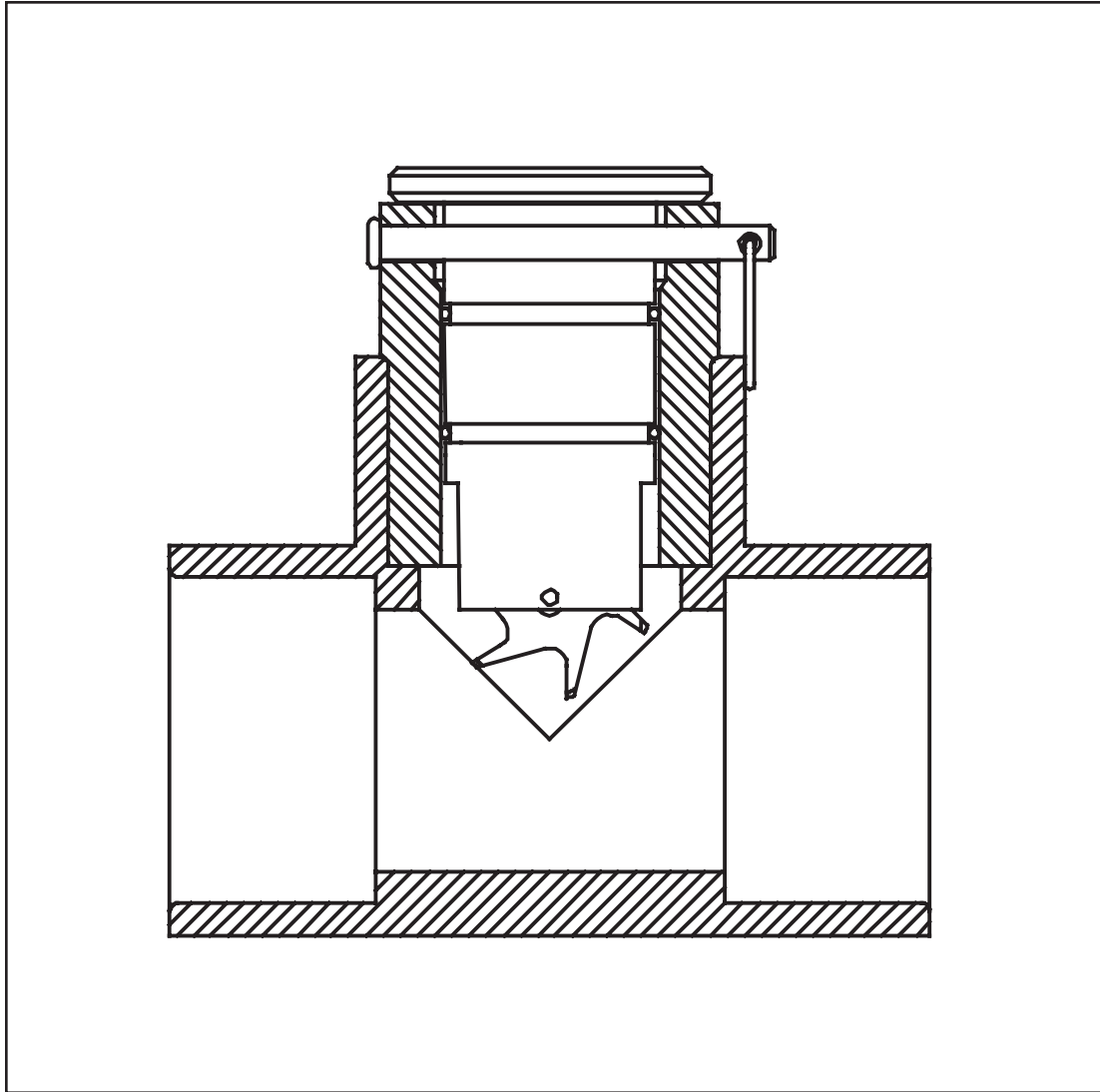


**Badger®  
228P Series**

**Plastic Tee Type Impeller  
Flow Sensor**

**Installation &  
Operation Manual**



## INTRODUCTION

Used in conjunction with any Badger Meter Impeller flow monitor or transmitter, 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 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.

## 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 Badger® 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 deg. F. Standard sensors are supplied with 20 feet of 2-conductor 20 AWG shielded U.L. type PTLC 105 deg. 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 deg. 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.



## "FM/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 140 deg. F. FM/CSA sensors are supplied with 20 feet of 2-conductor 20 AWG shielded U.L. type PTLC 105 deg. C cable. These sensors must be used with an approved safety barrier.

### Model 228PV (Formerly 220P)

These models feature 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" are available.

## 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 ten pipe diameters upstream and five 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, then 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 and increase wear. Any circumferential location is correct for installation in vertical pipes. Rising flow preferred to reduce effects of any trapped air.

200 Series Plastic Tee Sensors Matrix (1 1/2" to 4")

Example: 2	x	x	x	x	x	-	x	x	x	x
<b>Style</b>	Tee Mounted	28								
<b>Material</b>	PVC	PV								
<b>Size</b>	1.5"	15								
	2"	20								
	3"	30								
	4"	40								
<b>Electronics Housing</b>	PPS	0								
<b>ELECTRONICS</b>	FM/CSA Approved	4								
	Standard	5								
	IR-Irrigation	6								
<b>O-RING</b>	Viton®	0								
	EPDM	1								
	Kalrez®	2								
	Food Grade Silicone	3								
	Neoprene	4								
	Chemraz®	5								
	Teflon® Encapsulated Viton®	6								
	Teflon® Encapsulated Silicone	7								
	Buna N	8								
<b>SHAFT</b>	Zirconia Ceramic	0								
	Hastalloy C®	1								
	Tungsten Carbide	2								
	Titanium	3								
	Monel®	5								
	316 Stainless Steel	6								
	Tantalum	7								
<b>IMPELLER</b>	Nylon	1								
	Tefzel®	2								
<b>BEARING</b>	Pennlon	1								
	Tefzel®	2								
	Teflon®	3								

## MECHANICAL INSTALLATION FOR 228PV PLASTIC TEE SENSORS

- 1) Note intended direction of flow as 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.
- 2) Remove the clevis pin and remove the sensor from the tee.
- 3) Properly clean the pipe ends and tee sockets.
- 4) For the Series 228PV, solvent cement the pipe to the tee.
- 5) Reinstall sensor in tee as follows:
  - a) Align the flow arrow on the top of the sensor housing in the direction of flow.
  - b) Carefully press sensor straight into tee.
  - c) Install clevis pin through tee, sensor, and conduit cap, and install cotter ring.

## ELECTRICAL INSTALLATION "STANDARD" SENSORS

- 1) 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.
- 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 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**".
- 3) When interfacing with other equipment consult manufacture for input designations. The signal wave forms and power requirements are as shown in the Specifications section. Refer to Technical Brief DTB-058.

## ELECTRICAL INSTALLATION "IR" SENSORS

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

- 1) **DO NOT** remove the plastic caps from the sensor leads until ready to splice. See Application Note DAB-031 and Technical Brief DTB-043 at [www.badgermeter.com](http://www.badgermeter.com)
- 2) 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.
- 3) Make a water tight splice. Two part epoxy type waterproof kits are recommended. Be sure the epoxy seals the ends of the cable jacket.
- 4) Make sure the epoxy is hardened before inverting the splice or dropping it in standing water.
- 5) **DO NOT** make an underground splice unless absolutely necessary.
- 6) 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.

- 7) 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**".
- 8) When interfacing with other equipment, the signal wave forms and power requirements are as shown in the Specifications section. Refer to Technical Brief DTB-058 at [www.badgermeter.com](http://www.badgermeter.com)

## ELECTRICAL INSTALLATION (FM SENSORS)

The Badger® 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 (samples shown on Page 5) 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.

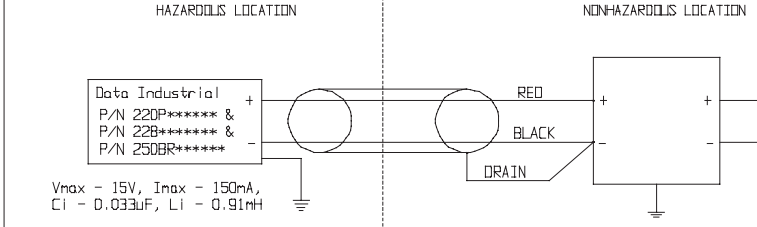
Manufacturer:	Barrier:
Crouse-Hinds Spec 504	Cat No. SB19140M0715
Measurement Technology Ltd.	MTL 715+ 15 V
R Stahl Intrinsicpak	9001/01-158-150-101

## 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. K and Offset numbers for

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REVISIONS			
REV	DESCRIPTION	DATE	
A	RELEASED ECD 3250		
B	ECD 3263	7-6-94	
C	ECD 3262	12/27/94	
D	ECD 3649		



USABLE IN HAZARDOUS LOCATIONS  
 CLASS I, DIVISION 1,  
 GROUPS A, B, C, D  
 CLASS II, DIVISION 1,  
 GROUPS E, F, G  
 CLASS III

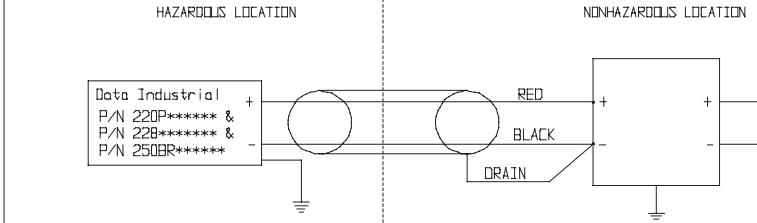
- NOTES
- FMRC APPROVED BARRIER PARAMETERS MUST MEET THE FOLLOWING CONNECTION REQUIREMENTS:  
 -  $V_{oc}$  OR  $V_t$  MUST BE LESS THAN  $V_{max}$   
 -  $I_{sc}$  OR  $I_t$  MUST BE LESS THAN  $I_{max}$   
 - C1 PLUS INTERCONNECTION WIRING MUST BE LESS THAN THE  $C_0$  OF THE FMRC APPROVED BARRIER  
 - L1 PLUS INTERCONNECTING WIRING MUST BE LESS THAN THE  $L_0$  OF THE FMRC APPROVED BARRIER
  - INSTALLATION SHALL BE IN ACCORD WITH THE MANUFACTURER'S INSTRUCTIONS AND THE NATIONAL ELECTRICAL CODE (ANSI/NFPA 70).
  - FOR GUIDANCE ON INSTALLATION, SEE ANSI/ISA RP12.6 "INSTALLATION OF INTRINSICALLY SAFE INSTRUMENT SYSTEMS IN CLASS I HAZARDOUS LOCATIONS"
  - NO CHANGES TO THIS DRAWING WITHOUT PRIOR WRITTEN AUTHORIZATION FROM FMRC.

DRAWN BILL HEELAN	DATE 04/20/94		11 INDUSTRIAL DRIVE MATTAPANSETT, MA 02739 (508)-759-6390	
CHECKED	DATE		PROJECT FM APPROVED SENSORS	
APPROVAL	DATE	PART INSTALLATION DRAWING FOR FMRC APPV'D 220P*, 228*, & 250BR SENSORS		REV D
FMRC APPROVAL	DATE	SIZE B	FSCN NO. DNG NO. 06-480-002	SHEET 1 OF 2
SCALE NONE				

DO NOT SCALE DRAWING

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REVISIONS			
REV	DESCRIPTION	DATE	BY
A	RELEASED ECD 3250		
B	ECD 3263	7-6-94	
C	ECD 3292		
D	ECD 3649		B.H.



USABLE IN HAZARDOUS LOCATIONS  
 CLASS I, DIVISION 1,  
 GROUPS A, B, C, D  
 CLASS II, DIVISION 1,  
 GROUPS E, F, G  
 CLASS III

CSA CERTIFIED  
 INTRINSIC SAFETY BARRIER  
 CROUSE-HINDS SPEC 504 CAT. NO. SB9140M0715  
 MEASUREMENT TECHNOLOGY LTD. MTL715+ 15V,  
 R. STAHL INTRINSPAK 9001/01-15B-150-10

- NOTES:
- INSTALLATION SHALL BE IN ACCORD WITH THE INTRINSIC SAFETY BARRIER MANUFACTURER'S INSTRUCTIONS AND CANADIAN ELECTRICAL CODE
  - NO CHANGES TO THIS DRAWING WITHOUT WRITTEN AUTHORIZATION FROM CSA

DRAWN BILL HEELAN	DATE 04/20/94		11 INDUSTRIAL DRIVE MATTAPANSETT, MA 02739 (508)-759-6390	
CHECKED	DATE		PROJECT CSA CERTIFIED SENSORS	
APPROVAL	DATE	PART INSTALLATION DRAWING FOR CSA CERTIFIED 220P*, 228*, & 250BR SENSORS		REV D
FMRC APPROVAL	DATE	SIZE B	FSCN NO. DNG NO. 06-480-002	SHEET 2 OF 2
SCALE NONE				

DO NOT SCALE DRAWING

each tee configuration are listed in the following table.

**Calibration Tables**

The table below provides calibration and operation data for Badger Meter Plastic Tee Sensors 1 1/2" to 4".

- Column 1            Sensor 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:

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

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. 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 for Series 228PV**

Model	Apparent I.D. for Series 1000, 900	K	Offset	Suggested Operating Range (GPM)
228PV15xx-xxxx	1.5	1.697	-0.316	5-100
228PV20xx-xxxx	1.94	2.8429	0.1435	10-200
228PV30xx-xxxx	4.02	8.309	0.227	20-300
228PV40xx-xxxx	5.15	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/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) Remove the clevis pin.
- 3) Remove the sensor from the tee.
- 4) Note the impeller blade orientation relative to flow arrows. In order to maintain proper calibration, the impeller will have to be reinstalled in the same manner with the impeller blades pointing toward the flow source 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 below. To reinstall, position the impeller in the cavity oriented as in Step 4 so that the impeller blades point into the flow direction. 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 housing and impeller, taking care not to damage bearings. Make sure that the shaft is inserted far enough so that it clears the housing 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 relubricate with silicone grease from the packet provided, or use some other acceptable lubricant.
- 10) Install the sensor into the tee so the flow arrows points in the direction of the actual flow.
- 11) Install or replace the clevis pin.
- 13) This completes the replacement procedure. The system may now be repressurized and tested.

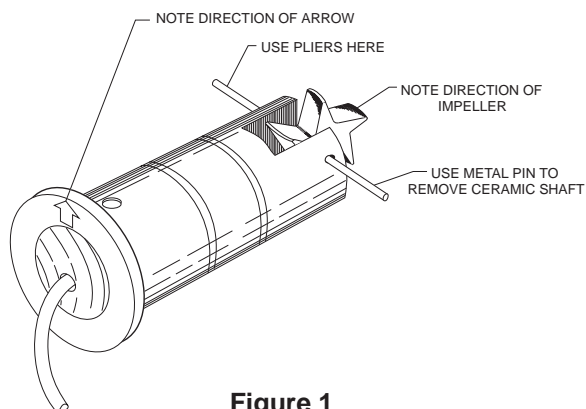


Figure 1

Impeller Assembly and Shaft Replacement

## SPECIFICATIONS

### Wetted Materials (except tees)

- See Ordering Matrix

### 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

- Depends on hardware configurations
- See diagrams at end of this section

### Recommended Design Flow Range

- ½ to 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 for 228PV

### Linearity

- ± 0.2% of full scale over recommended design flow range for 228PV

### Transducer Excitation

- Quiescent current 600uA@8.0VDC to 35.0VDC max.
- Quiescent voltage ( $V_{high}$ ) Supply voltage  $-(600uA * \text{Supply impedance})$
- ON state ( $V_{Low}$ ) max 1.2VDC@40mA current limit (15ohm+0.7VDC)

### Output Frequency

- 3.2 Hz to 200 Hz for all except 228PF

### Output Pulse Width

- 5 msec ±25%

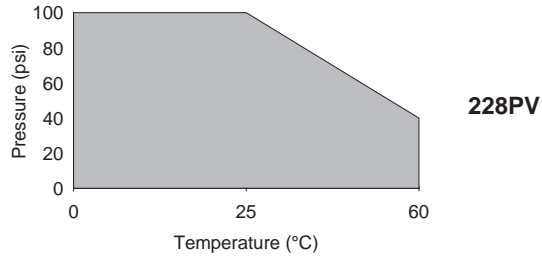
### Electrical Cable for Standard Sensor Electronics

- 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 deg. 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 UL style 116666 copper solid AWG 18 wire with direct burial insulation. Rated to 105 deg. C.

## PRESSURE/TEMPERATURE DIAGRAMS FOR BADGER METER FLOW SENSORS



### TROUBLESHOOTING

- 1) 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).
- 2) 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.
- 3) 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.
- 4) If the cable tests ok, drain the pipe line, verify the pressure is off, and pill the clevis pin 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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