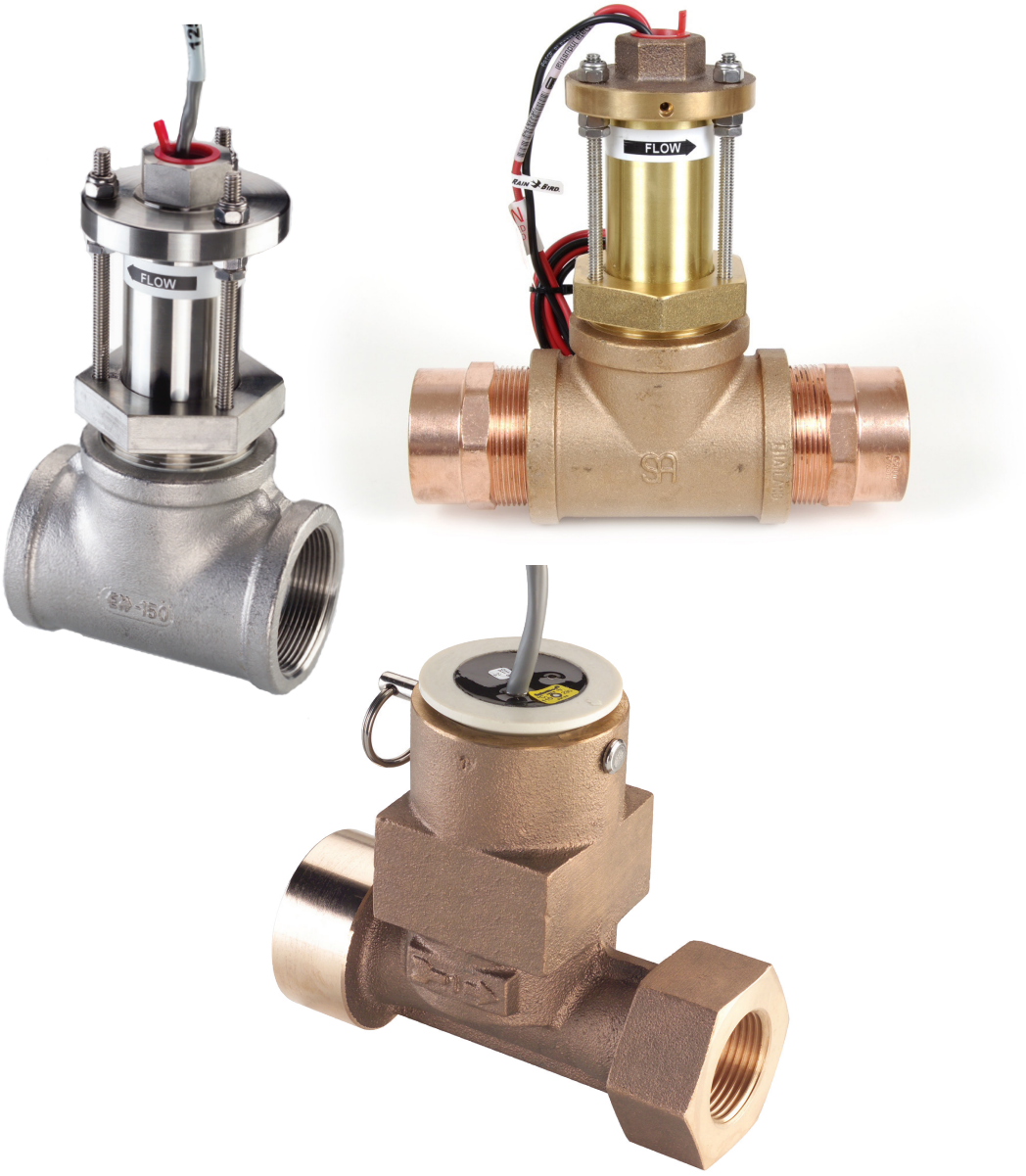
Impeller
Data Industrial®

Flow Sensors

Series 228 and 250 Metal Tee Sensors



Badger Meter

SEN-UM-01663-EN-03 (February 2018)

User Manual

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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 (610 meters) 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 (6 meters) of 2-conductor 20 AWG shielded UL type PTLC 221° F (105° C) cable. Optional sensors designated with the prefix ***IR*** feature two single-conductor 18 AWG solid copper wire leads 48 inches (122 cm) in length with UL 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 *"Specifications" on page 9*. These models are further described as follows.

Standard Sensor

Standard sensors are 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 (105° C). Sensors are supplied with 20 feet (6 meters) of 2-conductor 20 AWG shielded UL type PTLC 221° F (105° C) cable.

IR Sensor

IR sensors are 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 (82° C). Sensors are supplied with two single-conductor, 18 AWG solid copper wire leads, 48 inches (122 cm) in length, with UL Style 116666 direct burial insulation.

Models 228BR, 228CB, and 228SS

Sizes 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 in., 3/4 in., 1 in., 1-1/4 in., and 1-1/2 in. proprietary cast bronze pipe tee with threaded NPT connections.

CERTIFICATIONS

CE

All sensor versions carry the CE certification, Equipment Class A EN 50082-2, generic immunity for industrial environments and EN-55011, Conducted and Radiated Emissions for industrial, scientific and medical (ISM) radio frequency equipment.

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 for maximum system accuracy.

- 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.
- 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 is 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. Remove the sleeve assembly by removing the top 7/16 inch (11 mm) nuts only. Pull the sleeve assembly straight out of the mounting adaptor.

⚠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.

⚠ AVERTISSEMENT

NE PAS CHANGER LA POSITION DE L'ADAPTATEUR HEXAGONAL OU DES DEUX ÉCROUS INFÉRIEURS SUR LES TIGES FILETÉES DES ADAPTATEURS HEXAGONAUX. CELA POURRAIT CONDUIRE À UN ÉTALONNAGE ET À UNE LECTURE INEXACTS DU DÉBIT.

To install the sensor tee:

1. Make sure there is free, unrestricted pipe for at least 10 diameters upstream and 5 diameters downstream of the tee.

   NOTE: If soldering threaded adapters is to be done near the assembly, remove the sensor sleeve, and O-rings from the tee or Hex Mounting Adapter, 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 the sensor in the tee:

1. Apply a small amount of silicone grease to O-rings on the 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 the 7/16 in. (11 mm) lock nuts on the threaded rod and tighten. Do not move the bottom nuts as they set sensor depth.
5. Before pressurizing the pipe, verify that:

   - All threaded connections are tight.
   - The flow direction arrow on the sensor is aligned with the flow direction.
   - The 7/16 inch (11 mm) nuts are re-installed on the threaded rods above the metal collar.

Mechanical Installation for 250BR Sensor

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

To install the sensor tee:

1. Note the intended direction of flow as indicated by the 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. Using a wrench, tighten the pipe an additional 1-1/2 turns.

To install the sensor in the tee:

1. Apply a small amount of silicone grease to the O-rings on the sensor insert and chamfer on the inside lip of the tee. Clean off any grease which could be deposited on the impeller.
2. Align the flow arrow on the sensor with the direction of flow.
3. Carefully press the sensor straight into the tee.
4. Install the clevis pin through the tee, sensor and conduit cap, and install the split ring.
5. Before pressurizing the 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

NOTE: If the sensor has white and black wires instead of red and black, connect the *white* wire wherever *red* is indicated.

Standard Sensors

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 (38 mm) threaded conduit fittings.

1. Route the cable from the sensor to a Badger Meter flow monitor/transmitter. The cable can be extended up to 2000 feet (610 meters), 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 the sensor, if necessary.
2. 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 (or white) wire to **IN**, **SIGNAL(+)** or **SIGNAL** terminal, connect the black wire to the **GND**, **SIGNAL(-)** or **COM** terminal, and the shield drain wire (if applicable) to **SLD**.
3. When interfacing with other equipment, consult the manufacture for input designations. The signal wave forms and power requirements are as shown in *"Specifications" on page 9*.

IR Sensors

The sensor leads are supplied with watertight caps over the ends. DO NOT remove the plastic caps from the sensor leads until you are ready to splice.

1. 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.
2. Make a water tight splice. Two-part epoxy type waterproof kits are recommended. Be sure the epoxy seals the ends of the cable jacket. Make sure the epoxy is hardened before inverting the splice or dropping it into standing water.

   NOTE: DO NOT make an underground splice unless absolutely necessary.
3. Route the cable from the sensor to a Badger Meter flow monitor/transmitter. The cable can be extended up to 2000 feet using two-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 the sensor, if necessary.
4. 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 (or white) wire to **IN**, **SIGNAL(+)** or **SIGNAL** terminal, connect the black wire to the **GND**, **SIGNAL(-)** or **COM** terminal, and the shield drain wire (if applicable) to **SLD**.
5. When interfacing with other equipment, the signal wave forms and power requirements are as shown in *"Specifications" on page 9*. Refer to the *Impeller Series 200 Product Data Sheet* available at *www.badgermeter.com*.

High Temperature Sensors

1. Route a cable from the sensor to a Badger Meter flow monitor/transmitter. The cable can be extended up to 2000 feet using two-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 the cable inside the 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 (or white) wire to **IN**, **SIGNAL(+)** or **SIGNAL** terminal, connect the black wire to the **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 *"Specifications" on page 9*.

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.

Column Descriptions

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 Legacy Series 900 and Series 1000 monitors
Columns 3 and 4	The K value and Offset values to use in our frequency equation

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

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

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, refer to the calibration instructions in flow monitor manual.

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

   Before removing the lock nuts, record the dimension from the top of the 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.

   NOTE: Notice the impeller blade orientation relative to the flow arrows and the alignment hole next to one of the sight holes in metal sensors. 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.
4. 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.
5. Inspect the shaft and bearings for wear, and replace as necessary.
6. Refer to *Figure 1*. To reinstall, position the impeller in the cavity as described in the **NOTE** above so that the impeller blades point into the flow direction and toward the small alignment hole located next to one of the sight holes on the metal sensors. For the 250BR, the flow direction arrow on the top of the sensor housing should point downstream with the impeller blades pointing upstream.
7. Carefully push the shaft through the sleeve and impeller, taking care not to damage the 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 the shaft is not carefully installed, the bearing can be deformed, preventing free rotation.
8. 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.

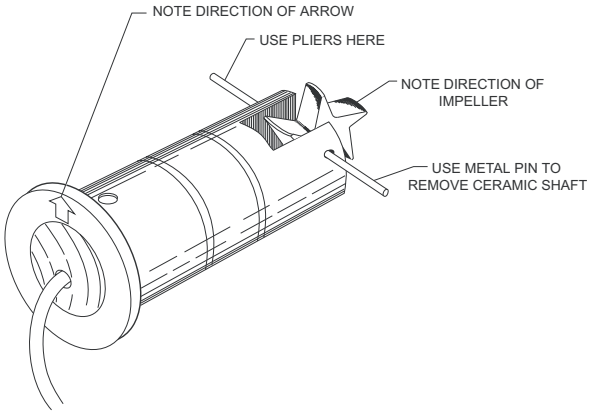

Figure 1: Impeller assembly

9. Install the sensor into the 2 inch NPT adapter or tee so that alignment hole is facing upstream and the 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 the collar has been accidentally loosened, refer to the installation instructions for the alignment of the flow sensor unit.
10. Install and tighten the nuts or replace the clevis pin.
11. 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***. Make sure that the holes in the sleeve sight exactly down the pipe, the arrows point in the direction of flow, and the alignment holes located next to one sight hole are pointing towards the source.

This completes the replacement procedure. The system can now be repressurized and tested.

SPECIFICATIONS

Wetted Materials (except tees)	See Product Data Sheet for material specifics	
Sensor Sleeve and Hex Adapter for 228BR, 228CB	Sleeve: Lead-free brass, UNS C44300	
	Hex Adapter: Valve bronze, UNS C83600	
Sensor Sleeve and Hex Adapter for 228SS	Series 300 Stainless Steel	
Tee for 228BR	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 250BR	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
228BR	200 psi	165 psi
228CB	175 psi	140 psi
228SS	400 psi	325 psi
Recommended Design Flow Range	0.5 to 30 ft/sec for 228	
	0.3 to 15 ft/sec for 250BR	
Accuracy	± 1.0% of full scale over recommended design flow range for 228	
	± 1.0% of rate for 250BR	
Repeatability	± 0.3% of full scale over recommended design flow range for all except 250BR	
	± 0.7% of full scale over recommended design flow range for 250BR	
Linearity	± 0.2% of full scale over recommended design flow range for all except 250BR	
	± 0.7% of full scale over recommended design flow range for 250BR	
Transducer Excitation	Supply voltage = 8V DC min. 35V DC max.	
	Quiescent current = 600 µA (typical)	
	OFF State (V_{High}) = Supply voltage – (600 µA * Supply impedance)	
	ON State (V_{Low}) = 1.2V DC @ 40 mA (15 Ω + 0.7V DC)	
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 ±25% to 100 Hz	
	Square wave above to 200 Hz limit	
Electrical Cable for Standard Sensor Electronics	20 ft (6 m) of 2-conductor 20 AWG shielded UL type PTLC wire provided for connection to display or analog transmitter unit. Rated to 221° F (105° C). May be extended to a maximum of 2000 ft (610 m) with similar cable and insulation appropriate for application.	
Electrical Cable for IR Sensor Electronics	48 in. (122 cm) of UL Style 116666 copper solid AWG 18 wire with direct burial insulation. Rated to 221° F (105° C).	
Certification	CE Equipment Class A EN 50082-2 and EN 55011	

TROUBLESHOOTING

- If the voltage at the sensor input is less than 7.0V DC 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 8.0V DC and 20.0V DC. If the voltage at the sensor input is still below 7.0V DC or 3.0V DC, 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 above.
- If the cable tests OK, drain the pipe line, verify the pressure is off, and pull the clevis pin for Series 250, or remove the top lock nuts holding the sensor electronics for Series 228. Spin the impeller by hand. If flows are noted on the display, and the 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, replace the sensor.

Control. Manage. Optimize.

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