Impeller
Data Industrial®

Flow Sensors

Series 228PV PVC Tee Type Flow Sensors

Badger Meter

SEN-UM-01664-EN-10 (February 2018)

User Manual

CONTENTS

INTRODUCTION

Used in conjunction with any Badger Meter® impeller flow monitor or endpoint, Badger Meter non-magnetic impeller 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 preamplifier 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 impeller 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.

This manual provides instructions for the Series 228PV tee type impeller flow sensor.

CERTIFICATIONS

CE

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 Badger Meter Series 200 sensor electrical components are self-contained. Pressure/temperature ratings for the various models are contained in *"Specifications" on page 10*. 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). Standard 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). IR 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.

Model 228PV

The model 228PV features a modified PVC tee with solvent weld socket end connections, and a removable PPS or PVDF sensor insert. Sizes of 1-1/2, 2, 3 and 4 inches are available.

⚠CAUTION

- The impeller style flow sensor described in this manual is not intended for use in safety critical applications. Use of the device in this manner is done at the sole discretion of the customer and/or end user of the device.
- The impeller style flow sensor described in this manual is not intended for use in systems with flammable liquids or gases. Additionally, the device is not intended for systems containing hazardous fluids or fluids other than water.
- The impeller style flow sensor described in this manual must be installed in accordance with all local and federal codes or end-use standards, as applicable.
- If the devices described in this manual are used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

⚠ ATTENTION

- Le capteur de débit de type turbine décrit dans le présent manuel n'est pas destiné à être utilisé dans des applications de sécurité critiques. L'utilisation du dispositif de cette manière se fait à la seule discrétion du client et/ou de l'utilisateur final du dispositif.
- Le capteur de débit de type turbine décrit dans le présent manuel n'est pas destiné à être utilisé dans des systèmes comportant des liquides ou gaz inflammables. En outre, le dispositif est pas destiné à des systèmes contenant des liquides dangereux ou autres que l'eau.
- Le capteur de débit de type turbine décrit dans le présent manuel doit être installé en conformité avec tous les codes locaux et fédéraux ou toutes les normes d'utilisation finale, selon le cas.
- Si les dispositifs décrits dans le présent manuel sont utilisés d'une manière non spécifiée par le fabricant, la protection fournie par l'équipement peut être altérée.

MECHANICAL INSTALLATION

Depressurize and vent the piping system prior to any installation or maintenance of the flow sensor.

General Information

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, or other obstructions 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:

- 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 at the 12 o'clock position. 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 and increase wear. Any circumferential location is correct for installation in vertical pipes, with rising flow preferred to reduce the effects of any trapped air.

Mechanical Installation Procedure

NOTE: The intended direction of flow is indicated by arrows on the tee. There must be free, unrestricted pipe for at least 10 diameters upstream and 5 diameters downstream of the tee.

1. Remove the clevis pin and remove the sensor from the tee.
2. Properly clean the pipe ends and tee sockets.
3. Use solvent cement to attach the pipe to the tee.
4. Reinstall the sensor in the tee as follows:
   a. Align the flow arrow on the top of the sensor housing in the direction of flow.
   b. Carefully press the sensor straight into the tee.
   c. Install the clevis pin through the tee, the sensor, and the conduit cap, and install the cotter ring.

ELECTRICAL INSTALLATION

IMPORTANT

Disconnect the power from the flow sensor source and/or receiving device prior to any installation or maintenance of the system. Flow sensor source and/or receiving device must provide basic isolation from mains for safe operation of the system.

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

Standard Sensors

1. Route the cable from the sensor to a Badger Meter flow monitor/endpoint. The cable may 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/endpoint, 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 **GND**, **SIGNAL(–)** or **COM** terminal, and connect the shield drain wire (if applicable) to **SLD**.
3. When interfacing with other equipment, consult the manufacturer for input designations. The signal wave forms and power requirements are as shown in *"Specifications" on page 10*.

IR Sensors

The sensor leads are supplied with watertight caps over the ends.

NOTE: DO NOT remove the plastic caps from the sensor leads until ready to splice.

1. Use a **twisted pair** cable suitable for direct burial to connect the sensor to the endpoint, monitor or controller. Multi-pair telecommunication cable or direct burial cables may be used.
2. Make a watertight splice. Two-part epoxy type waterproof kits are recommended. Be sure the epoxy seals the ends of the cable jacket.
3. Make sure the epoxy is hardened before inverting the splice or dropping it in standing water.

   NOTE: Do **NOT** make an underground splice unless absolutely necessary.
4. Route the cable from the sensor to a Badger Meter flow monitor/endpoint. The cable can be extended up to 2000 feet (610 meters), 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 the sensor, if necessary.
5. When connecting to a Badger Meter flow monitor/endpoint, 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 **GND**, **SIGNAL(–)** or **COM** terminal, and connect the shield drain wire (if applicable) to **SLD**.
6. When interfacing with other equipment, the signal wave forms and power requirements are as shown in *"Specifications" on page 10*.

Intrinsically Safe Electrical Installation

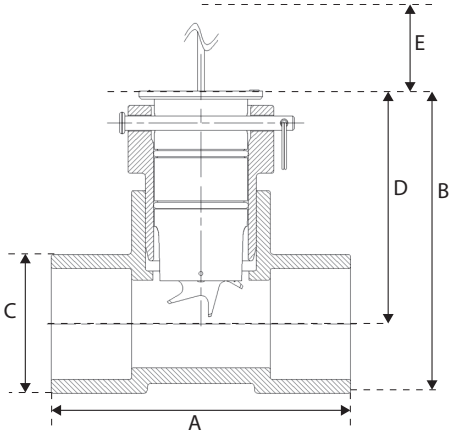
The Series 200 sensor is approved, as an entity, as intrinsically safe when installed in conformance with Badger Meter installation drawings 06-480-001 or 06-480-002 (sample shown in *"Impeller Assembly and Shaft Replacement" on page 9*) as specified on the blue label identifying an intrinsically safe 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. This interface must be constructed and all wiring must be performed by qualified contractors. To make sure the installation is intrinsically safe, 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 nonhazardous area. These barriers, listed below, are readily available from various suppliers.

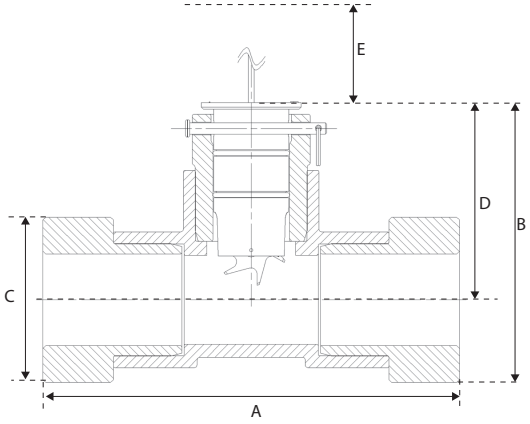
Manufacturer	**Barrier**
Crouse-Hinds Spec 504	Cat No. SB19140M0715
Measurement Technology Ltd.	MTL 715+ 15 V
R Stahl Intrinspak	9001/01-158-150-101

DIMENSIONS

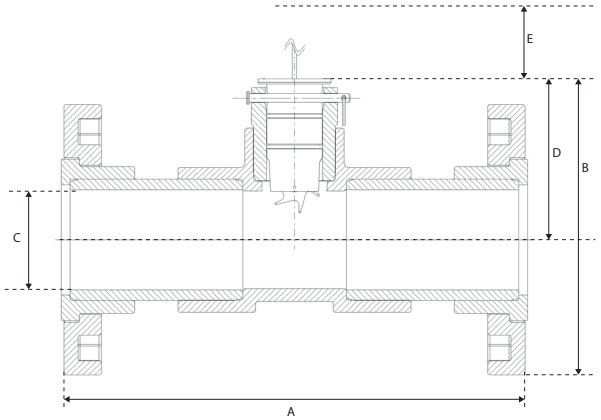
Series No. Complete	228PV15XX-XXX	228PV2XXX-XXXX	228PV3XXX-XXXX	228PV4XXX-XXXX
A5	5.0 in. (127 mm)	5.63 in. (143 mm)	6.50 in. (165 mm)	7.38 in. (187 mm)
B5	5.16 in. (131 mm)	5.64 in. (143 mm)	6.83 in. (173 mm)	6.83 in. (199 mm)
C2	2.38 in. (60 mm)	2.88 in. (73 mm)	4.23 in. (107 mm)	5.38 in. (137 mm)
D3	3.97 in. (101 mm)	4.20 in. (107 mm)	4.68 in. (119 mm)	5.10 in. (130 mm)
E5	5.0 in. (127 mm)	5.0 in. (127 mm)	5.0 in. (127 mm)	5.0 in. (127 mm)



No Fittings



BSP Fittings



Flanged (4 in. only)

Figure 1: A = Overall Length; B = Overall Height; C = Diameter; D = Center of Tube to Top Height; E = Minimum Clearance for Sensor Removal

CALIBRATION

Badger Meter impeller 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 factor alone. The K and offset numbers for each tee configuration are listed in the Calibration Table below.

Column Descriptions

Column	Description
Column 1	Sensor model number
Columns 2 and 3	The K and offset values to use in the 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 4	This column indicates the suggested flow range of each tee sensor. Badger Meter sensors 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 upstream (supply) side, and at least 5 pipe diameters in length on the downstream (delivery) side before making the transition in pipe size. If a lesser flow rate is chosen, an insufficient span exists for the proper operation of these circuits. This can result in excessive ripple and fluctuations in signal, which can adversely affect system performance.

Calibration Table

The table below provides calibration and operation data for Badger Meter plastic tee sensors 1-1/2…4 inches (38…102 mm). See the column descriptions above for additional information.

Column 1	Column 2	Column 3	Column 4
Model for	**K**	**Offset**	**Suggested Operating Range (gpm)**
228PV15xx-xxxx	1.697	-0.316	5…100
228PV20xx-xxxx	2.8429	0.1435	10…200
228PV30xx-xxxx	8.309	0.227	20…300
228PV40xx-xxxx	13.74283	0.23707	40…500

IMPELLER ASSEMBLY AND SHAFT REPLACEMENT

If you are replacing an existing Badger Meter sensor and have already calibrated your flow monitor/endpoint, 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 this manual.

1. Depressurize and vent the pipe, and remove power to the installation from which the sensor is to be removed.
2. Remove the clevis pin.
3. Remove the sensor from the tee.

NOTE: Note the impeller blade orientation relative to the flow arrows. To maintain proper calibration, the impeller must be reinstalled in the same manner with the impeller blades pointing toward the flow source 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. See *Figure 2* below. To reinstall, position the impeller in the cavity, oriented so that the impeller blades point in the flow direction (as described in the **NOTE** above). 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 housing and impeller, taking care not to damage the bearings. Make sure the shaft is inserted far enough so that it clears the housing 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 relubricate with silicone grease from the packet provided, or use another acceptable lubricant.
9. Install the sensor into the tee so the flow arrow points in the direction of the actual flow.
10. Install or replace the clevis pin.

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

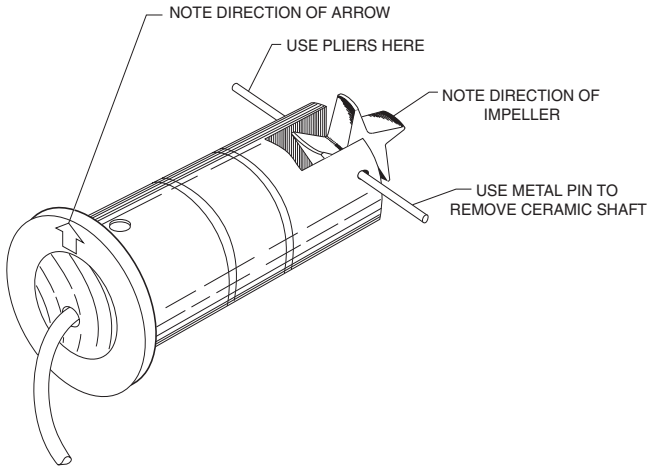
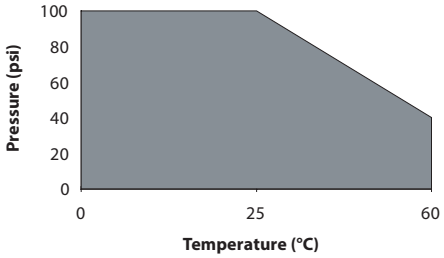


Figure 2: Impeller Assembly and Shaft

SPECIFICATIONS

Wetted Materials (except tees)	See **Ordering Matrix** in the Series 228PV Product Data Sheet for material specifics.
Tee for 228PV	Schedule 80 PVC per ASTM D-2462 and D-2467, Virgin, unplasticized PVC resin, Type 1 cell classification 12454-B. Fittings and solvent carry approval for potable water by NSF and IAMPO.
Pressure/Temperature Ratings (DO NOT EXCEED)	Depends on hardware configurations. 
Rated Temperature (DO NOT EXCEED)	Operating: 35…110° F (2…43° C) Storage 14…110° F (-10…43° C)
Recommended Design Flow Range	0.5…30 ft/sec
Accuracy	± 1.0% of full scale over recommended design flow range
Repeatability	± 0.3% of full scale over recommended design flow range
Linearity	± 0.2% of full scale over recommended design flow range
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…200 Hz
Output Pulse Width	5 msec ±25%
Environmental	• IP 68 / NEMA 4X • Suitable for pollution degree 4 environments • Suitable for outdoor use above grade, IR version below grade • Suitable for use in 100% humidity
Electrical Cable for Standard Sensor Electronics	20 feet (6 meters) of 2-conductor AWG 20 with AWG 22 drain wire shielded UL type PTLC wire provided for connection to display or endpoint unit. Rated to 221° F (105° C). May be extended to a maximum of 2000 feet (610 meters) with similar cable and insulation appropriate for application.
Electrical Cable for IR Sensor Electronics	48 inches (122 cm) of UL Style 116666 copper solid AWG 18 wire with direct burial insulation. Rated to 221° F (105° C).

TROUBLESHOOTING

Series 200 flow sensors are active devices that are most easily tested at the connection point of the controller to which they are connected.

The sensor is essentially a 15 Ohm switch with a 600 uA leakage current. With no flow running (the impeller not turning), the sensor will appear to the controller input as a small current load. When the impeller is turning, it appears a quick series of 5 ms short circuits.

- Before trying to troubleshoot, confirm that the flow rates are well above the minimum recommended flow rates. This will usually purge any air out of the line, and make sure that the impeller is actually spinning in the flow.
- If the controller is not recognizing a flow input from this sensor, test the controller itself by disconnecting the flow sensor, and very quickly and repeatedly short together the two terminals that the flow sensor was connected to. The controller should report some flow. If it does not, the problem is in the controller, and not the flow sensor or the wiring to it.
- If the controller appears to be working, while the sensor is still disconnected, measure the open circuit voltage on the controller's sensor input terminals. This voltage must be between 8…24V DC for the sensor to operate. If the voltage is acceptable, reconnect the flow sensor and re-measure. Depending on the age of the flow sensor, the voltage should drop slightly. Current production sensors will drop about a volt or so. Sensors manufactured prior to 2001 will drop to about 8V DC. If no drop is observed, the sensor is wired backwards, or there is a break in a wire or splice, or the sensor is open internally. If the voltage drops to near zero, there is either a short in the wiring or splice or the sensor is shorted internally. If the voltage drops below 7V—but not to levels indicating a short—there is most likely moisture penetration or corrosion in the wiring or in the sensor itself.
- If the electrical tests all look normal, you will have to drain the pipe, remove the sensing element, and spin the impeller by hand. When spun by hand, the impeller should spin freely and slide smoothly to a stop, with no evidence of damage or wear on any of the surfaces, and the controller should recognize the signal and report a flow. If it does not, the sensor electronics are no longer operational and must be replaced.
- If the impeller/bearing is simply worn or damaged, and signal is observed when the impeller is forced to turn, then an impeller repair kit can be installed as described in *"Impeller Assembly and Shaft Replacement" on page 9*.

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