



Flow Sensors
Insertion Style Flow Sensors
Series 220, 225, 226



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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 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 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 following insertion style flow sensors, as indicated:

220BR; 220SS; 220PV; 225BR; 226BR; 226SS

CERTIFICATION



MECHANICAL INSTALLATION

Flow measurement accuracy for all flow measuring devices is highly dependent on proper location in the piping system. Irregular flow velocity profiles caused by valves, fittings, and pipe bends can lead to inaccurate overall flow rate indications although local flow velocity measurement may be accurate. A sensor located 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. Follow these recommendations to provide 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 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 center. The sensor should never be located at the bottom of the pipe, as sediment may collect there. Locations off top 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.
- Allow an insertion depth of 1-1/2 inches (38 mm) for pipe sizes 2-1/2 inches and larger for accurate flow rate calibration. Detailed installation instructions for various sensor mounting configurations on the following pages include methods for providing correct insertion depth.
- Align the sensor so that the impeller rotation is parallel to flow. Alignment instructions are included on the following pages.

INSTALLATION FOR 220BR, 220SS, 220PV

Installation Procedure

The insertion depth and alignment of the flow sensor assembly are critical to the accuracy of the flow measurement. The flat end of the sensor sleeve assembly **MUST BE INSTALLED** 1-1/2 inches (38 mm) from the inside wall of the pipe. To allow for variations in wall thickness, lining, or coatings, the depth adjustment is controlled by the position of the hex nuts on the three threaded studs of the hex mounting adapter. The hex mounting adapter is provided with a 2 inch male NPT connection.

There are two methods of mounting these sensors in a 2-1/2 inch or larger pipe. One is with a 2 inch NPT threaded pipe saddle. The other is with a welded-on fitting such as a Thredolet®, also tapped for a 2 inch NPT connection. In either case, cut a 2 inch (51 mm) hole through a depressurized pipe and then secure the saddle or weld-on fitting to the pipe. (For drilling into a pressurized pipe, see "*Installation into a Pressurized Pipeline*" on page 7.) Install the 2 inch NPT adapter provided, using a thread sealant to prevent leakage. Tighten as necessary. Badger Meter insert style flow sensors are calibrated with the sensor inserted 1-1/2 inches (38 mm) into the pipe flow.

To determine the proper insertion depth, follow these steps:

1. Apply anti-seize thread lubricant (supplied with the sensor) to the threaded studs of the mounting adapter.
2. Insert the depth gauge into the mounting adapter and set it against the inside wall of the pipe as shown in *Figure 1*. Set the top of the upper adjusting nut to 3-3/4 inches (95 mm) as measured. Lock it in place with the bottom nut on the same stud. Repeat for the other adjusting nuts.

NOTE: For Model 220PVS, set the nuts 6-1/2 inches (165 mm) above the inside wall of the pipe.

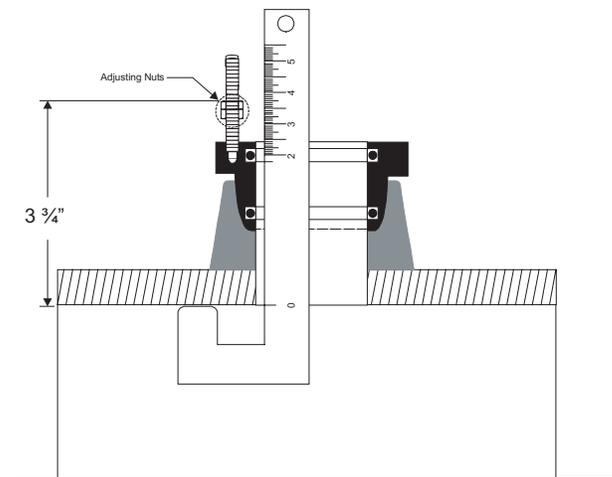


Figure 1: Installation for 220BR and 220SS

3. Clean the O-rings and the flow sensor sleeve, and lightly lubricate the O-rings with silicone grease from the packet provided (or another acceptable lubricant). Take care not to get grease on the impeller or bearing.
4. Insert the flow sensor into the 2 inch NPT adapter so that the mounting holes in the positioning collar fit over the studs on the adapter.
5. Lower the sensor onto the previously adjusted nuts. Install the lock nuts on top of the positioning collar and tighten. Now tighten the lower jam nuts firmly against the upper adjusting nuts to secure them for future removal of the sensor for inspection or service.

Alignment of Flow Sensor

1. Loosen the positioning collar set screws with a 3/32 inch Allen wrench. Place the alignment rod through the sight holes in the flow sensor. See *Figure 2*. Using the alignment rod as a guide, align the flow sensor so the flow label arrow matches the pipe flow direction and the alignment rod is exactly parallel to the pipe. This procedure aligns the impeller directly into the fluid flow.

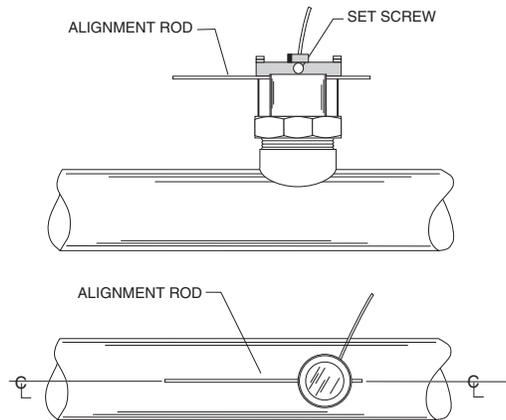


Figure 2: Alignment of Flow Sensor 220BR and 220SS

2. As a backup to the flow arrow label, there is a small hole next to the larger sight hole of the upstream side. With a 3/32 inch Allen wrench, tighten the positioning collar set screws.
3. Double check that the sight holes in the sleeve are parallel down the pipe and the flow arrow label matches the pipe liquid flow direction.
4. Cable routing: The positioning collar is threaded for connection of a standard 1/2 inch electrical conduit (flex cable) or a wire strain relief. Route the cable as required. Be sure to leave enough flex in the cable or conduit to allow future removal of the sensor for service or cleaning.

HOT TAP INSTALLATION FOR 225BR, 226BR, AND 226SS

Badger Meter Series 200 hot tap style liquid flow sensors are designed for use in cases where pipelines will be in continuous service, and depressurizing or draining the system for installation or service is not practical.

The Series 200 hot tap flow sensors are designed to be installed either in a depressurized pipe by hand, or “hot tapped” into a pressurized pipeline. Both installation procedures are in this manual. **If there is the slightest possibility the pipe could be full or pressurized, follow the installation for a pressurized pipe.** See “Installation into a Pressurized Pipeline” on page 7.

See Figure 4 for the location or identification of the various parts described in the following procedures.

Sensor Assembly Depth and Alignment

The insertion depth and alignment of the sensor assembly are critical to the accuracy of the flow measurement. The flat end of the sensor tube assembly **must be installed** 1-1/2 inches (38 mm) from the inside wall of the pipe. To allow for variations in wall thickness, lining or coatings, the depth adjustment is controlled by the position of the hex nuts on the three threaded studs of the hex mounting adapter. The hex mounting adapter is provided with a 2 inch male NPT connection. Both gate and ball valve units are provided with 2 inch nipples for mounting onto saddles and weld-o-lets.

Setting the Depth

1. Position the hex nuts 14-7/8 inches (378 mm), minus the thickness of the pipe, from the outside diameter of the pipe. For example, measure the wall thickness of the pipe from the coupon removed when the 1-7/8 inch (48 mm) hole was cut into the pipe. If the pipe was 1/8 inch (3 mm) thick, subtract 1/8 inch (3 mm) from 14-7/8 inches (378 mm), or position the nuts 14-3/4 inches (375 mm) from the outside diameter of the pipe. This will allow the 16-3/8 inch (416 mm) sensor to protrude 1-1/2 inches (38 mm) into the pipe.
2. Apply anti-seize thread lubricant, supplied with the sensor, to the threaded studs of the mounting adaptor.

Aligning the Impeller with the Flow

1. To align the impeller with the flow in the pipe, align the two sight holes at the top of the sensor tube assembly with the center line of the pipe. Make sure the alignment is made to the pipe, and not to a wall or surface near the sensor.
2. To adjust, loosen the two set screws in the positioning collar with the 3/32 inch Allen wrench (supplied in the installation kit).
3. Slip one end of the 1/4 inch x 18 inch steel rod (supplied in the installation kit) through the holes in the sensor tube.
4. Rotate the sensor tube until the rod is centered on the pipe. Make sure the flow label arrow on the sensor matches the liquid flow direction.
5. Tighten the positioning collar Allen screws to lock the sensor sleeve assembly in position.

NOTE: As a backup to the flow label arrow, there is a small hole located beside one of the sight holes to also indicate the upstream side of the sensor.

Installation if the Pipe is Depressurized and Drained

1. Drill or cut a hole in the pipe with a 1-7/8 inch (48 mm) drill or hole saw. Note the pipe wall thickness for use in calculating sensor assembly depth. A location on the top of the pipe is best for overall performance and service life; however, any radial location on the top half of the pipe is acceptable. Allow a minimum of 10 pipe diameters upstream and 5 diameters downstream from the sensor of straight unobstructed pipe to allow full development of the flow profile.
2. Install either a service saddle or welded pipe fitting (2 inch female NPT) on the outside diameter of the pipe over the 1-7/8 inch (48 mm) hole.
3. Install the Badger Meter isolation valve and nipple onto the fitting using pipe thread sealant or Teflon® tape on all threads.
4. Install the Badger Meter hex mounting adapter onto the valve assembly. Use pipe thread sealant on the adapter.
5. Tighten the hex mounting adapter so that no stud is aligned with the center-line of the pipe. This could interfere with final sensor alignment.
6. Measure the depth and set the height of the nuts of the hex mounting adapter.

NOTE: Badger Meter recommends that you purchase a Hot Tap insertion/removal Tool (Model HTT) for future service, even if the sensor is installed in a drained system. The Model HTT allows you to remove the sensor sleeve assembly from the pipe line without draining the entire loop where the sensor is mounted.

7. In a fully depressurized and drained pipe, the sensor tube assembly may be installed by hand. If reinstalling into a drained system thought to have been depressurized and drained, verify by very slowly opening the isolation valve.
 - a. Carefully and very slowly open the isolation valve to relieve any pressure that may have built up.
 - b. Fully open the isolation valve.
 - c. Push the sensor sleeve into the pipe with a slight twisting motion.
 - d. Guide the sensor collar holes over the three hex adapter studs until the collar rests on the nuts. Hex nuts should have been previously set to the correct height.
 - e. Install the three lock nuts onto these studs at the top of the positioning collar and securely tighten.
8. Loosen the two set screws in the positioning collar with a 3/32 inch Allen wrench.
9. Align the sensor sight holes along the pipe axis using the alignment rod from the sensor installation kit. M
10. Verify that the flow label arrow on the sensor matches the liquid flow direction inside the pipe.
11. Tighten the positioning collar set screws.

NOTE: As a backup to the flow label arrow, there is a small hole located beside one of the sight holes to also indicate the upstream side of the sensor.

Installation into a Pressurized Pipeline

The Model HTT (Hot Tap Tool) provides the mechanical advantage required to safely insert and remove a Badger Meter hot tap flow sensor from line pressure, and provides a restraint when removing the sensor from a pressurized pipe.

Refer to *Figure 3* for identification and location of the HTT parts described in this section.

For pipe sizes 2-1/2 inch and above, all Badger Meter sensors are inserted 1-1/2 inches (38 mm) from the inside wall of the pipe. The insertion depth is controlled by the position of the hex nuts on the three threaded rods.

To calculate the distance (D) between the top of the sensor hex mounting adapter and the bottom of the positioning collar (the top of the hex nut), **ADD** the H dimension, pipe wall thickness, and insertion depth, and **SUBTRACT** the total from the overall sensor length. See the example and formula on the next page, and refer to *Figure 4*.

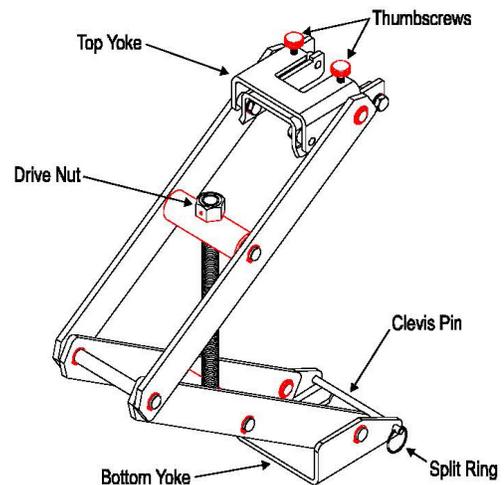


Figure 3: Model HTT (Hot Tap Tool)

Example: The sensor is installed in an 8 inch schedule 80 pipe, with a pipe wall thickness of 1/2 inch. If the overall sensor length is 16-3/8 inches and the H dimension is 10 inches, the D value is calculated as follows:

$$\begin{aligned}
 D &= \text{Overall length} - (\text{H} + \text{pipe wall thickness} + \text{Insertion Depth}) \\
 D &= 16\text{-}3/8 \text{ in.} - (10 \text{ in.} + 1/2 \text{ in.} + 1\text{-}1/2 \text{ in.}) \\
 D &= 16\text{-}3/8 \text{ in.} - 12 \text{ in.} \\
 D &= 4\text{-}3/8 \text{ in.}
 \end{aligned}$$

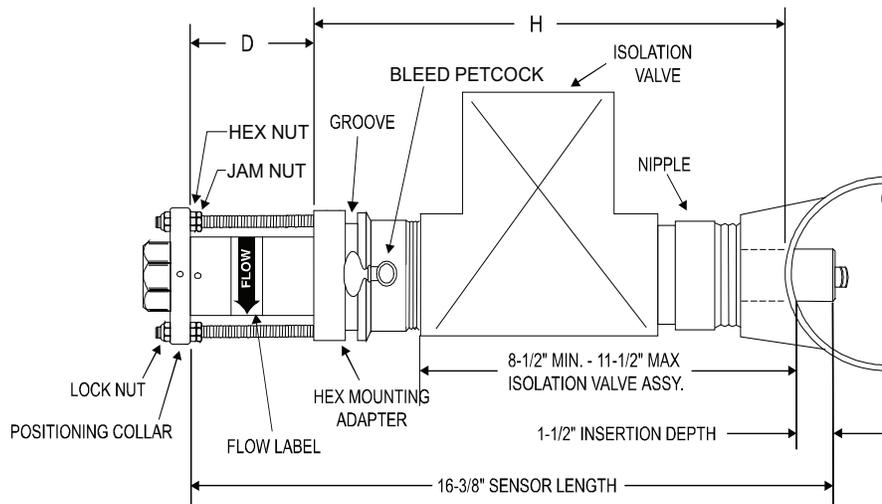


Figure 4: Sensor parts

1. Set one set of the hex/jam nuts so that the distance between the top surface of the hex nut and the top surface of the hex mounting adaptor is equal to the D dimension calculated above.
2. Then adjust the other two sets of hex/jam nuts 1-1/2 inches (38 mm) below the first jam nut to allow clearance for the Model HTT (Hot Tap Tool) top yoke.
3. Fully extend the HTT by turning the drive nut counterclockwise with a 15/16 inch socket or box wrench (customer supplied) until the drive nut contacts the tool. Slide the positioning collar into the tool top yoke.
4. Remove the HTT split ring and clevis pin and slide the tool bottom yoke into the groove on the sensor hex mounting adaptor. Secure by replacing the clevis pin and split ring.
5. Mark the sleeve 2-3/4 inches (51 mm) from the impeller end of the metal sleeve. This mark is a stopping point to prevent the impeller/bearing from being damaged.
6. Open the bleed petcock valve on the hex mounting adapter to relieve the pressure resulting from the flow sensor sleeve insertion.
7. Carefully hand insert the hot tap flow sensor sleeve assembly into the hex mounting adapter until the mark lines up with the top of the hex mounting adapter. At this point, the sleeve will have been inserted past the top two O-rings in the adapter, approximately 1...1-1/4 inches (25...32 mm). Take care not to push the sensor past the mark on the sleeve as the impeller could be damaged if it strikes the closed valve.
8. Rotate the HTT so the threaded rod with the adjusted hex/jam nuts is centered in the top yoke of the hot tap tool.
9. Rotate the sensor sleeve so the positioning collar holes align with the threaded rods and flow direction label is in general direction making sure the positioning collar is located in the recessed area of the top yoke.
10. Slide the top yoke of the HTT over the positioning collar and secure by tightening the two thumbscrews on top of the yoke.
11. Close the bleed petcock and slowly open the isolation valve.
12. Slowly turn the 15/16 inch drive nut clockwise to insert the sensor sleeve assembly through the valve and into the pipeline.
13. Carefully guide the three threaded studs of the hex mounting adapter through the holes of the sensor positioning collar.
14. Carefully lower the sensor until the positioning collar contacts the hex nut preset for the correct depth adjustment.

15. Install the three lock nuts onto the threaded rods, tightening only the lock nut on the threaded rod with the preset hex/jam nut.
16. Then bring the two remaining lock nuts down until they just contact the positioning collar. Do not tighten at this time.
17. Remove the HTT by loosening the two thumbscrews, removing the clevis pin and sliding the insertion tool off the sensor. Then bring the two remaining sets of hex/jam nuts up to the underside of the positioning collar and tighten.
18. Align the sensor by loosening the two set screws in the side of the positioning collar with a 3/32 inch Allen wrench.
19. Align the sensor sight holes along the pipe axis using the alignment rod from the sensor installation kit. Make sure the flow label arrow on the sensor matches the liquid flow direction inside the pipe.
20. Tighten the positioning collar set screws.

NOTE: As a backup to the flow label arrow, there is a small hole located beside one of the sight holes to also indicate the upstream side of the sensor.

For removal of a Series 225, 226 flow sensor from a pressurized pipeline, refer to the document titled *Hot Tap Flow Sensors Application Data Sheet*, available in the Resource Library at www.badgermeter.com.

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 top of the 220 sensors or an optional conduit cap on the Series 250 sensors will accept 1/2 inch 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, 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 flow 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 **GND, SIGNAL(-)** or **COM** terminal, and connect the shield drain wire (if applicable) to **SLD**.

NOTE: When interfacing with other equipment, consult the manufacturer for input designations. The signal wave forms and power requirements are described in "*Specifications*" on page 18. See additional technical literature in the Resource Library at www.badgermeter.com.

IR Sensors

NOTE: The sensor leads are supplied with watertight caps over the ends. 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 transmitter, monitor, or controller. Multi-pair telecommunication cable or direct burial cables can 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. 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.

3. Route the cable from the sensor to a Badger Meter flow monitor/transmitter. The cable can 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.
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 **GND, SIGNAL(-)** or **COM** terminal, and connect the shield drain wire (if applicable) to **SLD**.

NOTE: When interfacing with other equipment, the signal wave forms and power requirements are described in "*Specifications*" on page 18. See additional technical literature in the Resource Library 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 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 the cable inside the sensor electronic housing on the Series 220 sensors, or attach to the sensor cable on the Series 225/226 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 **GND, SIGNAL(-)** or **COM** terminal, and connect the shield drain wire (if applicable) to **SLD**.

NOTE: When interfacing with other equipment, the signal wave forms and power requirements are as described in "Specifications" on page 18.

ELECTRICAL INSTALLATION SAFETY

The Series 200 sensor is approved, as an entity, as intrinsically safe when installed in conformance with Badger Meter installation drawing 06-480-002 (*Figure 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 protect 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+ 15V
R Stahl Intrinspak	9001/1-158-150-10

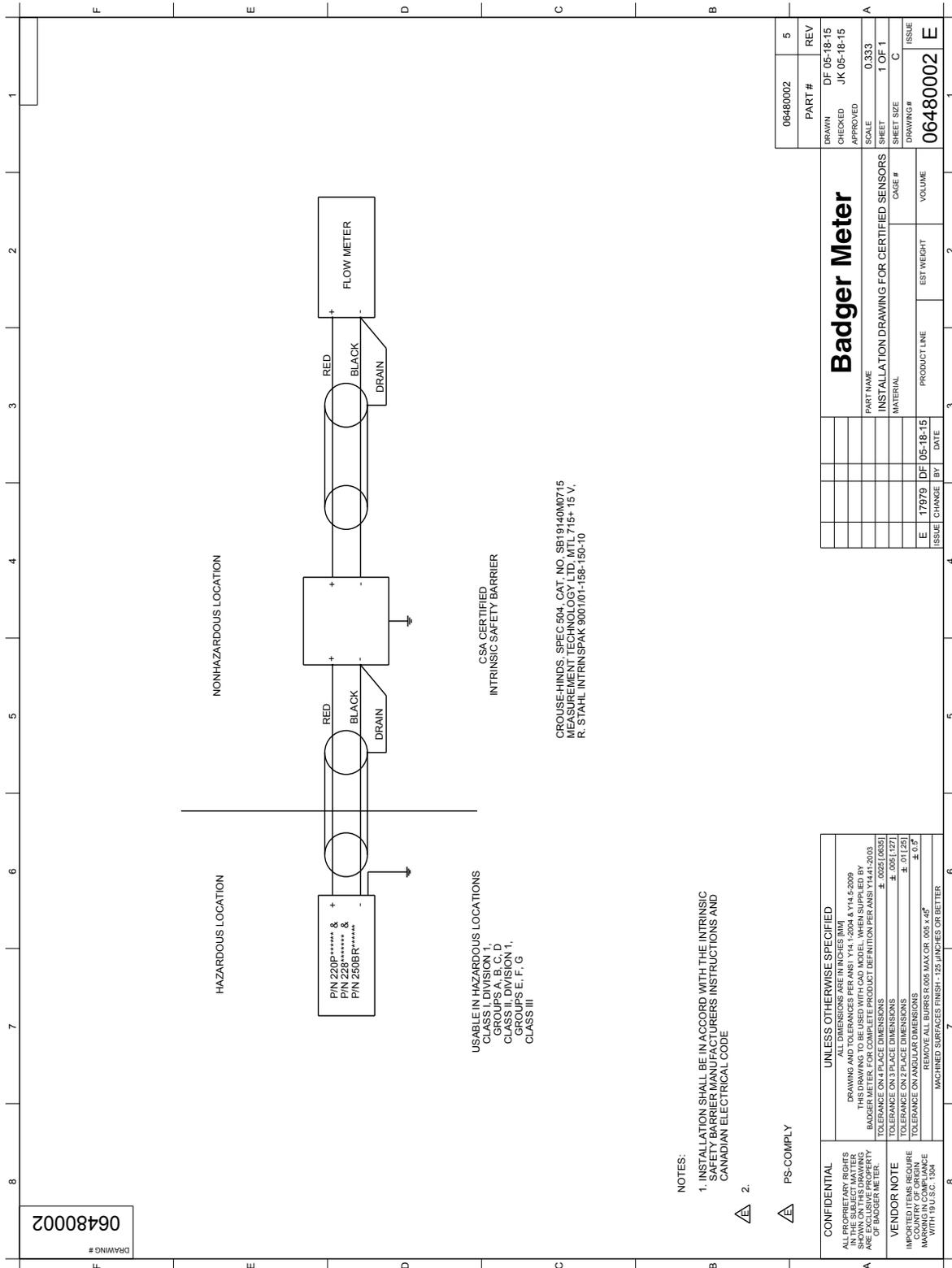


Figure 5: Sample installation drawing

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.

The "Calibration Table for Pipe Sizes 3...36 Inches" on page 14 provides calibration and operation data for most scheduled pipe sizes 3...18 inches. For tee-mounted sensors, see the Metal Tee or the Plastic Tee user manual, available in the Resource Library at www.badgermeter.com.

Description of Calibration Table Columns

Column	Description
Column 1	Nominal Pipe Size (NPS)
Column 2	Pipe outside diameter (O.D.) as defined by ASA B36.10 and other standards
Column 3	Pipe inside diameter (I.D.) as defined by ASA B36.10 and other standards
Columns 4 and 5	<p>The K value and Offset that should be used in our frequency equation:</p> $\text{Freq} = \frac{\text{Gpm}}{K} - \text{Offset}$ <p>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.</p>
Column 6	<p>This column indicates the suggested flow range of sensors in each pipe size. 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.</p> <p>Sensors should be sized for flow rather than pipe size. To prevent disturbances to the flow profile, always connect the sensor tee to the pipe nipples measuring at least ten pipe diameters in length on the downstream (delivery) side before making the transition in pipe size.</p>

Calibration Table for Pipe Sizes 3...36 Inches

See the column descriptions on the previous page for additional information about the calibration table.

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6
Pipe Size	Pipe O.D. (in.)	Pipe I.D. (in.)	K Value	Offset	Suggested Operating Range (gpm)
3 inch Sch 10S	3.5	3.260	5.009	0.090	12...400
Std. Wt., Sch 40	3.5	3.068	4.362	0.063	12...400
Extra Strong, Sch 80	3.5	2.900	3.858	0.043	12...400
PVC Class 125	3.5	3.284	5.094	0.093	12...400
PVC Class 160	3.5	3.230	4.902	0.085	12...400
PVC Class 200	3.5	3.166	4.682	0.076	12...400
4 inch Sch 10S	4.5	4.260	9.597	0.241	20...600
Std. Wt., Sch 40	4.5	4.026	8.34	0.229	20...600
Extra Strong, Sch 80	4.5	3.826	7.354	0.188	20...600
PVC Class 125	4.5	4.224	9.396	0.240	20...600
PVC Class 160	4.5	4.154	9.013	0.240	20...600
PVC Class 200	4.5	4.072	8.578	0.239	20...600
5 inch Sch 10S	5.563	5.295	16.305	0.250	30...900
Std. Wt., Sch 40	5.50	5.047	14.674	0.248	30...900
Extra Strong, Sch 80	5.50	4.813	13.165	0.246	30...900
6 inch Sch 10S	6.625	6.357	24.089	0.260	50...1500
Std. Wt., Sch 40	6.5	6.065	21.574	0.257	50...1500
Extra Strong, Sch 80	6.5	5.761	19.457	0.254	50...1500
PVC Class 125	6.625	6.217	22.853	0.258	50...1500
PVC Class 160	6.625	6.115	21.968	0.257	50...1500
PVC Class 200	6.625	5.993	21.068	0.256	50...1500
8 inch Sch 10S	8.625	8.329	43.914	0.286	80...2500
Sch 20	8.625	8.125	41.653	0.283	80...2500
Sch 30	8.625	8.071	41.063	0.283	80...2500
Std. Wt., Sch 40	8.625	7.981	40.086	0.281	80...2500
Sch 60	8.625	7.813	38.288	0.279	80...2500
Extra Strong, Sch 80	8.625	7.625	36.315	0.276	80...2500
PVC Class 125	8.625	8.095	41.324	0.283	80...2500
PVC Class 160	8.625	7.961	39.869	0.281	80...2500
PVC Class 200	8.625	7.805	38.203	0.279	80...2500
10 inch Sch 10S	10.75	10.420	70.195	0.321	125...4000
Sch 20	10.75	10.250	67.668	0.318	125...4000
Sch 30	10.75	10.136	66.069	0.316	125...4000
Sch 40, Std.Wt.	10.75	10.020	64.532	0.314	125...4000
Extra Strong, Sch 60	10.75	9.750	61.016	0.309	125...4000
Sch 80	10.75	9.564	58.644	0.306	125...4000
PVC Class 125	10.75	10.088	65.431	0.315	125...4000
PVC Class 160	10.75	9.924	63.272	0.312	125...4000
PVC Class 200	10.75	9.728	60.733	0.309	125...4000
12 inch Sch 10S	12.75	12.390	104.636	0.367	175...5000
Sch 20	12.75	12.250	102.553	0.364	175...5000
Sch 30	12.75	12.090	99.347	0.36	175...5000
Std. Wt., Sch 40S	12.75	12.000	97.576	0.358	175...5000
Sch 40	12.75	11.938	96.369	0.356	175...5000
Sch 60	12.75	11.625	90.441	0.348	175...5000
Extra Strong	12.75	11.750	92.775	0.351	175...5000
Sch 80	12.74	11.376	85.922	0.342	175...5000
PVC Class 125	12.75	11.966	96.912	0.357	175...5000
PVC Class 160	12.75	11.770	93.152	0.352	175...5000
PVC Class 200	12.75	11.538	88.842	0.346	175...5000

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6
Pipe Size	Pipe O.D. (in.)	Pipe I.D. (in.)	K Value	Offset	Suggested Operating Range (gpm)
14 inch Sch 10S	14.00	13.500	122.307	0.391	200...6000
Sch 20	14.00	13.375	120.216	0.388	200...6000
Std. Wt., Sch 30	14.00	13.250	118.151	0.385	200...6000
Sch 40	14.00	13.124	116.096	0.382	200...6000
Sch 60	14.00	12.814	111.148	0.376	200...6000
Extra Strong	14.00	13.00	114.098	0.33	200...6000
Sch 80	14.00	12.50	106.299	0.369	200...6000
16 inch Sch 10S	16.00	15.500	159.243	0.44	300...9000
Sch 20	16.00	15.375	156.742	0.436	300...9000
Std. Wt., Sch 30	16.00	15.250	154.267	0.433	300...9000
Sch 60	16.00	14.688	143.456	0.419	300...9000
Extra Strong, Sch 40	16.00	15.000	149.394	0.427	300...9000
Sch 80	16.00	14.314	136.548	0.41	300...9000
18 inch Sch 10S	18.00	17.500	202.739	0.498	350...10,000
Sch 20	18.00	17.375	199.828	0.494	350...10,000
Sch 30	18.00	17.124	194.061	0.486	350...10,000
Std. Wt.	18.00	17.250	196.943	0.49	350...10,000
Sch 40	18.00	16.876	188.464	0.479	350...10,000
Sch 60	18.00	16.500	180.171	0.469	350...10,000
Extra Strong	18.00	17.000	191.25	0.482	350...10,000
Sch 80	18.00	16.126	172.152	0.457	350...10,000
20 inch Std. Wt., Sch 20	20.00	19.25	246.179	0.555	400...12,000
Sch 40	20.00	18.812	234.836	0.540	400...12,000
Extra Strong, Sch 30	20.00	19.000	239.666	0.547	400...12,000
Sch 80	20.00	17.938	213.14	0.511	400...12,000
22 inch Std. Wt., Sch 20	22.00	21.25	301.975	0.621	500...15,000
Extra Strong, Sch 30	22.00	21.00	294.642	0.616	500...15,000
Sch 80	22.00	19.75	259.513	0.573	500...15,000
24 inch Std. Wt., Sch 20	24.00	23.25	364.331	0.666	600...18,000
Extra Strong	24.00	23.00	356.178	0.660	600...18,000
Sch 40	24.00	22.624	344.109	0.652	600...18,000
Sch 80	24.00	21.562	311.271	0.628	600...18,000
26 inch Sch 10	26.00	25.376	437.809	0.719	700...21,000
Std. Wt.	26.00	25.25	433.247	0.716	700...21,000
Sch 20, Extra Strong	26.00	25.00	424.274	0.709	700...21,000
28 inch Sch 10	28.00	27.376	513.698	0.774	900...23,000
Std. Wt.	28.00	27.25	508.723	0.770	900...23,000
Extra Strong, Sch 20	28.00	27.00	498.930	0.763	900...23,000
30 inch Sch 10	30.00	29.376	596.147	0.833	1000...30,000
Std. Wt.	30.00	29.25	590.759	0.829	1000...30,000
Sch 20, Extra Strong	30.00	29.00	580.146	0.822	1000...30,000
32 inch Sch 10	32.00	31.376	685.156	0.897	1200...35,000
Std. Wt.	32.00	31.25	679.355	0.893	1200...35,000
Sch 20, Extra Strong	32.00	31.00	667.922	0.885	1200...35,000
Sch 40	32.00	30.624	650.919	0.873	1200...35,000
34 inch Sch 10	34.00	33.312	777.566	0.964	1300...40,000
Std. Wt.	34.00	33.25	774.511	0.962	1300...40,000
Extra Strong, Sch 20	34.00	33.00	762.258	0.953	1300...40,000
Sch 40	34.00	32.624	744.022	0.940	1300...40,000
36 inch Sch 10	36.00	35.376	882.855	1.040	1500...45,000
Std. Wt.	36.00	35.25	876.227	1.035	1500...45,000
Sch 20, Extra Strong	36.00	35.00	863.154	1.025	1500...45,000
Sch 40	36.00	34.50	837.315	1.007	1500...45,000

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, see the calibration instructions in this manual.

1. Depressurize the pipe from which the sensor is to be removed. If the sensor is one of the Series 225/IR225 or 226/IR226, consult the installation section on hot tap sensors. **NEVER disturb the securing lock nuts on a pipe under pressure without the hot tap insertion tool Model HTT installed.**
2. Remove the three lock nuts that secure the positioning collar to the threaded rods of the metal sensor.

NOTE: 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.

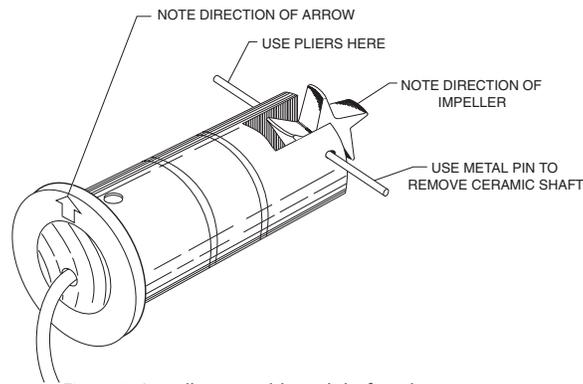


Figure 6: Impeller assembly and shaft replacement

3. Remove the sensor from the hex adapter or the tee.

NOTE: Note the impeller blade orientation relative to the flow arrows and the alignment hole in metal sensors beside one of the sight holes. To maintain proper calibration, the impeller must 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. See *Figure 5*. To reinstall, position the impeller in the cavity, oriented as in the **NOTE** above, so that the impeller blades point into the flow direction and toward the alignment hole located beside one of the sight holes on the metal sensors.
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 relubricate with silicone grease from the packet provided or some other acceptable lubricant.
9. Install the sensor into the 2 inch NPT adapter or tee so that the 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 sight holes are parallel to pipe. If this has been accidentally loosened, see "*Electrical Installation Safety*" on page 11.
10. Install and tighten the nuts.
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**, and holes in sleeve sight exactly down the pipe, the arrows point in the direction of flow, and alignment holes located beside one sight hole are pointing towards the source. If not, see "*Mechanical Installation*" on page 3.

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

TROUBLESHOOTING

1. If the voltage at the sensor input is less than 7V DC in a no flow situation, disconnect the sensor from the barrier strip and measure the voltage again at the sensor input terminals of the barrier strip. It should be between 8...20V DC. If the voltage at the sensor input is still below 7V DC or 3V DC, 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 remove the top lock nuts holding the sensor electronics. 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 the design minimums, or the line was full of air. Try again. If the sensor fails to respond then replace the sensor.

SPECIFICATIONS

Sensor Sleeve and Hex Adapter for 220BR	Sleeve: Admiralty brass, UNS C44300 Hex adapter: Lead-free brass, C89833																				
Sensor Sleeve and Hex Adapter for 225BR, and 226BR	Sleeve: Admiralty brass, UNS C44300 Hex adapter: Lead-free brass, C89833																				
Sensor Sleeve and Hex Adapter for 220SS and 226SS	Series 300 stainless steel																				
Sensor Sleeve and Mounting Adapter for 220PV	Polyvinyl chloride (PVC)																				
Temperature Ratings for 220BR, 220SS	Standard version: 221° F (105° C) continuous service High temperature version: 285° F (140.6° C) continuous service; 305° F (150° C) peak temperature (limited duration)																				
Temperature Ratings	<table border="1"> <tr><td>220SS</td><td>180° F (82° C)</td></tr> <tr><td>220BR</td><td>180° F (82° C)</td></tr> <tr><td>220PV</td><td>140° F (60° C)</td></tr> <tr><td>225BR</td><td>180° F (82° C)</td></tr> <tr><td>226BR</td><td>180° F (82° C)</td></tr> <tr><td>226SS</td><td>180° F (82° C)</td></tr> </table>			220SS	180° F (82° C)	220BR	180° F (82° C)	220PV	140° F (60° C)	225BR	180° F (82° C)	226BR	180° F (82° C)	226SS	180° F (82° C)						
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	At 100° F	At 300° F																			
220SS	400 psi	325 psi																			
220BR	400 psi	325 psi																			
225BR	300 psi	210 psi																			
226BR	400 psi	250 psi																			
226SS	400 psi	300 psi																			
Recommended Design Flow Range	0.5...30 ft/sec Initial detection below 0.3 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 uA (typical) OFF State (V_{High}) = Supply voltage - (600 uA * 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%																				
Electrical Cable for Standard Sensor Electronics	20 feet 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 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 221° F (105° C).																				
Certifications	CE certified																				

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