operating Range (GPM)
228BR20xx-xxxx	1.99	2.747	0	10-100
228BR25xx-xxxx	2.52	3.741	0.386	16-160
228CB20xx-xxxx	2.07	2.809	0.276	12-120
150 PSI Tee	2.07			
400 PSI Tee	2.1	2.604	0.25	12-120
228CB25xx-xxxx	2.51	3.74	0.277	16-160
228SS20xx-xxxx	1.99	2.747	0	10-100
250BR05xx-xxxx				
sch40 PVC	none	0.337379	0.097041	0.8-8
sch80 PVC	none	0.338073	0.134854	0.8-8
sch40 steel	none	0.356212	0.075729	0.8-8
Type L	none	0.350899	-0.321666	0.8-8
250BR07xx-xxxx				
sch40 PVC	none	0.436827	0.567915	1-10
sch80 PVC	none	0.43983	0.692372	1-10
sch40 steel	none	0.434836	0.766196	1-10
Type L	none	0.432127	0.619813	1-10
250BR10xx-xxxx	1.05	0.397368	0.261768	2-40
250BR12xx-xxxx	1.38	0.76447	0.16489	3-60
250BR15xx-xxxx	1.61	1.06526	0.0892	4-80

IMPELLER ASSEMBLY AND SHAFT REPLACEMENT

If you are replacing an existing Badger Meter impeller or shaft and have already calibrated your flow monitor/transmitter, no calibration changes are necessary. For installation of a new flow monitor or for relocation of a sensor in a new pipe size, please refer to the calibration instructions in flow monitor manual.

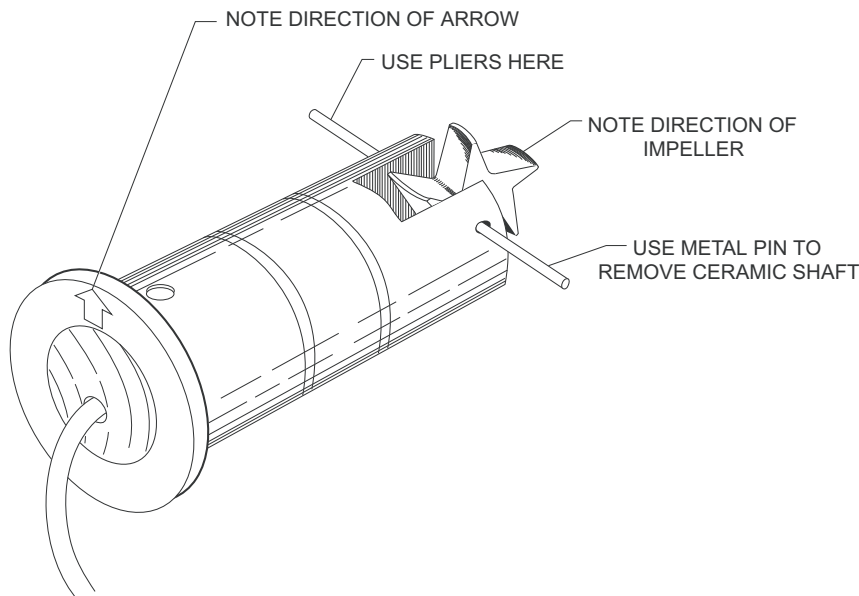
1. Depressurize pipe from which sensor is to be removed.
2. If insert style (Models 228xx) remove the three lock nuts that secure the positioning collar to the threaded rods of metal sensor.

NOTE: Before removing lock nuts, record the dimension from top of 2 inch NPT adapter to the bottom of the positioning collar. This dimension will be required later to reinstall. For Series 250BR style remove the clevis pin.

3. Remove the sensor from the hex adapter or the tee.
4. Note the impeller blade orientation relative to flow arrows and the alignment hole in metal sensors beside one of the sight holes. In order to maintain proper calibration, the impeller will have to be reinstalled in the same manner with the impeller blades pointing toward the small alignment hole, and into the flow direction as indicated by the flow arrows.
5. To remove the old impeller blade assembly, push the old shaft out of the sleeve with the new shaft (or small diameter rod) just far enough to grab the end with a pair of pliers and pull the shaft completely out. The impeller assembly will now be free, and will drop out.
6. Inspect the shaft and bearings for wear, and replace as necessary.
7. Refer to Figure 1. To reinstall, position the impeller in the cavity oriented as in Step 4 so that the impeller blades point into the flow direction and toward the small alignment hole located beside one of the sight ing holes on metal sensors. For 250B the flow direction arrow on the top of the sensor housing should point downstream with the impeller blades pointing upstream.
8. Carefully push the shaft through the sleeve and impeller, taking care not to damage bearings. Make sure that the shaft is inserted far enough so that it clears the sleeve on each side of the impeller housing.

NOTE: If shaft is not carefully installed, the bearing can be deformed, preventing free rotation.

9. Inspect the O-rings for damage and replace as necessary. Clean the O-rings and the sleeve and lubricate with silicone grease from the packet provided or some other acceptable lubricant.



10. Install the sensor into the 2 inch NPT adapter or tee so that alignment hole is facing upstream and flow arrows point in the direction of the actual flow. Since the positioning collar was not loosened during this operation,

the studs should all line up perfectly when the sighting holes are parallel to pipe. If this has been accidentally loosened, please refer to the installation instructions for the alignment of the flow sensor unit.

11. Install and tighten the nuts or replace the clevis pin.
12. For metal sensors, double check that the distance from the top of the 2 inch NPT adapter to the bottom of the positioning collar equals the dimension as measured in Step 2, and holes in sleeve sight exactly down the pipe, the arrows point in direction of flow and alignment holes located beside one sighting hole is pointing towards the source. If not, refer to Installation section in this manual.
13. This completes the replacement procedure. The system may now be repressurized and tested.

SPECIFICATIONS

Wetted Materials (except tees)

- See Technical Brief for material specifics.

Sensor Sleeve and Hex Adapter for 228BR, 228CB,

- Sleeve: Admiralty Brass, UNS C44300;
Hex Adapter: Valve Bronze, UNS C83600

Sensor Sleeve and Hex Adapter for 228SS

- Series 300 Stainless Steel

Tee for 228B

- Cast Bronze, Class 125 Per ASME B16.15 and Copper Coupling

Tee for 228SS

- Cast 316 Stainless, Class 150

Tee for 228CB

- Cast Iron, Class 125 Per ASME B16.4

Tee for 250B

- Cast valve bronze, UNS C83600

Temperature Ratings

- Standard Electronics - 221°F (105°C)
- Irrigation Electronics - 150°F (66°C)

Pressure Ratings

	At 100°F	At 221°F
250BR	400 psi	325 psi
228B	200 psi	165 psi
228CB	175 psi	140 psi
220SS	400 psi	325 psi

Recommended Design Flow Range

- 0.5 to 30 ft/sec for 228
- 0.3 to 15 ft/sec for 250B

Accuracy

- $\pm 1.0\%$ of full scale over recommended design flow range for 228
- $\pm 1.0\%$ of rate for 250

250 and 228 Metal Tee Impeller Flow Sensors

Repeatability

- $\pm 0.3\%$ of full scale over recommended design flow range for all except 250B
- $\pm 0.7\%$ of full scale over recommended design flow range for 250B

Linearity

- $\pm 0.2\%$ of full scale over recommended design flow range for all except 250BR
- $\pm 0.7\%$ of full scale over recommended design flow range for 250BR

Transducer Excitation

- Quiescent current 600uA@8.0VDC to 35.0VDC max.
- Quiescent voltage (Vhigh) Supply Voltage -(600uA*Supply impedance)
- ON state (VLow) Max. 1.2VDC@40mA current limit (15 Ω +0.7VDC)

Output Frequency

- 3.2 Hz to 200 Hz for all except 250BR
- 0.8 Hz to 80 Hz for 250BR

Output Pulse Width

- 5 msec $\pm 25\%$
- Square wave between 100Hz to 200Hz limit

Electrical Cable for Standard Sensor Electronics

- 20 feet of 2-conductor 20 AWG shielded U.L. type PTLC wire provided for connection to display or analog transmitter unit. Rated to 105°C. May be extended to a maximum of 2000 feet with similar cable and insulation appropriate for application.

Electrical Cable for IR Sensor Electronics

- 48 inches of U.L. Style 116666 copper solid AWG 18 wire with direct burial insulation. Rated to 105°C.

TROUBLESHOOTING

- If the voltage at the sensor input is less than 7.0 VDC in a no flow situation, disconnect the sensor from the barrier strip and measure the voltage at the sensor input terminals of the barrier strip again. It should be between 8.0 VDC and 20.0 VDC. If the voltage at the sensor input is still below 7.0 VDC or 3.0 VDC, the problem may be with the monitor. (hardware or programming)
- If you suspect that the sensor is bad, you can test the monitor circuitry by connecting a piece of wire to one of the sensor input terminals and tap the other side of the wire to the other sensor input terminal. Shorting across the sensor input terminals ON and OFF repeatedly allows the display to respond by trying to calculate a flow rate for the frequency of your shorting action. If the display does not show a change from 0.00, it indicates a problem with the monitor.
- If the monitor tests ok and there are any splices in the cable, break the sensor cable at the splice closest to the sensor and retry the shorting test in step 2.
- If the cable tests ok, drain the pipe line, verify the pressure is off, and pill the clevis pin for Series 250 or remove top lock nuts for Series 228 holding the sensor electronics. Spin the impeller by hand. If flows are noted on the display, and impeller spins freely then the flow rates may have been below our design minimums or the line was full of air. Try again. If the sensor fails to respond then replace sensor.

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